Water Supply

IWA PUBLISHING

Water Supply Vol 24 No 4, 1102 doi: 10.2166/ws.2024.058

Analysis of the factors influencing willingness to pay and payout level for watershed eco-compensation of the Huangbai river basin

Ren Junlin[a], Bie Xiao[a], Li Xinyue[a] and Peng Ziqian [b,*]

[a] School of Accountancy, Wuhan Textile University, Wuhan 430200, China
[b] School of Economics and Management, Hubei University of Technology, Wuhan 430068, China
*Corresponding author. E-mail: peng_ziqian@hbut.edu.cn

PZ, 0009-0004-4857-270X

ABSTRACT

Watershed Ecological Compensation (WEC), an essential institutional framework, is for watershed ecological protection and management in China. The governments play a leading role but watershed residents who are the direct stakeholders are not given enough attention in the legislation and practice of WEC in most river basins. Thereupon, it is necessary to study the resident's willingness to pay (WTP) and willingness to accept (WTA). Based on the field survey data of the Huangbai River Basin, the contingent valuation method, the Probit and Tobit models were used to explore the WTP and its influencing factors of residents in the basin. Additionally, parametric estimation methods were employed to estimate the payout level and willingness to accept (WTA) of residents in watersheds. Results show that 88.84% of the respondents intended to pay for WEC with an average price of 142.24 CNY per year. The crucial factors influencing WTP were environmental awareness, ecological compensation cognition and political outlook. In addition, attention to ecology and satisfaction with water quality are significantly related to their payment levels. Accordingly, the policy makers should balance WTP and basin economic level and explore the implementation of a comprehensive ecological compensation strategy.

Key words: contingent value method, Huangbai river, payment level, watershed ecological compensation, willingness to pay, Yangtze River basin

HIGHLIGHTS

- Measurement of willingness to pay (WTP) and willingness to accept (WTA).
- Not only analyzes the influencing factors of WTP, but also discusses the influencing factors of payment level.
- Probit and Tobit models are used to assess various variables on the WTP and payment level respectively.
- Crucial factors influencing WTP were environmental awareness, ecological compensation cognition and political outlook.

1. INTRODUCTION

The ecological compensation system is the core component of China's ecological civilization strategy. The watershed ecological compensation is one of the key contents of the ecological compensation system. Through a combination of administrative regulations and economic incentives, watershed ecological compensation can effectively solve the externalities of ecological protection or environmental damage of the watershed, protect the interests of the ecological environment protectors there, and concurrently make its spoilers pay the corresponding costs. This fosters enthusiasm and initiative among all stakeholders in the basin, encouraging them to contribute positively to both the protection and mitigation of ecological issues.

Implementing the watershed ecological compensation system involves many links, of which the calculation method of the compensation standard and the determination of the amount are the core principles. This involves the practical economic interests of the various interest stakeholders of ecological compensation, and it is the key to the smooth development of the ecological compensation project. At present, scholars mainly calculate compensation standards based on three dimensions: direct cost; opportunity cost; and the ecological value provided (Geng *et al.* 2018). In terms of the calculation method and model of ecological compensation standard, researchers proposed many calculation methods, such as: Ecosystem Service Function Value Method (Chen & Qi 2018); Selection Experiment Method (He &

Luo 2016); Water Resource Value Method (Liang *et al.* 2017); Water Ecological Cost Method (Feng *et al.* 2018); Water Footprint Method (Jiao & Ao 2008) and the Continuous Valuation Method (CVM) (Allen & Colson 2019). The Ecosystem Service Function Value Method is generally divided into two categories: direct calculations based on existing basic statistics and indirect analytical calculations based on land use/cover data. The Selection Experiment Method based on declarative preference is an important method for assessing the non-market value of resources. The Water Resource Value Method directly monetizes water resources by considering only the quality and quantity of water resources, and the calculation method is simple and feasible. The Water Ecological Cost Method obtains compensation standards by calculating the direct ecological protection and restoration costs, as well as the development opportunity costs borne due to ecological protection. Water footprint refers to the amount of water resources consumed in the production and consumption of products and services. Ecological compensation based on water footprint is an institutional arrangement that clarifies the principle of 'who benefits, who compensates' based on the unfairness of benefits and damages in the process of water resource development and utilization.

The CVM is one of the more mature and effective methods to determine the ecological compensation criterion at present (Moreno-Sanchez *et al.* 2012). It directly assesses the willingness and level of payment of stakeholders of ecological compensation, and can accurately measure the preference of stakeholders. Thus, scholars have widely applied this method in the research of ecological compensation standards of river basins.

In recent years, researchers have carried out a large number of studies on the WTP for watershed ecological compensation by using the contingent valuation method. For example, Moreno-Sanchez *et al.* (2012) took the Andean region of Colombia as the research area, and used CVM to explore the WTP and its influencing factors on users of ecological services in the basin in terms of participation in compensation. The results showed that the heterogeneity of residents had a significant impact on the WTP. Machado *et al.* (2017) used CVM and bidding game technology to study the WTP and the level of payment in the Feijao basin of SAN Carlos, Brazil. Saridewi & Fauzi (2019) used CVM to obtain the families WTP for an eco-compensation project in the Ciliwung basin in Indonesia, and to determine the amount of compensation that Jakarta government agencies should pay to upstream communities. Eregae *et al.* (2021) used CVM to evaluate the WTP of users in the Elgeyo basin in Kenya, and measured the residents payment level in the basin. Through descriptive analysis and CVM analysis, Puspitasari *et al.* (2021) studied the WTP in the Garang Basin.

In China, scholars have also actively used CVM to carry out research on WTP for ecological compensation in river basins. Chen & Ma (2017) used CVM to analyze the ecological compensation in the Taihu Lake basin, showing that the downstream regions have a higher level of WTP. Zhao *et al.* (2017) used CVM to analyze the impact of psychological ownership and psychological distance of residents in the Ganjiang River basin on their WTP. Tao & Zhao (2018) found that the factors affecting residents' WTP and the level of payment in the Ganjiang River basin were different. Ma *et al.* (2020) found that residents' WTP for ecological compensation in the Yellow River basin were mainly affected by educational level, work, income and their understanding of ecological compensation. Zhao *et al.* (2020) used parametric and non-parametric estimation methods to measure the payment level of residents in the lower reaches of the Jiuzhou River basin and found that residence, gender, occupation, and other characteristics significantly affected the WTP. Wang & Li (2021) compared and analyzed the real WTP and its influencing factors on residents in the middle and lower reaches of the Weihe River by constructing the Logit model, Probit model, and Tobit model.

