water

Article

Study on Farmers' Willingness to Accept for Chemical Fertilizer Reduction Based on the Choice Experiment Method: A Case Study of Communities Surrounding Poyang Lake, China

Ting Liu, Qiang Li and Hui Wang *

School of Economics and Management, Beijing Forestry University, No. 35 Qinghua East Road, Haidian District, Beijing 100083, China; liuting@bjfu.edu.cn (T.L.); qiangli@bjfu.edu.cn (Q.L.)
* Correspondence: huiwang@bjfu.edu.cn

Abstract: Chemical fertilizer loss during agricultural production is an important factor leading to the eutrophication of lakes and reservoirs. As fertilizer technology has become more widespread, it has become necessary to explore the ecological compensation mechanism in areas with important ecological functions to further reduce chemical fertilizer application. Among these, farmers' preferences for chemical fertilizer reduction are one of the most important issues. Based on the survey data of 142 farmers surrounding Poyang Lake, this paper studies the farmers' willingness to accept (WTA) the attributes of a chemical fertilizer reduction scheme using the choice experiment method. The results are as follows: (1) The farmers' WTA value for each additional year of the program was 63.75 CNY/ha/year, the WTA value for every 10 percent increase in the proportion of participating land area was 73.875 CNY/ha/year, and the WTA value for every 10 percent reduction in the fertilizer application was 413.505 CNY/ha/year. (2) The household support burden, the proportion of non-agricultural income, and farmers' understanding of the importance of wetlands significantly affect farmers' WTA value. (3) The interviewed farmers can be divided into four different types: farm type, farm-oriented hybrid type, off-farm-oriented hybrid type, and off-farm workers, each with different preferences for fertilizer reduction schemes.

Keywords: chemical fertilizer reduction; willingness to accept; choice experiment method; Poyang Lake

check for updates

Citation: Liu, T.; Li, Q.; Wang, H. Study on Farmers' Willingness to Accept for Chemical Fertilizer Reduction Based on the Choice Experiment Method: A Case Study of Communities Surrounding Poyang Lake, China. *Water* **2023**, *15*, 3863. https://doi.org/10.3390/w15213863

Academic Editor: Helvi Heinonen-Tanski

Received: 7 September 2023
Revised: 22 October 2023
Accepted: 23 October 2023
Published: 6 November 2023

1. Introduction

Since the beginning of the 21st century, the water quality in China has greatly improved, but eutrophication is still an important problem affecting the water quality of lakes and reservoirs. According to the *2021 Bulletin on China Ecological and Environmental Status*, of the 209 important lakes and reservoirs monitored, 27.3% suffered from eutrophication to some extent [1]. Chemical fertilizer loss during agricultural production is an important factor contributing to the eutrophication of water [2]. According to the Bulletin of the Second National Pollution Source Survey, in 2017, China's planting agriculture emitted 719,500 tons of total nitrogen, which accounted for 23.7% of the total nitrogen discharge of 3,041,400 tons [3].

Agricultural non-point source pollution, such as chemical fertilizer loss during planting, has the characteristics of dispersion, randomness, and imperceptibility [4], which make it impossible to monitor and regulate as an industrial point source pollution [5]. Chemical fertilizer loss can only be reduced by adjusting planting activities [6,7]. Therefore, farmers play a key role in the prevention of agricultural non-point source pollution in planting agriculture [8,9]. Generally speaking, if farmers were required to reduce the application of chemical fertilizers in order to reduce fertilizer loss, they would be at risk of lower crop yields and lower agricultural income, which they are unwilling to do [10,11]. In response, China has taken a number of measures to encourage farmers to reduce fertilizer application such as promoting soil testing, formula fertilization technology, and slow-release fertilizer technology to improve the utilization rate of chemical fertilizers [12,13]. In Beijing, Shanghai, Zhejiang, and some other provinces, the governments have begun to provide subsidies to encourage farmers to replace chemical fertilizers with organic fertilizers. However, in some areas with high requirements for water quality, such as drinking water sources and areas inhabited by rare and endangered wildlife, there is still a need to further reduce the amount of chemical fertilizer used [14], which means that economic compensation is necessary for the farmers involved.

