

Retraction

Retracted: Incentive Measures for Agricultural Nonpoint Source Pollution Control of Farmers Based on Choice Modelling: A Case Study on the Water Source Region of Xin'an River Reservoir

Discrete Dynamics in Nature and Society

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] J. Lin, B. Liu, and S. Huang, "Incentive Measures for Agricultural Nonpoint Source Pollution Control of Farmers Based on Choice Modelling: A Case Study on the Water Source Region of Xin'an River Reservoir," *Discrete Dynamics in Nature and Society*, vol. 2021, Article ID 5336382, 11 pages, 2021.

Research Article

Incentive Measures for Agricultural Nonpoint Source Pollution Control of Farmers Based on Choice Modelling: A Case Study on the Water Source Region of Xin'an River Reservoir

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In water governance, the government, downstream residents, and upstream farmers are closely associated stakeholders. The participation willingness of upstream farmers directly bears on the success of environmental policies. Xin'an River Reservoir Water Protection Zone is the second water source region of Hangzhou, China. Taking this region, for example, this paper surveys the willingness to accept compensation of local rice farmers, mainly using Choice Modelling (CM) methodology. This paper assesses the farmers' willingness of minimum compensation amount to adopt various ecological compensation means and, on this basis, discusses the key factors determining their willingness to accept compensation. It helps to confirm that the farmer participation mainly depends on whether the government could provide satisfactory compensation incentives to cover farmers' losses. Hence, at the ending of the paper, we call for the relevant departments of the government fully understanding the farmers' willingness to accept compensation before formulating compensation policies, so that the compensation at least reaches the minimum requirements of farmers. Only in this way could the water source region achieve the optimal efficiency in environmental governance.

1. Introduction

Drinking water source regions guarantee the safe water supply to urban and rural areas. The safety of water environment should be top priority of these regions [1]. Zhejiang, a province in southeastern China, has effectively controlled industrial point-source pollution in major water source regions, including Xin'an River Reservoir, under the regulation policies that limit or ban development. The livestock and poultry pollution in these regions has also been actively controlled by prohibitory policies. However, agricultural nonpoint source pollution, which is caused by intensive agrochemical input in agricultural production activities, contributes to declining water quality and aquatic ecosystems [2] and has long been a difficulty in governance

because it is dispersed, concealed, random, ubiquitous, and difficult to detect [3, 4]. As a result, agricultural nonpoint source pollution becomes a major pollution source of the rural environment in water source regions [5, 6].

Agricultural nonpoint source pollution causes a global water safety problem. The pollution sources from planting industry have direct and indirect impacts on drinking water, and the hazard is on the rise. The most concerned pollutants include fertilizer and pesticide [7]. The effects of fertilizer on the water body are mainly reflected in the water quality problems caused by nitrogen and phosphorus entering the water system [8]. Excessive fertilization could lead to the accumulation of nitrogen and phosphorus in the water body [9, 10]. The loss of pesticide also brings serious surface water pollution [11]. Lots of monitoring data from Europe and

Japan suggest that the excess pesticide in agricultural production, especially rice planting, is a major pollutant of groundwater and surface water. Due to the loss of pesticide, the pesticide concentration of drinking water in many regions of Europe surpasses the European drinking water standard [12–15], posing a more serious pollution to reservoir water than stream water [16].

Aiming at this problem, Zhejiang province took the lead in exploring ecological compensation system in China. For example, the water source region of Xin'an River Reservoir has been committed to discussing how to build up a mutually beneficial ecological compensation mechanism, so that ecological protection will not sacrifice the interests of farmers. Rather than the simple "compensation, action" means, the proposed mechanism benefits farmers during and after environmental protection, making them more willing to participate in environmental governance. According to the experience of ecological compensation at home and abroad, balancing relationship between economic objectives and institutional cost objectives should be treated as one of the prerequisites for the successful implementation of a compensation system [17, 18]. For this purpose, an important task of the paper is to select a suitable survey method, which helps to design a survey plan with reference value, increase the accuracy of willingness survey, and guarantee the farmers' willingness to accept compensation. On this basis, the next key task is to optimize the ecological compensation mechanism, trying to improve the control efficiency of agricultural nonpoint source pollution in the water resource region, and ease the conflict between the government and farmers.