On the analysis of existing literature, we found the previous research mainly focused on the WTP of basin residents and its influencing factors, and the quantitative studies on the payment level were less. Secondly, few scholars discussed the influencing factors of the two different processes of 'willingness to pay' and 'amount to pay' in the basin ecological compensation. Meanwhile, in terms of the choice of explanatory variables, most literature considers the factors of individual characteristics. The focus on the residents' awareness of the ecological environment and understanding of environmental protection is much less. Finally, the research objects are usually rivers with large drainage areas or located in economically developed regions, but few studies focused on residents' WTP in small watersheds located in underdeveloped areas.

In summary, i) this paper takes the Probit and Tobit regression models as the main tools and selects the underdeveloped Huangbai River basin in the western mountainous area of Hubei Province, China, as the research object. ii) It uses parametric estimation and non-parametric estimation to calculate the payment amount and compensation amount of the residents in the basin, and examines the main factors that affect the WTP and payment level of the residents in the basin. iii) It is expected to provide a theoretical basis and experience for the formulation of ecological compensation standards for small watersheds in mountainous areas of underdeveloped regions, iv) to effectively improve the enthusiasm for ecological compensation to

residents in such watersheds and v) promote the construction of an ecological compensation mechanism for small watersheds in underdeveloped regions.

The rest of this paper is organized as follows. Section 2 explains the data sources and descriptive statistics of samples. Section 3 presents the empirical results and related discussion. Section 4 provides important policy implications. Section 5 is the conclusion.

2. DATA SOURCES AND DESCRIPTIVE STATISTICS OF SAMPLES

2.1. Study area and data sources

The Huangbai River is located northwest of Yichang City, Hubei Province and originates from Heiliang Mountain in Yiling District, Yichang City (Figure 1). The Huangbai River is a primary tributary of the Yangtze River, with a total length of 162 km and a basin area of 1,902 km^2. It is an important industrial cluster in Yichang City, where a large number of phosphate ore industries are distributed in the basin. With the continuous utilization and development of water resources, the ecological problems in the Huangbai River basin have become increasingly prominent. To improve the water ecological system of the basin, the watershed ecological compensation mechanism for the Huangbai River basin was established in 2017 by the local government.

The sample data of the study are from questionnaire surveys and household interviews in August 2019. The basic method was that the trained investigators took the Huangbai River as the center, radiated 65 kilometers around, randomly selected residents near the basin as the survey objects, and completed the questionnaire survey through face-to-face direct interviews. In addition, discussions were held with the Yichang Huangbai River basin administration bureau, Huangbai River basin water resources protection comprehensive law enforcement bureau, villages and towns in the basin and other departments. A total of 260 questionnaires were distributed and 224 valid ones were recovered.

2.2. Analysis of data characteristics

2.2.1. Basic information of sample data

In the statistical sample, the basic information of the respondents is as follows: males account for 52.68% of the total. The average age of the sample was 40.11, and the annual family income accounts for the largest proportion of 30,000 CNY and 50,000 CNY, representing 21.4%. In terms of occupational distribution, mainly enterprise employees, farmers, and

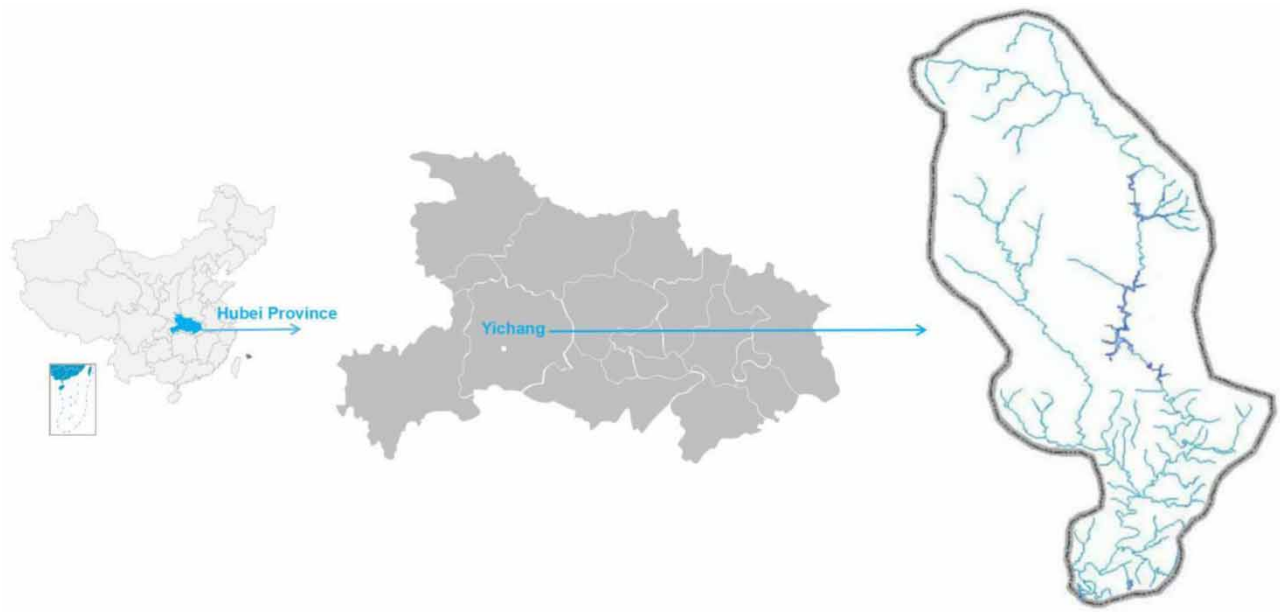

Figure 1 | Sketch map of Huangbai River basin.

self-employed households, accounted for 38.4, 24.1, and 20.5% respectively. The education level is mainly junior high school and senior high school education, accounting for 33.9 and 36.6% respectively.

2.2.2. The cognition status of residents in the river basin on ecological compensation

The survey results showed that nearly 25% of the surveyed residents had no understanding of ecological compensation and 27% of the residents mostly have no understanding of ecological compensation and related policies and regulations. This indicates that the current residents in the Huangbai River basin have, at present, a low awareness of the ecological compensation policies. Only 7.14% of the respondents agree that ecological compensation is a matter of the government and has little to do with ordinary individuals. Some residents believe ecological compensation is the government's responsibility because they believe the ecological environment in the watershed has the attribute of public goods. The government should be responsible for providing public goods rather than individuals. At the same time, under the background of China's centralized political system, some residents believe that the government should bear more social responsibility.