Poyang Lake in Jiangxi Province, which is the focus of this paper, is located on the international migratory route for hundreds of migratory birds. It is on the list of wetlands of international importance maintained by the Convention on Wetlands. However, in recent years, it has suffered from lowered water levels [15], serious water pollution, and a sharp decline in biodiversity [16]. Since 2015, for major crops, China has been implementing the Action Plan for Zero Growth of Fertilizer Use nationwide and expects to achieve zero growth of chemical fertilizer use in major crops by 2020; however, it is more difficult to promote fertilizer reduction in Jiangxi Province, and the target of chemical fertilizer reduction in the region in 2021 does not meet the national requirements [17]. Therefore, it is difficult to achieve the target of chemical fertilizer reduction by only improving chemical fertilizer application technology, and it is necessary to establish an ecological compensation mechanism to encourage a reduction in chemical fertilizer use. Encouraging farmers to reduce their fertilizer application through the implementation of an eco-compensation policy is a relatively effective strategy [18], and the compensation rate is the main component of the ecological compensation mechanism [19,20]. Therefore, in this study, we analyze farmers' willingness to accept (WTA) different fertilizer reduction schemes and we explore the preference differences among farmers with different characteristics, which have great significance for constructing an ecological compensation system for fertilizer reduction and for promoting the coordinated development of agricultural production and ecological conservation.

The structure of this paper is as follows: Section 1 is the introduction, Section 2 outlines the literature review, Section 3 provides the methodology and experimental design, Section 4 describes the research area and data source, Section 5 states the empirical results, and the final section includes the conclusions and policy implications.

2. Literature Review

Some studies have explored farmers' WTA values for reducing chemical fertilizer applications and their acceptance of certain ecological protection activities surrounding Poyang Lake.

First, studies have mostly used contingent valuation methods (CVMs) and choice experiments (CEs) to analyze farmers' WTA values for chemical fertilizer reduction. Lu Yue feng et al. used the CVM to survey 205 farmers in Nanjing, Jiangsu Province, in 2017. They calculated that, when the amount of fertilizer was reduced by 14%, the farmers' WTA was 882.45 CNY/ha/year [21]. Zhu et al. studied the WTA value for fertilizer reduction of 500 corn farmers in Shiyan City, Hubei Province, in 2020, using the CVM. They found that for a fertilizer reduction of 20%, the WTA value was 980.1 CNY/ha/year [22]. Yu Liangliang et al. used the CVM to calculate the WTA value for fertilizer reduction of 170 farmers in Jingshan County, Hubei Province, in 2015, and they found that the WTA for a fertilizer reduction of 50% was 7737 CNY/ha/year [23]. Li Xiaoping et al. used the choice experiment method to investigate 632 farmers in Ankang City and Hanzhong City of Shaanxi Province, in 2021, and concluded that the farmers needed to be provided with 227.85 CNY/ha/year compensation for a 10% reduction in chemical fertilizer [18]. In terms of research methods, except for the choice experiment method used by Li Xiaoping et al., other studies have mostly adopted the CVM. In terms of research results, most of the existing studies have evaluated the WTA value for a fertilizer reduction of 10–20%, and the WTA was mainly in the range of 750–900 CNY/ha/year.

Secondly, the existing studies have also explored the willingness of farmers around Poyang Lake to accept certain ecological protection activities. Pang Jie and Jin Leshan investigated 503 farmers around Poyang Lake and concluded that for the restriction placed on farmers' production and daily life by the wetland protection policy, the farmers' WTA was 2503.35 CNY/ha/year [24]. Xiong Kai et al. conducted a survey on 271 farmers around Poyang Lake and found that the farm households' WTA for wetland ecological conservation was 5531.08 CNY/year [25]. Li Fen et al. investigated 271 farmers in the area around Poyang Lake and concluded that the WTA of farmers for losses caused by "returning farmland to lake" was 917.4 CNY/ha/year [26]. Jiang Hongyao and Wen Yali surveyed 193 farmers around Poyang Lake and concluded that the average WTA value for wetland ecological conservation was 339.9 CNY/household/year [27]. It can be seen that the existing research has mainly evaluated the farmers' WTA for wetland conservation, returning land to lake, and other aspects, but has rarely involved the farmers' WTA for reducing the amount of fertilizer in the surrounding planting agriculture.

The existing studies have provided a research basis for analyzing the WTA of farmers in planting agriculture around Poyang Lake to participate in a fertilizer reduction program, but there is still room for further research. In terms of research areas, there are few studies on the WTA value for fertilizer reduction around Poyang Lake, which is an important way to alleviate the problem of eutrophication in the region. In terms of research methods, the current research has mostly used the CVM to evaluate farmers' WTA for fertilizer reduction, but the method is easily affected by farmers' subjective willingness to accept the compensation level. In contrast, the choice experiment method can indirectly obtain information on farmers' willingness to participate in ecological conservation programs through the preference ranking of different programs, which can better overcome the abovementioned shortcomings. In terms of model estimation methods, the mixed logit model is commonly used to estimate the choice experiment data. In recent years, the random parameter mixed logit model has been developed, which is more accurate and allows for preference consistency [28]. At the same time, in recent years, the latent-class logit model has often been used to analyze choice experiment samples, classifying the respondents into several groups based on their characteristics, which is conducive to further revealing the heterogeneity of respondents' WTA [29].