2. Literature Review

To control and govern nonpoint source pollution in water source regions, most scholars preferred to take economic means to motivate farmers to voluntarily participate in eco-environment protection [19, 20]. This idea comes from the theory of participatory development, a solution to community development [21]. By applying the theory to agriculture, domestic and foreign researchers proposed the concept of community participation in agricultural development, aiming to overcome the extensive negative impacts of rural and agricultural development on community, and the damages on local farmers caused by unfair income distribution [22]. For example, China has implemented a series of ecological compensation policies in water source regions to prevent various pollutions of water sources, among which financial subsidies are most popular [23]. On the other hand, relevant studies have proved the unsatisfactory effect of coordinating ecological service supplies through cash subsidies [24]. Hence, governments are inclined to select Hematopoiesis-Compensation Policies, such as technical training [25]. Nevertheless, estimating the standards for ecological compensations can provide suggestions for achieving BMP (Best Management Practice) with minimum effective policy costs.

It is important to note that the government dominates the various ecological compensation practices. In actual

practices, however, the government does not fully understand the willingness of farmers and why they change their behaviors [26]. If the goal of ecological compensation plan is realized, for farmers, the utility maximization of compensation policies not only depends on the level of compensation control but also hinges on the reasonability of compensation means [27]. The researchers engaging in this issue hold vastly different views. Some surveys show that farmers prefer cash compensation [28], while some studies reveal that farmers will accept technical compensation if costs, usefulness, familiarity with the technology, and its different attributes desirable [29]. Overall, the existing research indicates that any compensation means has an applicable range. In particular, the farmers' preference for different forms of compensation could change with regions, cultures, groups, and objectives. So, the selection of compensation instruments should be discussed more from a microscopic angle. However, at present, there are still very few researches that can provide suggestions on the optimal structure of combination compensation and the estimation of the desirable interval of cash compensation under combination compensation.

Meanwhile, the existing literature has realized that fertilizers and pesticides are core input elements of modern agricultural production, which overlap and lead to most agricultural nonpoint source pollution [30, 31]. Nevertheless, the vast majority of studies on the governance of the ecological environment, such as the study of Zheng et al. [32], still choose to separate fertilizers from pesticides and study them as two independent decision-making projects. This research approach is still widely used to study farmers' compensations through farmers' production activities. The study of Yu and Cai [33] is an example. Regarding saving social costs for comprehensive compensations and raising its incentive efficiency, however, it is vital to include fertilizers and pesticides into the analytical framework for comprehensive research.

In conclusion, selecting an evaluation technique that can depict a complex compensation scenario is essential to studying structured, comprehensive compensations. The economic evaluations of a farmer's willingness to receive compensations are supported by the utility theory and conducted on the condition of knowing their preferential structures [34]. Given that farmers' preferences for environmentally friendly actions are complicated and incomplete, the compensation price for their actions cannot be demonstrated entirely through the market. Hence, it will be ineffective to evaluate farmers' willingness to receive compensations through the RP technique (Revealed Preferences). To measure the object attribute whose economic values cannot be judged by traditional market evaluation methods, SP (Stated Preferences) is currently the most scientific method [35]. SP consists of CV (Contingent Valuation) and CM (Choice Modelling) methods. These two approaches are used to estimate the values of objects whose market values are unquantified, such as the willingness to pay or the willingness to receive compensations reflected by the imaginary scenario. The Choice Modelling method not only measures an individual's preferences but also finds how

the person selects from different competition choice sets. Thus, this approach is more suitable for analyzing individuals' behavioral decisions [36, 37]. Besides, it also provides a series of value measurements based on environmental attributes and personal characteristics [38].

For these reasons, the paper plans to build a selection set that includes strategies for the reduction of fertilizers and pesticides, as well as other noncash compensatory devices through the Choice Modelling method, aiming to analyze farmers' sense of achievements from considering the attribute levels in the backup plan.