More than 80% of the respondents believe that it is 'very necessary' or 'relatively necessary' to participate in the ecological compensation work of the Huangbai River basin to promote the improvement of the basin environment. This indicates that most of the respondents were consciously involved in the ecological compensation of the basin. In addition, statistics show that residents in the Huangbai River basin generally agree with the principles of 'those who sacrifice, benefit' and 'those who benefit, compensate'. This indicates that residents hold a majority of supportive attitudes towards relevant concepts and principles. 63.39% of the residents 'strongly agree' or 'relatively agree' that the benefits sacrificed due to ecological environment protection need to be compensated, and 58.49% 'strongly agreed' or 'somewhat agreed' that the beneficiaries of ecological environmental protection should pay a certain fee to the environmental protectors. In general, although the residents in the Huangbai River basin have a low level of awareness of the current ecological compensation policy, their awareness of environmental protection, and the sense of equal rights and responsibilities are generally high. This has a significant positive effect on the development of ecological compensation in the basin.

2.2.3. Willingness to pay for ecological compensation and payment level of residents in the river basin

The survey shows that 88.84% of the respondents are willing to participate in the protection of the Huangbai River basin. Of these, 54.91% are willing to provide free labor, 28.23% are willing to pay, 16.86% are willing to pay while providing free labor, and 11.16% are unwilling to pay. The maximum cash payment level for ecological compensation is 2,500 CNY per year, and the minimum cash payment level is 5 CNY per year. The proportion of the payment level between 91 and 100 CNY per year is 18.75%, and the annual payment level of 17.41% of residents is not more than 10 CNY. When asked, 'If you are a destroyer of the ecological environment of the Huangbai River, how much would you like to pay for ecological compensation (CNY) at most every year?' and 'If you are a beneficiary of the protection of the ecological environment of the Huangbai River, how much would you like to pay for ecological compensation (CNY) at most every year?', 14.29% and 16.07% of the respondents indicated that at most, every year they were willing to pay 91–100 yuan (excluding the blank data option). This is equivalent to the cost that the residents are willing to pay, indicating that 91–100 CNY is the cost that most residents of the Huangbai River basin are willing to pay to participate in the ecological compensation of the Huangbai River basin every year.

3. RESULTS AND DISCUSSION

3.1. Empirical model

3.1.1. Analysis model of influencing factors of willingness to pay

To understand the influencing factors of 'willingness to pay' and 'level of payment' of the residents in the basin, this paper uses stata16.0 statistical software to carry out regression analysis between the respondents' willingness to pay for ecological compensation and related variables.

The individual characteristics of the respondents (age, residence, occupation, political outlook, annual income) and the resident's awareness of the ecological environment (the respondents' attention to the ecological environment, their awareness of the importance of the ecological environment in the upper reaches of the Huangbai River, their confidence in the government's protection and governance of the Huangbai River basin, and whether they agree that those who destroy and pollute the ecological environment must pay a certain amount of fines) are independent variables. Taking the residents' willingness to pay and annual payment level as dependent variables respectively, a measurement model is constructed. This will be used to

describe the individual characteristics of respondents and the impact of residents' awareness of the ecological environment on residents' willingness to pay, and the payment level of ecological compensation.

Since the willingness to pay ecological compensation includes 'willing' and 'unwilling' choices and the dependent variable is a discrete binary categorical random variable, it needs to be transformed into a utility model to evaluate it, and the Probit model is suitable for analyzing utility maximizing behavioral choices, and is the ideal model for analyzing individual decision-making behavior. Therefore, this paper establishes a Probit regression model to analyze the relationship between willingness to pay ecological compensation and the influencing factors. The specific form of the model is as follows:

Let YY^* be a determined latent variable ($Y^* = \beta_0 + \beta X + \mu$), β is a parameter to be estimated, $\beta = (\beta_1, \beta_2, \ldots, \beta_9)$, Y is the actual observed dependent variable, X is the observed independent variable, $X = (X_1, X_2, \ldots, X_9)$, and has:

$$Y = \begin{cases} 1, \text{if } Y* > 0, \text{ Residents are willing to pay} \\ 0, \text{if } Y* \leq 0, \text{ Residents are unwilling to pay} \end{cases} \tag{1}$$

Assuming that μ is a random disturbance term and follows the standard normal distribution, the binary discrete choice model that affects residents' willingness to pay for ecological compensation can be expressed as follows:

$$\begin{aligned} P(Y = 1|X) &= P(Y* > 0) \\ &= P(\mu > -(\beta_0 + \beta X)) \\ &= 1 - (\Phi - (\beta_0 + \beta X)) \\ &= \Phi(\beta_0 + \beta X) \end{aligned} \tag{2}$$

where P represents the probability and Φ is the standard normal cumulative distribution function. Therefore, the Probit regression equation is established as follows:

$$Y* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \mu \tag{3}$$

where β_0 is a constant term, β_i is the regression coefficient of the desired Probit equation, X_i is the independent variable (influencing factor), μ is the random error term, Y is the willingness to pay, and represents whether residents are willing to pay a certain fee for ecological protection.

3.1.2. Analysis model of influencing factors of payment level

The survey data shows that 25 out of 224 people are unwilling to pay, indicating that the observation value of the dependent variable is 0, and there is a problem of biased sample selection. Therefore, when analyzing the factors that affect the ecological compensation payment level of residents in the basin, the observation of residents with zero willingness to pay must be reviewed to ensure that the estimation of the ecological compensation payment level of residents is unbiased. The Tobit model can also include the observations value of residents who have no willingness to pay in the estimation range. The specific form of the Tobit model is as follows:

$$y* = \alpha_0 + \alpha X + \sigma\mu \tag{4}$$

where y^* is a potential variable, α is the parameter to be estimated for each variable, $\alpha = (\alpha_1, \alpha_2, \ldots, \alpha_9)$, X is the independent variable, and σ is the parameter of the random variable μ. The relationship between the observed data y and the potential variable y^* is as follows:

$$y = y_i = \begin{cases} 0, \textit{if } y_i^* \leq 0 \\ y_i^*, \textit{if } y_i^* > 0 \end{cases} \tag{5}$$

Thus, the Tobit regression equation is established as follows:

$$y* = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + \alpha_7 X_7 + \alpha_8 X_8 + \alpha_9 X_9 + \sigma\mu \tag{6}$$

where y represents the payment level, that is, the amount that residents are willing to pay for ecological protection in the upper reaches of the Huangbai River.