Therefore, here, we used the choice experiment method and the random parameter logit model to evaluate the farmers' willingness to participate in the fertilizer reduction program around Poyang Lake, and we examined the influence of farmers' characteristics on this willingness. The results can provide a reference for the formulation of ecological compensation policies for fertilizer reduction around Poyang Lake.

The marginal contributions of this paper are as follows: First, the choice experiment method and the random parameter logit estimation model are applied to evaluate the willingness of farmers to participate in the fertilizer reduction program around Poyang Lake, which is the first study on the region. Secondly, the latent-class logit model is applied to analyze the heterogeneity of the respondents, which reveals the heterogeneity of the different groups participating in the fertilizer reduction program. This increases the knowledge of the heterogeneity of willingness across different groups, instead of the analysis of heterogeneity from the perspective of farmers' individual characteristics and household characteristics.

3. Research Methods and Experimental Design

In this section, we introduce the basic principles of the choice experiment method, the random parameter logit estimation method, and the latent-class logit estimation method, and then we introduce the design of the choice experiment.

3.1. Research Methods

3.1.1. Basic Principles of the Choice Experiment Method

The theoretical foundations of the choice experiment (CE) method are the Characteristics Theory of Value [30] and the Random Utility Theory [31]. According to the Characteristics Theory of Value, any commodity can be described by its set of characteristic attributes and its level, and the utility obtained by consumers from consuming a commodity can be decomposed into the utility obtained from the consumption of each characteristic attribute of the commodity. The Random Utility Theory holds that the utility of a consumer in terms of a certain commodity consists of two parts: the observable deterministic part and the unobservable random part. According to the theory, the utility U_{ij} obtained by the individual consumer i when they choose a scheme j in the face of each scheme can be expressed as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (1)$$

where U_{ij} is the total utility obtained by the individual, V_{ij} is the observable deterministic part of the total utility, and ε_{ij} is the unobservable random part. Further, the observable utility is defined as a function of the attribute variable of the scheme j and the characteristic variable of the individual consumer i:

$$V_{ij} = \sum_{k=1}^{K} \beta_k x_{ijk} \quad (2)$$

where x_{ijk} is a series of variables, such as scheme attribute variables and consumer characteristic variables and their possible interaction terms, and β_k is the coefficient to be estimated for each variable.

According to the principle of consumer utility maximization, individual i will choose the alternative j when the utility they obtain from alternative j is greater than the utility obtained from alternative m. Then, compared to choosing the alternative m, the probability that the consumer chooses j is:

$$P(U_{ij} > U_{im}) = P(V_{ij} + \varepsilon_{ij} > V_{im} + \varepsilon_{im}) = P(V_{ij} - V_{im} > \varepsilon_{im} - \varepsilon_{ij}), \forall\ j \neq m \quad (3)$$

3.1.2. Model Estimation of the Choice Experiment Method

Multiple measurement models can be used to estimate choice experiment models. Under the assumption that the random error term is independent and identically distributed and satisfies the Type I Extreme Value Distribution, the probability of an individual i from each alternative j is:

$$P_{ij} = P(y_i = j) = \frac{\exp(V_{ij})}{\sum_{r=1}^{J} \exp(V_{ir})} \quad (4)$$

Under this assumption, the multinomial logit model can be used for estimation. In contrast, the mixed logit (also known as the random parameter logit model) relaxes the assumption of independent and identically distributed random error terms, allowing the parameters to randomly change between different individuals, and characterizes the heterogeneity between individuals through the distribution of model parameters (mean, standard deviation). The random parameter logit model assumes that its parameter $\overline{\beta_k}$ is a random parameter rather than a fixed value and follows a certain distribution. Common distribution forms include normal distribution, logarithmic normal distribution, and uniform distribution. $\overline{\beta_k}$ is replaced with the multiple logit model to export the random-parameter logit model [32].

$$E(P_{ij}) = \int_{\beta} P_{ij}(\beta) f(\beta|\Omega) d\beta \quad (5)$$

where $f(\beta|\Omega)$ is the probability density function of the given distribution parameters β. In the random parameter logit model, maximum likelihood estimation is used to estimate the parameters.