3. Methodology

3.1. Principles of CM. The CM and the CV are the same in many respects. Their main difference lies in the scenario design of the questionnaire. The CM believes that the values of all items can be characterized by their attributes, features, and levels. If the level of any attribute changes, the value of the entire item will change. With this belief, the CM analyzes whether one or several factors are the main impactors of the values of nonmarket products and estimates the total economic value of an item by evaluating the value of each attribute. The CM is employed based on two theories, including Lancaster's characteristics theory of value [39] and the Random Utility Theory [40, 41]. It follows one core thought: any object can be described by a group of characteristic elements and these elements' varying levels; the decision-maker's utility stems from the object's attributes rather than the object itself; individuals can achieve utility from such elements; and the changes in attributes may lead to changes in utility. The CM designs the choice set composed of different attribute states in the form of a questionnaire and asks each respondent to choose the alternative with the highest utility in his/her mind from each choice set. Then, an econometric model was called to analyze the value of each preference of the respondents, that of each attribute, and the relative value of each alternative made up of attributes under different states. The CM converts the selection problem into a utility comparison problem by setting up the random effect functions to be selected by the respondents. The formulas of the model are as follows:

The utility function of each respondent can be defined as

$$U_i(X_i, S_i) = V_i(X_i, S_i) + \varepsilon_i, \quad (1)$$

where $U_i(X_i, S_i)$ and $V_i(X_i, S_i)$ are the direct and indirect utility functions of a respondent choosing alternative i ; X_i is the attribute feature of a respondent choosing alternative i ; S_i is the socioeconomic feature of respondent i ; and ε_i is the random variable of respondent i choosing alternative i .

The CM assumes that ε_i obeys independent homogenous distribution. Then, the probability for a respondent to choose alternative i can be described by multinomial logit model (MNL):

$$\text{pro}(i) = \frac{\exp(\lambda V_i)}{\sum \exp(\lambda V_j)}, \quad (2)$$

where $\lambda = 1$ is a constant scalar.

The indirect utility function of a respondent choosing alternative i can be viewed as the linear function of the attribute features of alternative i :

$$V(x, \beta) = \lambda(\beta + \beta_1 X_1 + \cdots + \beta_n X_n + \beta_M X_M), \quad (3)$$

where β is the alternative substitutive constant (ASC), reflecting the influence of unobservable attributes over the selection result; X_n is feature n of an alternative. Then,

$$CS = \frac{1}{\beta_M [\ln \sum \exp V_0 - \ln \sum \exp V_1]}, \quad (4)$$

where CS is the compensation surplus; β_M is the marginal utility of income; and V_0 and V_1 are the indirect utilities of nonmarket items before and after state change, respectively. In the model, the value of each attribute of the ecological compensation mechanism can be described by

$$W = \frac{\beta_{\text{attribute}}}{\beta_M}, \quad (5)$$

where $\beta_{\text{attribute}}$ is the estimation coefficient of nonmarket attributes in indirect utility function.

3.2. Selection for CV Methodology. Since the attribute level of compensation amount is unknown, the respondents need to provide answers by themselves. In this case, it is more appropriate to obtain the attribute level through CV in the presurvey. The CV offers four export technologies for core evaluation problems, including iterative bidding game (IBG), open-ended (OE) questionnaire, payment card (PC) method, and dichotomous choices (DC). To reflect farmers' willingness to participate, this paper chooses the IBG to guide farmers to report the maximum willingness to accept the compensation for the control of agricultural nonpoint source pollution. First, the bidding card was used to guide each farmer to provide the initial bid value. Next, the bid level was lowered continuously until reaching the minimum amount acceptable to farmers.

4. Survey Design

4.1. Survey Site. The water source region of Xin'an River Reservoir includes the reservoir area and the upstream basin of Xin'an River. The total area is about 11,452.5 km². The part of the region in Zhejiang Province reaches 4,715.7 km², covering the whole of Chun'an County and some districts of Jiande City (Xin'anjiang Subdistrict Office, Yangxi Subdistrict Office, and Lianhua Town). The regular agricultural activities of local farmers have a potential impact on the water source.

There are three unique features of the water source region of Xin'an River Reservoir: first, the main income of farmers comes from part-time jobs. Agriculture is a fixed but not primary source of income. Second, scale farming is rare in the region, and the farmers have a weak awareness of scientific farming. Third, rice is the main crop cultivated by farmers, accounting for more than 90% of all local crops. In fact, it is the most widely planted crop in the region.

Considering the above features, this paper selects rice farmers as the main objects, discusses their planting behaviors and willingness to accept compensation, and designs a compensation mechanism for the agricultural nonpoint source pollution control in the water source region.

4.2. Detailed Presurvey Plan. Steps of the questionnaire survey are given as follows.

Step 1. Guide the farmers to report the initial values.