3.1.3. Parametric and non-parametric estimation models of willingness to pay and willingness to be compensated

At present, the calculation methods of willingness to pay (WTP) and willingness to accept (WTA) are divided into parametric estimation and non-parametric estimation. The non-parametric estimation method considers the influence of the basic characteristics of the respondents and other relevant variables. It is obtained by the mathematical expectation of discrete variables according to the average of the willingness to pay. The parameter estimation method considers that the respondents' willingness to pay is affected by many factors, then uses the maximum likelihood function to estimate the relationship between the bid value and the respondents' personal characteristics and environmental goods attributes, selects the logarithmic normal distribution of the midpoint value of willingness to pay as the explained variable, and uses multiple linear regression to estimate the expected value of WTP and WTA. The WTP and WTA expectations under non-parametric estimation can be calculated using the following model:

$$\mathrm{E(WTP)} = \sum_{i=0}^{n} \alpha_i \mathrm{Pr}_i \tag{7}$$

$$\mathrm{E(WTA)} = \sum_{i=0}^{n} \alpha_i \mathrm{Pr}_i \tag{8}$$

where, α_i represents the willing bidding value selected by the surveyed residents; this paper chooses the midpoint value of the willingness to pay and the willingness to be compensated as the bidding value; Pr_i represents the probability of the bidding interval selected by the surveyed residents; and n represents the sample number of the surveyed residents.

Considering that the basic characteristics of the surveyed residents and other relevant variables such as age, gender, average annual income of the family, together with the degree of understanding of the ecological compensation policy, these factors combined will affect the selection results. This paper refers to Xu *et al.* (2012) and Zhao *et al.* (2020). For the measurement of WTP and WTA, the maximum likelihood function estimation method is used to estimate the relationship between the bid value and the variables representing the characteristic information of the respondents, and the lognormal distribution of the midpoint value of the willingness to pay or the willingness to be compensated is selected as the explained variable (Zhao *et al.* 2020). This parameter estimation method is used to measure the WTP and WTA of residents in the Huangbai River Basin. This paper uses the maximum likelihood function estimation method to estimate the relationship between the bid value and the variables representing the respondents' characteristic information, referring to the calculation methods of Xu *et al.* (2012) and Zhao *et al.* (2020), and selects the lognormal distribution of the midpoint value of willingness to pay or willingness to be compensated as the explained variable. This parameter is then used as an estimation method to calculate the WTP and WTA of residents in the Huangbai River basin. The calculation model is as follows:

$$\ln \mathrm{WTP} = \alpha X + \mu \tag{9}$$

$$\begin{aligned} \mathrm{E(WTP)} &= \exp\left(\alpha X + \delta^2/2\right) \\ &= \exp\left(C + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_n X_n + \delta^2/2\right) \end{aligned} \tag{10}$$

$$\ln \mathrm{WTA} = \alpha X + \mu \tag{11}$$

$$\begin{aligned} \mathrm{E(WTA)} &= \exp\left(\alpha X + \delta^2/2\right) \\ &= \exp\left(C + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_n X_n + \delta^2/2\right) \end{aligned} \tag{12}$$

where, X represents the basic characteristics of individual residents, as shown in Tables 1 and 2 below, α represents the regression coefficient of the explanatory variable, μ is a random variable subject to the normal distribution of $[0, \delta^2]$, and $\ln \mathrm{WTP}$ also follows the distribution of $[0, \delta^2]$, δ is the standard deviation of the normal distribution function, and in the formulae (11) and (12), X, α, μ, δ is the same as the formulae (9) and (10).

Table 1 | Basic statistical information of respondents

Variable	Classification indexes	Proportion of/%	Variable	Classification indexes	Proportion of/%
Area	Xiaoxi tower	33.50		30,000–50,000 CNY	21.40
	Fenxiang towns	29.00		50,000–70,000 CNY	8.50
	Huanghua town	2.70	Income	70,000–100,000 CNY	7.60
	Leizu town	34.80		More than 100,000 CNY	6.70
Gender	Male	52.68	Professional	Company worker	38.40
				Farming	24.10
	Female	47.32		Self-employed	20.50
	18 years old and under	3.12		Students	6.30
	18–29 years old	17.41		Business unit	10.70
Age	30–39 years old	22.76	The household registration	Cities and towns	51.34
	40–49 years old	34.37		Rural	48.66
	50–59 years old	16.51		Primary school and below	8.90
	60 and above	5.83		Junior high school	33.90
	10,000 CNY and less	36.60	Level of education	High school or technical secondary school	36.60
Income	10,000–30,000 CNY	19.20		Bachelor degree or college degree	20.60

3.2. Empirical results and discussion

Taking the data collected from the questionnaire as the sample, and using stata16.0 to estimate the model and the estimated results of Probit model and Tobit model, the estimation results of the Probit model and Tobit model are shown in Tables 3 and 4.

3.2.1. Empirical results of influencing factors of willingness to pay

Table 3 shows the results of regression analysis by the Probit model, with respondents' willingness to pay as explanatory variables and their characteristic data as independent variables. The parameter symbols of each variable are consistent with the expectation except the annual household income (X_5) (see Table 3). Among the nine explanatory variables, residents' political outlook (X_4) has a significant positive impact on their willingness to pay for ecological compensation. According to the assignment in Table 2, this variable divides the political outlook of residents into party members and non-party members. The regression results show that party members have a higher willingness to pay, indicating that grass-roots party members can play a significant role in the construction of China's modern environmental governance system. This may be because members of the Communist Party of China have a clear sense of political consciousness and responsibility. The party membership makes it an example, and example of environmental protection, plays an exemplary and leading role in participating in environmental governance, and encourages and drives more people to take active action. The residents' attention to the ecological environment issues (X_6) and their awareness of the importance of the ecological environment of the Huangbai River (X_7) are significantly positively correlated with their willingness to pay, indicating that the residents' attention to the environmental issues, especially the level of concern for the immediate environmental issues, will significantly affect their willingness to pay. Residents concerned about the environment often receive relevant education and information dissemination, understand the importance of environmental problems and their impact on people and society, and have environmental values and a sense of responsibility. The more residents pay attention to the ecological environment, the stronger their awareness of the ecological environment, and the more willing they are to pay for it.