- (1) Compute and provide the farmers' loss in terms of gross profit and net income.
- (2) Provide the farmers with a scale of 0–2,000 with an interval of 50 and ask them to choose the amount of acceptable compensation, based on their loss of gross profit and net income. Do not provide the loss unless they cannot select the initial values by themselves.

Step 2. Determine the final compensation.

Ask the farmers whether they would accept a lower compensation. If the answer is yes, go on asking them if they would accept an even lower compensation. Repeat this process until the answer is no.

There are four benefits of this questionnaire design: (1) This design helps to reduce the error. Any dichotomous choice method has an error in the range, interval, and starting point of the selected values. Our design can largely eliminate the uncertainty of the values. In particular, low-income farmers tend to exaggerate their acceptable compensation, if they are not properly guided. These farmers basically live on farming and attach a great importance to agricultural income. (2) This design encourages the participation of farmers. During the presurvey, it was found that some farmers could not select the initial values because they know nothing about ecological compensation. They do not know how to judge if a compensation standard is satisfactory or acceptable. (3) The open-ended yet dichotomous questions from the interviewers guide the farmers to think and expedite their decision-making process, so that they could select an answer quickly. (4) The open-ended questions help to obtain the true willingness to accept compensation of the farmers and reflect the individual difference in the willingness, with a limited number of initial values.

4.3. Presurvey Results. According to the survey results on pesticide and fertilizer uses (Table 1), the farmers frequently chose three compensation amounts: 400, 700, and 1,000. Considering the frequency in each value range, this paper selects the median of each value interval for subsequent discussion, trying to boost farmer participation, reflect government cost-saving, and ensure data authenticity. The three medians were taken as the state level of the variable of compensation amount.

4.4. Questionnaire Design for the Formal Survey. During the presurvey, the authors learned about the situation of agricultural nonpoint source pollution from the agriculture and

environmental protection departments in the water source region of Xin'an River Reservoir. Based on the actual situation, the preliminary questionnaire was designed in accordance with the geographic and economic situations in the region and the relevant results at home and abroad.

Since our investigation takes the perspective of farmers, the model attributes were selected from this perspective. Hence, five attributes, which are independent from each other, were chosen: fertilizer use management based on farmers' experience, pesticide use management based on farmers' experience, technical support, compensation method, and compensation amount.

The five attributes basically cover both traditional means (management of pesticide and fertilizer use) and technical means, as well as the specific compensation form (compensation method) that farmers consider during the selection of compensation amount. Together, the attributes demonstrate how the farmers weigh their capabilities during decision-making and manifest the intrinsic features of policies. During the presurvey, these attributes caught much attention from farmers during decision-making. They basically cover all the environmental behaviors that could be understood and adopted by farmers.

Next is to determine the state interval of each selected attribute. State can be described quantitatively or qualitatively. From the angle of model construction, quantitative description has an absolute advantage for results analysis. However, some attributes cannot be easily quantified. For example, fertilizer use management could only be qualified. Table 2 presents the attributes and their states in the ecological compensation mechanism for agricultural nonpoint source pollution.

From the attributes and their states in Table 2, choice sets of $2^3 \times 3^2$ different attributes were established through factor design method. Constrained by research cost and quality, it is impossible to provide all the attribute combinations to the farmers. Therefore, the orthogonal design of some factors was adopted to screen the unrealistic options in the questionnaire, leaving only the orthogonal terms. Through the screening, a total of 10 choice sets were preserved, each of which contains 3 schemes, among which 2 are alternatives and 1 is the current state set (Table 3). Each farmer needs to choose his/her most preferred scheme from each choice set. The first part briefly introduces the management of agricultural nonpoint source pollution in the water source region, such that the farmers can intuitively feel and understand each attribute of the ecological compensation mechanism, laying a solid basis for proper modeling.

The final questionnaire mainly includes 3 parts: (1) social and economic information of the farmers (gender, age, number of family labour force, family size, family income, part-time employment, health status, whether relatives live downstream, farmland area, etc.); (2) farmland management behaviors of the farmers (agricultural nonpoint source pollution hazard awareness, environmental protection awareness, ecological compensation policy awareness, pesticide and fertilizer application reduction actions); (3) scheme selection set composed of different attribute states.

TABLE 1: Compensation amount that can incentivize farmers' actions.

Compensation for fertilizer reduction	Frequency	Percentage	Compensation for pesticide reduction	Frequency	Percentage
200	1	5.0	0	3	15.0
300	1	5.0	300	2	10.0
400	4	20.0	350	1	5.0
500	1	5.0	400	1	5.0
600	2	10.0	500	2	10.0
700	4	20.0	600	2	10.0
800	4	20.0	700	5	25.0
900	1	5.0	800	1	5.0
1,000	2	10.0	1000	1	5.0
Total	20	100.0	1100	1	5.0

TABLE 2: Attributes and states.

Attribute	Definition	State	Code
Fertilizer use management	Reducing fertilizer use	Reduction	1
		Nonreduction	0
Pesticide use management	Reducing pesticide use	Reduction	1
		Nonreduction	0
Technical support	Providing fertilizer/pesticide-saving technology	Yes	1
		No	0
Compensation method	Coupling compensation amount with environmental actions	Action-based compensation	2
		Action-independent compensation	1
		No compensation	0
Compensation amount	Annual compensation standard	400	400
		700	700
		1,000	1,000

TABLE 3: A choice set.

Attribute	Scheme 1	Scheme 2	Scheme 3 (current state)
Fertilizer use management	Proper reduction	Nonreduction	Nonreduction
Pesticide use management	Proper reduction	Proper reduction	Nonreduction
Technical support	No	Yes	No
Compensation method	Action-independent compensation	Action-independent compensation	No compensation
Compensation amount	1,000	700	No compensation

4.5. Sampling Method. The samples were collected through stratified random sampling. First, 4 typical towns and townships were selected from the 26 towns and townships in the water resource region, in view of the following factors: rice planting area, level of economic development, and location factor. The selected places include Qiandaohu Town, Jieshou Township, and Lishan Township (Chun'an County), and Lianhua Town (Jiande City). A total of 300 questionnaires were issued to the randomly selected farmers. Excluding the illogical and incomplete ones, the research team received 241 valid questionnaires. The questionnaires were filled out by the farmers during one-on-one interviews.

5. Empirical Analysis

5.1. Current State of Farmers in the Water Source Region

5.1.1. Individual Features of Farmers. As shown in Table 4, most of the interviewed farmers are males. There are only 3 females among the 241 respondents returning valid

questionnaires. This is in line with the reality: rice planting requires a lot of time and physical fitness. Compared with females, males are responsible for paddy field management and clear about the cultivation situation. On average, each family has 2.61 laborers and 5.26 members. The mean, minimum, and maximum ages of the farmers are 61.68, 33, and 85, respectively. Many age groups are covered: 30% of the farmers are 50–60, 40% are 60–70, and 20% are above 70. Thus, the agricultural practitioners in the water source region are generally old. The mean of part-time job (Yes/No) was 0.60, and 144 farmers said they have a part-time job. This means nearly 60% of farmers can earn money from non-agricultural channels. The total family income covers a wide range, with a mean of 517,000, a minimum of 5,000, and a maximum of 200,000, suggesting that the farmers come from all income levels. The average farmland area stands at 2.71, indicating that most farmers own a small farmland. Rather than scale management, the farmlands are mostly tilted by their respective owners. The health state averages 0.95. Only 12 farmers revealed the intention to stop farming, due to

TABLE 4: Descriptive statistics of individual features of farmers.

Variable	Definition	Min.	Max.	Mean	Standard deviation
Gender	0 = female; 1 = male	0	1	0.99	0.111
Labour force	Number of family labours older than 16 (each)	1	8	2.61	1.171
Family size	Number of family members (each)	1	13	5.26	2.187
Age	Age reported by the respondent (year)	33	85	61.68	9.660
Part-time job	1 = Yes; 0 = No	0	1	0.60	0.491
Total family income	Total income of the family in the previous year (10,000 yuan)	0.5	20	5.17	3.260
Farmland area	Total area of farmlands (mu)	0	18	2.71	1.800
Health state	1 = healthy; 0 = unhealthy	0	1	0.95	0.218
Whether relatives live downstream (downstream relatives)	1 = Yes; 0 = No	0	1	0.10	0.294

poor health conditions. Therefore, most farmers are healthy enough for agricultural activities. The mean of downstream relatives (Yes/No) is 0.1. Only 23 reported that they have straight relatives living in the downstream of the water source region, while most farmers have no such relatives.