The degree of confidence in the government's protection and governance of the Huangbai River basin (X_8) is significantly positively correlated with the willingness to pay, indicating that the higher the residents' confidence in the government's protection and governance of the basin, the more willing they are to pay for environmental governance. This shows that the

Table 2 | Explanatory variable selection and description table

Variable	Definition and assignment	Average	Standard deviation	Expected direction
Age (X_1)	Dummy variable, assignment: 1 = under 18 years old; 2 = 18–29 years old; 3 = 30–39; 4 = 40–49 years old; 5 = 50–59 years old; 6 = 60 years and older	3.61	1.21	−
Where (X_2)	Dummy variable, Xiaoxi Town = 1, Fenxiang Town = 2, Huanghua Town = 3, Leizu town = 4	2.42	1.31	+
Professional (X_3)	Dummy variables, farming = 1, enterprise employee = 2, self-employed = 3, student = 4, public institution = 5, others = 6	2.58	1.48	−
Political status (X_4)	Dummy variable, party member = 1, non-party member = 0	0.11	0.32	+
Income (X_5)	Dummy variable, assignment: 1 = <5,000; 2 = 5,001–10,000; 3 = 10,000–20,000; 4 = 20,001–30,000; 5 = 30,001–40,000; 6 = 40,001–50,000; 7 = 50,001–70,000; 8 = 70,001–90,000; 9 = 90,001–11,000; 10 = 11,001–13,000; 11 = 130,001–150,000; 12 = 150,001 and above	4.47	2.85	+
Attention to ecological environment (X_6)	Dummy variable, not knowing at all = 1; Most do not know = 2; Partial understanding = 3; Most understand = 4; Perfect knowledge is equal to 5	2.38	1.08	+
Cognition on the importance of ecological environment in the Upper reaches of Huangbai River (X_7)	Dummy variable, not significant at all = 1; Not very important = 2; Not important = 3; Relatively important = 4; Very important = 5	4.58	0.75	+
Degree of confidence in the government's protection and governance of Huangbai River Basin (X_8)	Dummy variable, no confidence at all = 1; Not very confident = 2; Neutral = 3; More confident = 4; Very confident = 5	3.94	0.97	+
Are you satisfied with the current water quality of Huangbai River (X_9)	Dummy variable, completely dissatisfied = 1; Not very satisfied = 2; General satisfaction = 3; Relatively satisfied = 4; Very satisfied = 5	2.91	1.01	+

Table 3 | Regression results of the Probit model

Explanatory variable (Y)	Regression coefficient	Standard deviation	Z value	*P* value
Age (X_1)	−0.019 *	0.011	−1.68	0.093
Residence (X_2)	0.275	0.259	1.06	0.288
Professional (X_3)	−0.064	0.056	−1.14	0.254
Political status (X_4)	0.649 * *	0.305	2.13	0.033
Annual household income (X_5)	−1.08E-06	3.08E-06	−0.28	0.776
Attention to ecology (X_6)	1.022 * *	0.487	2.1	0.036
Cognition of Huangbai River (X_7)	0.979 * *	0.479	2.04	0.041
Confidence in government governance (X_8)	0.806 * *	0.343	2.34	0.019
Satisfaction with water quality (X_9)	1.572 *	0.913	1.72	0.085
Constant term	−0.628 * * *	0.404	−3.04	0.008

Note:*,**,***It is significant at the levels of 0.1, 0.05 and 0.01, respectively.

residents of the Huangbai River basin recognize the current situation of the local government's watershed environmental governance. Simultaneously, it shows that the residents have high trust in the government and are willing to pay for the government's governance measures. Increased confidence in the government's ability to protect and manage watersheds is often based on recognition of the government's capacity and commitment. They believe in the government's

Table 4 | Tobit model regression results

Explanatory variable (Y)	Regression coefficient	Standard deviation	*Z* value	*P* value
Age (X_1)	0.088	0.061	1.45	0.148
Residence (X_2)	0.054	0.056	0.95	0.343
Professional (X_3)	−0.013	0.011	−1.17	0.242
Political status (X_4)	0.044	0.075	0.57	0.572
Annual household income (X_5)	0.077	0.063	1.22	0.224
Attention to ecology (X_6)	0.018 * * *	0.064	2.78	0.006
Cognition of Huangbai River (X_7)	0.025	0.128	0.20	0.841
Confidence in government governance (X_8)	0.092	0.088	1.04	0.298
Satisfaction with water quality (X_9)	0.245 * *	0.098	2.49	0.013
Constant term	1.41 * * *	0.467	3.03	0.003

Note:*,**,*** significant at the levels of 0.1, 0.05 and 0.01, respectively.

ability to take effective measures to improve the environment of the watershed and are willing to pay the price. The annual household income (X_5) of residents in the Huangbai River basin has no significant impact on their willingness to pay all together. This indicates that the willingness to pay of residents has nothing to do with their annual household income. This is inconsistent with the inertial thinking that the more annual household income is, the more willing they are to pay.

The Probit model results indicate that among the factors influencing residents' willingness to pay, the subjective factors have a significantly higher degree of influence than the objective factors, that is, willingness to pay is more from residents' inner cognition, rather than the objective factors. Therefore, in promoting the construction of ecological compensation in river basins in underdeveloped regions, all localities should give priority to the pioneering and exemplary role of basic party organizations and party members, and publicize the knowledge of ecological compensation.

3.2.2. Empirical results of influencing factors of payment level

In this paper, the Tobit model is used to analyze the influence of the above variables on the payment level. The regression results are shown in Table 4. Attention to the ecological environment (X_6) and satisfaction with the current environment (especially the water quality in the river) of Huangbai River and its surrounding rivers (X_9) are factors that positively and significantly affect the level of residents' ecological compensation payment, indicating that the higher the attention of residents to the ecological environment, the higher the level of ecological compensation payment. However, the higher the satisfaction (X_9) of the environment of Huangbai River and its surrounding rivers (especially the water quality in the river), the higher the level of ecological compensation payment. The reason is that the higher the satisfaction with the environment of Huangbai River and its surrounding rivers, the more they can feel the benefits brought by ecological protection. The mentality of vested interests is amplified, so they are more willing to pay a higher amount. Among the individual statistical characteristic variables, age (X_1), residence (X_2), occupation (X_3), political status (X_4), family annual income (X_5), and other variables have a weak influence on the payment level. Additionally, the degree of significance is not high, indicating that the payment level has little relationship with the basic information of individuals. Based on the above analysis, it can be seen that among those willing to pay, it has little relationship with residents objective life, and the level of payment is mainly influenced by the subjective level of residents' inner cognition.

Through the comparative analysis of the Probit and Tobit models, except that residents' attention to the ecological environment (X_6) affects the two decisions of 'willingness to pay' and 'level of payment' of the respondents all at once, other significant influencing factors are not completely identical. This indicates that the willingness preference of the respondents is composed of two different processes. These should be analyzed separately.

3.2.3. Estimation results of willingness to pay and willingness to be compensated

According to the data in Tables 5 and 6, without considering the influence of other factors, the nonparametric estimation results are as follows:

$$E(WTP) = \sum_{i=0}^{n} \alpha_i \Pr_i = 145.09\,\text{yuan/a}$$

$$E(WTA) = \sum_{i=0}^{n} \alpha_i \Pr_i = 925.19\,\text{yuan/a}$$

Considering the influence of characteristic factors of the respondents, the parameter estimation method was adopted. The statistical software stata16.0 was used to process the formula, WTP, and WTA calculation model. The results are shown in Tables 7 and 8.

According to the formula, the expectation of WTP and WTA of respondents in Huangbai River Basin is:

$$E(WTP) = \exp(C + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_n X_n + \delta^2/2) = 139.39\ \text{yuan/a}$$

$$E(WTA) = \exp(C + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_n X_n + \delta^2/2) = 2361.65\,\text{yuan/a}$$

According to the above results, the WTP of residents calculated by the non-parametric estimation method and the parametric estimation method are 145.09 CNY per year and 139.39 CNY per year respectively. Since the two calculation methods may have certain errors, this paper refers to the treatment method of Zhao *et al.* (2020). Thus, when studying the WTP of residents

Table 5 | The ecological awareness of respondents

Project	Options	Sample size	Frequency (%)	Project	Options	Sample size	Frequency (%)
Degree of understanding of ecological compensation	Completely ununderstood	55	24.55	The impact of water quality on an individual's health	No effect at all	6	2.68
	Most do not understand	65	29.02		Basically no impact	36	16.07
	Partially understood	79	35.27		Don't know if there is an impact	33	14.73
	Most of the understanding	13	5.80		It has a big impact	63	28.13
	Totally understood	12	5.36		It has a huge impact	86	38.39
Do you know that the state is carrying out the protection of the Yangtze River	Know	178	79.46	Whether or not all costs of ecological compensation are considered to be borne by the government?	Completely disagree	51	22.77
	Don't know	46	20.54		Not quite agree	105	46.88
The degree of pollution considered in the place of residence	No pollution	59	26.34		Generally agree	32	14.28
	Minor contamination	62	27.68		Somewhat agree	20	8.93
	General contamination	79	35.27		Strongly agree	16	7.14
	More serious	24	10.71	Willing to participate in the ecological protection of the Yangtze River in what way	Contribute effort	123	54.91
	Very serious	0	0		Contribute money	23	10.27
					Contribute money and effort	38	16.96
					Unwilling to participate	25	11.16
					Other	15	6.70

Table 6 | Cumulative frequency distribution of willingness to Pay (WTP) and willingness to accept (WTA)

	WTP			WTA		
Amount/CNY	Absolute frequency/person-time	Frequency (%)	Cumulative frequency (%)	Absolute frequency/person-time	Frequency (%)	Cumulative frequency (%)
≤10	13	5.80	5.80	1	6.70	6.70
11–20	62	27.68	33.48	41	18.30	25.00
21–30	6	2.68	36.16	2	0.89	25.89
31–40	2	0.89	37.05	0	0.00	25.89
41–50	9	4.02	41.07	4	1.79	27.68
51–60	7	3.13	44.20	3	1.34	29.02
61–70	1	0.45	44.65	2	0.89	29.91
71–80	0	0.00	44.65	2	0.89	30.8
81–90	1	0.45	45.10	1	0.45	31.25
91–100	42	18.75	63.85	12	5.36	36.61
101–150	10	4.46	68.31	5	2.23	38.84
151–200	9	4.02	72.33	9	4.02	42.86
201–300	14	6.25	78.58	10	4.46	47.32
301–400	3	1.34	79.92	1	0.45	47.77
401–500	8	3.57	83.49	9	4.02	51.79
501–1,000	4	1.79	85.28	28	12.50	64.29
1,001–1,500	3	1.34	86.62	15	6.70	70.99
1,501–2,000	2	0.89	87.51	11	4.91	75.9
>2,000	2	0.89	88.40	54	24.10	100

Table 7 | Regression results of WTP and related variables of respondents in the Huangbai River basin

variable	Coefficient	*T* value	*P* value
X_1	0.243256	1.00	0.320
X_2	0.163776	0.72	0.472
X_3	0.050312	1.10	0.274
X_4	0.133260	0.44	0.659
X_5	0.317628	1.24	0.215
X_6	0.545090	2.11	0.036
X_7	−0.016065	−0.03	0.975
X_8	−0.396632	−1.12	0.266
X_9	0.294231	0.75	0.457
C	0.671970	0.36	0.720

in the Jiuzhou River Basin (Zhao *et al.* 2020) the results of the two estimation methods are averaged to reduce the error, and the average WTP of residents in the Huangbai River basin is finally calculated to be 142.24 CNY per year.

Compared with other research results, the WTP of residents in the Huangbai River basin is at the middle and downstream levels. For example, the WTP of residents in Zhengzhou in 2015 was 99.48 CNY per year (Zhou *et al.* 2015). In 2012, the WTP of Liaohe River basin residents was 160.72 CNY per year (Xu *et al.* 2012), and the WTP for ecological compensation

Table 8 | Regression results of WTA and related variables of respondents in the Huangbai River basin

Variable	Coefficient	*T* value	*P* value
X_1	−0.951925	−2.88	0.004
X_2	−0.176461	−0.57	0.567
X_3	−0.067131	−1.08	0.281
X_4	0.270830	0.66	0.507
X_5	0.174787	0.51	0.613
X_6	−0.357263	−1.02	0.309
X_7	−1.124512	−1.62	0.107
X_8	−0.556061	−1.16	0.248
X_9	1.089522	2.04	0.042
C	10.204710	4.03	0.000

of residents in the beneficiary areas in the lower reaches of the Jiuzhou River basin in 2020 is 154.30 CNY per year (Zhao *et al.* 2020). Considering the time value of money, the present value of the above funds converted according to the annual interest rate of 4% is 125.87, 228.79 and 160.47 CNY per year respectively.

According to the estimation of residents' willingness to accept (WTA), the minimum WTA of residents calculated by non-parametric estimation method and parametric estimation method is 925.19 and 2,361.65 CNY per year respectively. Similarly, the minimum WTA of residents in the Huangbai River basin is 1,643.42 CNY per year.

Compared with the minimum WTP and the amount of WTP, there is a serious asymmetry. Among the 224 valid questionnaires, 11.16% of residents chose zero payment (0 WTP), while no one chose zero compensation (0 WTA). The reason for the 0 WTP is that most respondents believe that 'ecological compensation is a government's business' and 'low income makes it difficult to afford'. From the above analysis, it can be seen that the annual household income (X_5) has no significant impact on the WTP and the level of payment of residents. It can be inferred that the root cause of the difference lies in the inner thoughts of residents in the basin. Residents rely more on the government to maintain the ecological environment in the basin. Thus, the public goods attribute of the ecological environment in the basin leads to asymmetry. For instance, the upstream residents pay more for the development of the basin than the downstream residents, so they need more compensation. However, downstream residents believe that 'ecological compensation is a matter for the government and should not be paid by individuals' and are unwilling to pay equivalent amounts. In addition, the contingent value method needs to make scenario assumptions for the interviewees, which may increase the probability of irrational judgment when the interviewees choose to be compensated.