5.1.2. Ecological Cognition and Environmental Awareness of Farmers. The survey found that the local farmers do not fully understand the functionality of the region in terms of water source protection. Nearly 48% of farmers said that they are not sure if their farmlands are within water source protection zone and naturally do not know if their farmlands affect the agricultural pollution of the water source.

The questions about farmers' understanding of water resource protection policies indicate that the local farmers have a low cognition of the farmer behaviors required by the ecological protection regulation for water source protection areas. Only 15% of the farmers said that they know the regulation and its provisions. In general, farmers believe that farmland cultivation has little effect on the water source. Among them, over 95% hold that the drinking water source of downstream residents is not greatly affected by farmland cultivation in the upstream, nearly 50% think that overuse of fertilizer does not influence surface water sources, and more than 70% believe fertilizer overuse has little to no influence over groundwater. This means farmers perceive that fertilizer affects groundwater more severely than surface water.

When it comes to the questions about pesticide use, most farmers (>60%) hold that the pesticide use has little to no influence, similar to their view on fertilizer use. The difference is that farmers perceive that pesticide has similar effects on surface water and groundwater, which indirectly reflects the large and extensive harm of pesticide.

5.2. Model Estimation of Farmers' Willingness to Accept Compensation and Results Analysis. This paper adopts multinomial logit (MNL) model to analyze the survey results of farmers' willingness to accept compensation. First, the authors considered how the state of the natural attributes (i.e., fertilizer use management, pesticide use management, technical support, compensation method, and compensation amount) of each scheme affects the probability of each

selected result. Then, the socioeconomic attributes of the respondents were added to reflect the influence of the socioeconomic situation over the selection made by the respondents. Tables 5 and 6 display the estimated results on how natural attributes affect the probability of each selected result. It can be seen that the model had a strong overall significance. Except for pesticide use management and compensation method, all explanatory variables were significant on the level of 5%. This proves the scientific and reasonable nature of our questionnaire and model.

The following can be derived from the model test results (Table 7):

- (1) The regression coefficient of fertilizer use management, an explanatory variable, was 71.613 ($P < 5\%$). When other attributes remain the same, farmers tend to accept reducing fertilizer use. Rather than sticking to the current state, farmers prefer to accept compensation by cutting down the use of fertilizer.
- (2) The regression coefficient of pesticide use management, an explanatory variable, was 65.849 ($P < 10\%$). The positive coefficient indicates that, when other attributes remain the same, farmers tend to accept reducing pesticide use. Rather than sticking to the current state, farmers prefer to accept compensation by descaling the use of pesticide.
- (3) The regression coefficient of technical support, an explanatory variable, was 14.148 ($P < 5\%$): when other attributes remain the same, farmers tend to accept technical support. Rather than sticking to the current state, farmers prefer to receive technical support.
- (4) The regression coefficient of compensation method, an explanatory variable, was -0.045 ($P < 5\%$). The negative coefficient indicates that, when other attributes remain the same, farmers tend to accept action-based compensation. Farmers prefer the current state over coupling compensation amount with specific actions. They wish that the compensation is unconstrained and free to use.

According to the estimation results of the model, the farmers' willingness to accept compensation and total amount of acceptable compensation for each attribute can be computed

TABLE 5: Model fitting information.

Model	Fitting criteria	Likelihood ratio tests	Sig.
	-2 log likelihood	Chi-square	
Intercept only	1,718.745		
Final	18.111	1,700.634	0.000

TABLE 6: Pseudo R-squared.

Fitting criteria	Test value
Cox and Snell	0.758
Nagelkerke	0.916
McFadden	0.807

TABLE 7: Estimated results of the MNL model.

	B	Standard error	Wald
ASC	-68.355***	621.062	0.012
Fertilizer use management	65.849**	423.689	0.024
Pesticide use management	71.613*	398.460	0.032
Technical support	14.148**	167.879	0.007
Compensation method	17.473*	230.913	0.006
Compensation amount	-0.045**	0.121	0.138

Note. The symbols *, **, and *** represent the significance on the levels of 0.1, 0.05, and 0.01, respectively.

by formula (5). As shown in Table 8, farmers demand a compensation of 1,463.31 yuan/year for implementing fertilizer management, 1,591.4 yuan/year for implementing pesticide management, 314.4 yuan/year for accepting technical support, and 387.49 yuan/year for accepting action-based compensation (i.e., being unfree to utilize the compensation).