4. RECOMMENDATIONS

4.1. Increase publicity and guidance of policies related to ecological compensation

The research results show that the key factor affecting the willingness and level of residents to pay for ecological compensation is not the level of residents' income, but the degree of concern for ecological environmental issues and the awareness of ecological compensation policies of residents in the basin. Strengthening publicity and guidance can not only convey the knowledge of relevant environmental governance issues to residents and enhance their awareness of environmental protection, but also strengthen society's attention and recognition of environmental protection, form social pressure, and urge residents to consciously participate in environmental governance and bear the corresponding costs. For this reason, in order to ensure that the residents of the river basin actively participate in the ecological compensation of the river basin, and especially to help them realize that ecological compensation of the river basin is not only the responsibility of the local government, many initiatives and steps are required. It is necessary to strengthen the publicity and guidance of the news media to explain and publicize the connotation, role, and precautions of the ecological compensation of the river basin in plain language. This will improve their cognitive level and willingness to act. By strengthening the environmental protection awareness and cognitive level of the residents in the basin, and enhancing the compensation concept and principle of compensation for the beneficiaries and the destroyer, we will guide all participants to gradually improve their willingness to pay

and their level of payment. In addition, by promoting the construction of ecological compensation for river basins in underdeveloped areas, all localities should give priority to the vanguard and exemplary role of basic party organizations and party members, playing a good demonstration significance.

4.2. Improve laws and regulations related to ecological compensation in river basins

Improving the laws and regulations related to ecological compensation in river basins can protect the rights and interests of residents, ensure fairness and justice, clarify cost sharing and shared responsibilities, establish incentive mechanisms and incentive measures, enhance residents' participation and recognition, and improve residents' willingness to pay. Ecological compensation involves the vital interests of the relevant stakeholders, so it is necessary to rely on relevant laws and regulations to clarify the rights, obligations, and responsibilities of all parties. First, the legal documents voted by the local people's congresses were issued to solve the legal system problem of ecological compensation in the river basin. Second, the formulation of corresponding detailed plans for specific river basins to solve the implementation of ecological compensation for river basins. Through laws and regulations to clarify the main body, method, standard, source of funds, and using the river basin for ecological compensation, it will ensure that the main body of river basin ecological compensation can have laws to follow, and improve the long-term mechanism at the institutional level.

4.3. Increase the effectiveness of watershed environmental governance and establish government credibility

The governance effect and trust degree of the residents in the basin means that the government have a significant positive impact on the willingness to pay and the level of payment. When the watershed management department can effectively manage the local ecological environment, it will establish good credibility in the region. Residents are more inclined to believe that the money or labor they put in will be used for watershed environmental governance and can improve the effectiveness of governance, thus having a higher willingness to pay for ecological compensation.

The local government of the basin should effectively increase the investment in the basins environmental governance and restoration, and make the basins residents feel the improvement of the ecological environment through the actual governance results. Furthermore, they can work to improve the transparency of the use of relevant funds and supervision, enhance the confidence of the basin residents in the government's improvement of the basin ecological environment, enable the residents to actively participate in the basin governance, and improve the willingness and payment level of the basin residents for ecological compensation.

4.4. Formulate scientific and reasonable compensation standards based on the level of payment and the economic level of the basin

The ecological compensation standard should not be too high, especially in economically underdeveloped areas. Compared to protecting and restoring the ecological environment, residents in underdeveloped areas are more concerned about improving their material lives. Inappropriate ecological compensation standards will hurt the livelihoods of residents and directly reduce their willingness to pay.

The river basin ecological compensation standard should not only be based on the cost of governance. It should also comprehensively consider the level of economic development of the river basin and the heterogeneity of residents' livelihood capital. In so doing, it should accurately identify the distance from the river, the length of residence, family economic affordability and other different situations, and develop differentiated and dynamic ecological compensation standards according to local conditions. It is necessary to comprehensively consider the cost of upstream ecosystem construction and protection and the economic losses caused by the destruction of the ecological environment in the downstream, and scientifically determine the ecological compensation standard. In addition, according to the basin characteristics and different payment preferences, diversified and differentiated payment methods can be adopted, such as paying taxes, providing labor, or providing ecological products.

5. CONCLUSION

This study examined the determinants of residents' WTP and WTA for ecological compensation of the Huangbai River Basin in China and their payment levels, using resident household-level field survey data. The CVM, Probit model and Tobit model were applied. This study illuminates the public goods attribute of the watershed ecological environment and highlights the importance of willingness-to-pay for WEC.

The results show that 88.84% of the residents are willing to pay a certain amount for ecological compensation, and 11.16% of the residents are unwilling to pay for it. Through the calculation of Probit and Tobit, it is evident that the political status, the degree of concern of residents on ecological and environmental issues, the recognition of the importance of the ecological environment of the Huangbai River, and the degree of confidence in the government's protection and governance of the Huangbai River basin are significantly positively related to willingness to pay. On the other hand, concern about the ecological environment and satisfaction with the current environment of Huangbai River and its surrounding rivers (especially the water quality in the river) are the factors that positively and significantly affect the level of residents' ecological compensation payment. Among the social characteristic variables and cognitive variables of respondents, except for residents' attention to the ecological environment variable, it was clear that other significant influencing factors are not completely the same in the two decisions of 'willingness to pay' and 'payment amount'. Empirical analysis demonstrates that subjective factors of residents in river basins have a greater impact on their willingness to pay than objective factors.

Through the combination of non-parametric estimation and parametric estimation, it is measured that the average annual willingness to pay of residents in the Huangbai River basin is about 142.24 CNY per year. The minimum willingness to receive compensation is 1,643.42 CNY per year. Since the respondents depend on the government for the protection of the basin ecology, there is a big difference between the two. The public goods attribute of the ecological environment of the river basin has led to a large difference in the expenditure and compensation cognition of the ecological protection costs of the river basin residents. Subjectively, they tend to exaggerate the interests sacrificed for the ecological environment protection, rationalize their demands for higher compensation charges, while weakening their ecological environment protection obligations as far as possible. This shifts the responsibility to the river basin government or enterprises to match the lower willingness to pay.