5.3. NML Model Coupling Socioeconomic Variables and Estimation Analysis. Note that the assumed error distribution leads to the independent and irrelevant alternatives (IIA) assumption of the MNL model, i.e., the probability for the decision-maker to choose an alternative is independent of the selection of other alternatives in the same set. If the IIA is violated, then the schemes estimated by the MNL model are highly mutually substitutive. Then, the addition of alternatives will affect the ranking of respondents' preferences and bias the estimation of coefficients.

There are mainly two ways to enhance the goodness of fit of the model and prevent the violation of the IIA. The first approach is to add socio economic variables of the respondents and use them to replace the specified constants and the cross terms between attributes before fitting the model. The second approach is to adopt the nested logit model. The former approach is adopted for this research.

Table 9 shows the socioeconomic variables added to the MNL model. Tables 10 and 11 reflect the fitting results of model estimation. The results demonstrate a strong overall significance of the model. Table 12 provides the final results of MNL model estimation fused with socioeconomic variables. All attributes were significant on the level of 10%, indicating the scientific and reasonable nature of our questionnaire and model.

Table 13 shows the attribute values obtained by formula (5), based on the model estimations in Table 12. It can be seen that farmers need to be compensated for by 1,463.09 yuan/year to empirically reduce fertilizer use, 1,604.79 yuan/year to empirically reduce pesticide use, 323.89 yuan/year to apply a technology, and 410.02 yuan/year to accept action-based compensation.

The model estimations show that part-time job (Yes/No), total family income, and health state were significant on the 1% level. Four conclusions can be drawn from this result:

- (1) Farmers' decision-making depends mainly on the economic situation of the family and the physical conditions of farmers. During the survey, farmers care much about the influence of changing farming method on yield. Lots of time and physical energy are necessary to change the farming method, especially the traditional proenvironmental tillage approach. That is why health has an impact on farmers' decision-making.
- (2) Part-time job (Yes/No) reflects whether farmers work part time. Our survey shows that nonagricultural part-time jobs often contribute greatly to the family income of farmers. Among the farmers who work part time, the agricultural income is mostly spent on grains and vegetables. Part-time job (Yes/No) has a negative correlation between farmers' decision-making. Almost every farmer who work part-time tend to stick to the current state. They are more willing to devote their time and energy to nonagricultural jobs that are more profitable than agriculture.
- (3) There is a positive correlation between total family income and farmers' decision-making. The better the family conditions, the more willing are the farmers to adopt protective measures. Our survey also shows that the farmers with good family conditions care little about potential agricultural losses. With a strong environmental awareness, they would have a try in the presence of compensation and would even accept compensation by abandoning production.
- (4) Health state has a negative correlation with decision-making. This is obviously in line with the actual situation. Thus, the body conditions of healthy farmers allow for protective farming measures. By contrast, the unhealthy farmers are reluctant to change the tillage method, but some of them are willing to accept compensation by abandoning production.

TABLE 8: Attribute values in the MNL model (unit: yuan/year).

Attribute	Fertilizer use management	Pesticide use management	Technical support	Compensation method	Total
Value	1,463.31	1,591.4	314.4	387.49	3756.6

TABLE 9: Social economic variables and their definitions in the MNL model.

Variables	Definitions
Gender	0 = female; 1 = male
Labour force	Number of family members older than 16 (each)
Family size	Number of family members (each)
Age	Age reported by the respondent (year)
Part-time job (Yes/No)	1 = Yes; 0 = No
Total family income	Total income of the family in the previous year (10,000 yuan)
Farmland area	Total area of farmlands (mu)
Health state	1 = healthy; 0 = unhealthy

TABLE 10: Model fitting information.

Model	Fitting criteria -2 log likelihood	Likelihood ratio tests Chi-square	Sig.
Intercept only	2,053.230		
Final	340.818	1,712.412	0.000

TABLE 11: Pseudo R-squared.

Fitting criteria	Test value
Cox and Snell	0.760
Nagelkerke	0.919
McFadden	0.813

TABLE 12: Estimations of the MNL model fused with social economic variables.

	Bias	Standard error	Wald
ASC	-64.892**	606.667	0.011
Fertilizer use management	68.765*	414.235	0.028
Pesticide use management	75.425*	392.559	0.037
Technical support	15.223**	166.840	0.008
Compensation method	19.271*	223.942	0.007
Compensation amount	-0.047**	0.120	0.156
ASC: labour force	0.731	0.685	1.140
ASC: family size	-0.517	0.287	3.243
ASC: age	0.012	0.054	0.047
ASC: part-time job (yes/No)	-0.514*	1.022	0.253
ASC: total family income	0.226**	0.249	0.828
ASC: farmland area	-0.100	0.271	0.135
ASC: health state	-8.468*	115.583	0.005
ASC: downstream relatives (yes/No)	-0.974	1.226	0.631

TABLE 13: Attribute values in the MNL model fused with socioeconomic attributes (unit: yuan/year).

Attribute	Fertilizer use management	Pesticide use management	Technical support	Compensation method	Total
Value	1,463.09	1,604.79	323.89	410.02	3801.79

6. Conclusions

6.1. Farmers Have Differences in Cognition and Preference for the Four Attributes of the Ecological Compensation Mechanism. The estimation results of the CM model show that farmers already understand the nonmarket values of various actions to improve water sources. Their cognition emphasizes more on the production restrictions and survival guarantees brought about by water source protection.

Therefore, they demand different levels of compensation for different protective farming measures or different attributes of the compensation mechanism. Pesticide use management induces the most intense and highest compensation demand, followed in turn by fertilizer use management, compensation method, and technical support. This means the farmers' cognition of empirical water source protection could lead to a major production risk. More compensation is needed to ensure that farmers would take actions. From the

perspective of government cost saving, the promotion of technology can greatly reduce related financial expenditures and limit the results in a more controllable range. In addition, farmers' cognitive preferences for the nonmarket values of various actions that can improve water sources could be influenced by their age, total family income, part-time jobs, and health state.

6.2. Compensation Mechanism Should Be Optimized by Making Up Four Defects. From the perspective of the government, the compensation mechanism must be designed to maximize social benefits. But farmers often take actions to maximize their private benefits. To incentivize farmers' actions, the government should fully consider farmers' preferences and needs of compensation means and methods in the compensation mechanism. Based on the empirical results, this paper points out four directions for the optimization of compensation mechanism:

6.2.1. Compensation Mechanism Should Promote Scientific Thinking. Our survey suggests that farmers' demand the lowest compensation for technical support. This means agricultural technology is acceptable to farmers, brings them a low risk, and guarantees the yield. The doubts about technical support mostly come from the unfamiliarity with technology. Agriculture is heavily affected by the natural environment. There are many uncertainties in the production process. Most farmers trust more about their own farming experience and have a strong dependence on the use of pesticide and fertilizer. To solve the problem, the government could spread agricultural technology by setting up demonstrative farmlands. If the few farmers succeed in changing their farming method, many farmers in the water source region will follow suit.

6.2.2. Compensation Should Be Linked to Policy Objectives. There is a heated debate on whether compensation should be linked to or independent from actions. From the perspective of farmers, action-independent compensation is preferred. From the perspective of the government, action-based compensation can ensure the realization of compensation goals. Empirical analysis shows that action-based compensation is not so unacceptable to farmers as expected. Suitable incentives can greatly bolster the farmers' participation in eco-friendly farming.

6.2.3. Fertilizer Use Should Be Adapted to Local Conditions. The farmers' empirical management of pesticide and fertilizer use push up government cost. It is not as good as technical support in agricultural management. Of course, the management of pesticide and fertilizer use is sometimes inevitable, if the farmlands are so scattered that agricultural technology cannot lead to the scale effect. Relatively speaking, if there exists a simple and low-threshold technical support to farmers' environmental actions, the government can shift its focus to technology promotion. If there is not such a technology, if the farmland quality is too poor to be

transformed, or if the nutritional level of farmlands needs to be improved by fallowing, it is feasible to encourage farmers to compost green manure between farming seasons and even support the fallowing by giving them a compensation equivalent to the annual mean income.

6.2.4. New Technology Should Be Adopted for Pesticide Management. According to the amount of compensation, farmers require more compensation for pesticide use management than that for any of the other three attributes. Through actual survey, it was found that pesticide is not linearly correlated with yield as fertilizer. On the farmers' pesticide use management, it is difficult to control pesticide use by reducing the number of sprays. Even if this reduction measure is taken, farmers would find it hard to implement because they are not professional enough to make sound judgements. Therefore, the empirical pesticide management by farmers is difficult, expensive, and risky. The only feasible solution is to manage pesticide use under the technical support of experts.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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