In order to effectively improve the residents' WTP for the ecological compensation of Huangbai River Basin and their payment levels, it is necessary to further improve the policy design and arrangement of the basin ecological compensation system. First, increase publicity and guidance of policies related to ecological compensation. Strengthening publicity and guidance can not only convey the knowledge of relevant environmental governance issues to residents and enhance their awareness of environmental protection, but also strengthen society's attention and recognition of environmental protection, form social pressure, and urge residents to consciously participate in environmental governance and bear the corresponding costs. Secondly, improve laws and regulations related to ecological compensation in river basins. Improving the laws and regulations related to ecological compensation in river basins can protect the rights and interests of residents, ensure fairness and justice, clarify cost sharing and shared responsibilities, establish incentive mechanisms and incentive measures, enhance residents' participation and recognition, and improve residents' willingness to pay. Third, increase the effectiveness of watershed environmental governance and establish government credibility. When the watershed management department can effectively manage the local ecological environment, it will establish good credibility in the region. Residents are more inclined to believe that the money or labor they put in will be used for watershed environmental governance and can improve the effectiveness of governance, thus having a higher willingness to pay for ecological compensation. Fourth, formulate scientific and reasonable compensation standards based on the level of payment and the economic level of the basin. The ecological compensation standard should not be too high, especially in economically underdeveloped areas. Compared to protecting and restoring the ecological environment, residents in underdeveloped areas are more concerned about improving their material lives. Inappropriate ecological compensation standards will hurt the livelihoods of residents and directly reduce their willingness to pay.

This study contributes to the recent literature not only by researching the residents' WTP for basin ecological compensation and their payment levels in underdeveloped areas of China but also by examining the residents' WTA. In addition, this paper further provides some insights into factors that lead to the differences in willingness to pay. This study has some limitations. The empirical analysis is based on 260 field survey data in 2019. Therefore, future research should consider a broader sample.

ACKNOWLEDGEMENTS

This work was supported by the National Social Science Fund of China (Grant No. 20CGL038).

DATA AVAILABILITY STATEMENT

Data cannot be made publicly available; readers should contact the corresponding author for details.

CONFLICT OF INTEREST

The authors declare there is no conflict.

REFERENCES

Allen, K. E. & Colson, G. 2019 Understanding PES from the ground up: A combined choice experiment and interview approach to understanding PES in Costa Rica. *Sustainability Science* **14** (2), 391–404.

Chen, Y. & Ma, J. 2017 Study on willingness to pay for bidirectional ecological compensation and its influencing factors in Taihu Lake Basin—A case study in upper reaches of Yixing, Huzhou City and lower reaches of Suzhou City. *Journal of Huazhong Agricultural University (Social Sciences Edition)* **1**, 16–22.

Chen, B. & Qi, X. 2018 Protest response and contingent valuation of an urban forest park in Fuzhou City, China. *Urban Forestry & Urban Greening* **29**, 68–76.

Eregae, E. J., Paul, N., Rebecca, K. & Moses, G. 2021 Economic valuation for cultural and passive ecosystem services using a stated preference (contingent valuation method (CVM)) case of the Elgeyo Watershed Ecosystem, Kenya. *International Journal of Forestry Research* **2021**, 1–12.

Feng, H. Y., Shi, P. J., Zhou, W. X., Chen, J. Y. & Zhang, X. B. 2018 Threshold analysis of urbanization with the constraint of 'Three red lines' on water resources management: A case study of Zhangye City. *Journal of Natural Resources* **33** (2), 287–301.

Geng, X. Y., Ge, Y. X. & Zhang, H. N. 2018 Study on ecological compensation standard of watershed based on reset cost:a case study of xiaoqing River Basin. *China Population, Resources and Environment* **28** (1), 140–147.

He, Y. & Luo, H. 2016 A study on ecological compensation of cities in upstream and downstream of Gan River Based on water footprint theory. *East China Economic Management* **30** (12), 9–13.

Jiao, Y. & Ao, Z. L. 2008 Research development of contingent value method in ecological environments evaluation. *Journal of Northeast Agricultural University* **5**, 131–136.

Liang, Y. X., Yu, L. J. & Zhang, P. 2017 Study on pricing for paid use of water pollutants emission permits based on a method of cost renewing. *Environmental Engineering* **35** (12), 159–162. + 153.

Ma, Y. F., Liu, J. J. & Lu, W. G. 2020 Empirical study on residents' willingness to pay for ecological compensation and its influencing factors in the Yellow River Basin: A case study of 2396 residents in Lanzhou city, Gansu Province. *Productivity Research* **8**, 54–57.

Machado, F. H., Silva, L. F., Dupas, F. A., Mattedi, A. P. & Vergara, F. E. 2017 Economic assessment of urban watersheds: Developing mechanisms for environmental protection of the Feijão river, São Carlos – SP, Brazil. *Brazilian Journal of Biology* **74** (3), 677–684.

Moreno-Sanchez, R., Maldonado, J. H., Wunder, S. & Borda-Almanza, C. 2012 Heterogeneous users and willingness to pay in an ongoing payment for watershed protection initiative in the Colombian Andes. *Ecological Economics* **75**, 126–134.

Puspitasari, T., Asdak, C. & Cahyandito, M. F. 2021 Factors affecting payments for environmental services (PES) implementation in the Garang watershed management. *Web of Conferences* **249**, 01006.

Saridewi, T. R. & Fauzi, A. 2019 A market-based mechanism as an alternative solution for watershed management: A case study of the Ciliwung Watershed, Indonesia. *International Journal of Global Environmental Issues* **18** (2), 171–186.

Tao, J. R. & Zhao, J. B. 2018 Study on willingness to pay for ecological compensation and its influencing factors in Ganjiang River Basin. *Construction of Old Areas* **6**, 19–23.

Wang, Y. Q. & Li, G. P. 2021 Study on the willingness to pay of downstream residents based on the demand for ecological services. *Ecological Economy* **37** (8), 163–168. + 177.

Xu, D. W., Chang, L., Hou, T. S. & Zhao, Y. F. 2012 Estimation of ecological compensation standard based on WTP and WTA: A case study of Liaohe River. *Resources Science* **34** (7), 1354–1361.

Zhao, Y., Zhang, Y. & Xiong, G. B. 2017 Study on willingness to pay for ecological compensation based on random utility theory in ganjiang river basin. *Resources and Environment in the Yangtze Basin* **26** (7), 1049–1056.

Zhao, S. Q., Sun, X., Dong, Z. F., Hou, D. L. & Liu, X. 2020 The benefited resident's willingness to pay for improved water quality within the framework of ecological compensation and its influencing factors in downstream area of Jiuzhou River. *Ecological Economy* **36** (12), 154–159. + 180.

Zhou, C., Ding, X. H., Li, G. P. & Wang, H. Z. 2015 Ecological compensation standards in the water source area of the middle route project of the South-North water transfer project. *Resources Science* **37** (4), 792–804.

First received 26 September 2023; accepted in revised form 8 March 2024. Available online 21 March 2024