Although the random parameter logit model can reveal individual preference heterogeneity, it is not suitable for explaining the sources of heterogeneity, whereas latent-class models can be used to analyze individual consumer heterogeneity [29]. The latent-class logit model is an extended multiple logit model that allows individuals to decompose their selection behavior into multiple categories and model each category independently. There are two assumptions of this model. The first is the interclass independence assumption, i.e., in the latent-class logit model, individuals are assigned to different categories, and the selection probabilities of different categories are independent of each other. This means that the selection behaviors of individuals of different categories are considered to be independent events and are not influenced by other categories. This assumption helps to avoid dependency issues between categories and enables the model to better fit the data. The second assumption is the hypothesis of disorder within categories, i.e., in the latent-class logit model, options within the same category have disorder, meaning that there is no fixed relative advantage between any two options. This means that for individuals in the same category, their selection preferences are similar, and the relative attractiveness or the advantage between options randomly changes. This assumption helps to avoid ordering issues within categories and enables the model to better fit the data [33]. Latent-class models are based on the theory that individual consumer behaviors depend on both the observable individual characteristics and the latent heterogeneity that varies with unobserved individual characteristics [34]. The latent-class model assumes that individuals are divided into several categories, but does not know which category an individual belongs to. Then, the probability of an individual choosing a scheme can be divided into two aspects, i.e., one aspect is the probability of choosing a scheme j when an individual i belongs to a class s, and the other aspect is the probability of an individual i belonging to a class s, as follows:

$$P_{ij} = \sum_{s=1}^{S} P(y_i = j,\ S_i = s) = \sum_{s=1}^{S} P(S_i = s) \times P(y_i = j \mid S_i = s) \tag{6}$$

The probability that an individual i chooses the alternative j when they belong to the class s is:

$$P(y_i = j \mid S_i = s) = \frac{\exp\left(\beta_s^T x_{ijk}\right)}{\sum_{j=1}^{J} \exp\left(\beta_s^T x_{ijk}\right)} \tag{7}$$

The probability that an individual i belongs to class s is:

$$P(S_i = s) = \frac{\exp\left(\eta_s^T D_i\right)}{\sum_{s=1}^{S} \exp\left(\eta_s^T D_i\right)} \tag{8}$$

where D_i is the variable of individual characteristics of consumers.

Through the maximum likelihood estimation of the sample data, the parameter estimates and the probability that each sample belongs to each category can be obtained.

3.1.3. Calculation

After estimating the parameters, the marginal rate of substitution between any attribute variable and monetary attribute variable can be calculated, that is, the value (willingness to pay or willingness to accept) assigned by individual consumers to the attribute of the scheme WTP.

$$WTP_{attribute} = -\frac{\beta_{attribute}}{\beta_{money}} \tag{9}$$

where $\beta_{attribute}$ is the coefficient of the attribute of the scheme, and β_{money} is the coefficient of the monetary attribute of the scheme.

When the interaction term of the scheme attribute variable and individual characteristic variable is added to observable deterministic utility, the calculation formula of WTP is as follows:

$$WTP_{attribute} = -\frac{\beta_{attribute} + \beta_{inter}\overline{x_l}}{\beta_{money}} \tag{10}$$

where β_{inter} is the coefficient of the interaction term between the scheme attribute variable and the individual characteristic variable x_l.

3.2. Experimental Design

The choice experiment method was used to evaluate farmers' WTA fertilizer reduction programs. After referring to the relevant literature on fertilizer reduction programs [35–39] and consulting relevant experts' opinions, we divided the attributes of the fertilizer reduction programs into the following four aspects: contract length, land area, fertilizer use, and annual cash subsidy. The contract length is the number of years of the contract, and the land area is the percentage of the total land area involved in the program. Undoubtedly, fertilizer reduction and annual cash subsidy were the key attribute variables. As for the reduction ratio of chemical fertilizer, most research and investigations set the reduction ratio to 15–20% [22,36]. Moreover, the Guiding Opinions on Accelerating the Control of Agricultural Non-Point Source Pollution in the Yangtze River Economic Belt, issued by the National Development and Reform Commission in 2018, pointed out that the amount of chemical fertilizer in the areas around Poyang Lake in 2020 should be reduced by more than 10% compared with 2015. Therefore, we set three fertilizer reduction ratios: 10%, 20%, and 30%. Regarding the attribute of annual cash subsidy, in the existing literature, the WTA for a reduction of 15–20% reduction is about 900 CNY/ha/year. In practice, the Action Plan for Zero Growth of Fertilizer Use by 2020 proposed by the Ministry of Agriculture in 2015 has reduced some fertilizer use through technological progress, and the cost of further reducing fertilizer application will be higher. Therefore, we set the annual cash subsidies to 1500 CNY/ha/year, 4500 CNY/ha/year, and 7500 CNY/ha/year. The levels of the four attribute variables are shown in Table 1.

Table 1. Selecting attribute variables and level settings in experiments.

Attribute	Level
Contract length	1 year, 5 years, 10 years
Land area	20%, 50%, 100%
Fertilizer reduction	10%, 20%, 30%
Annual cash subsidy	1500 CNY/ha/year, 4500 CNY/ha/year, 7500 CNY/ha/year

According to the attributes and their levels, we used SPSS to orthogonally combine the three levels of the four attributes, resulting in a total of nine choice schemes. A total of 36 choice sets were generated by combining these nine choice sets into pairs. Each choice set included one option of "Do not choose any of the above options" in addition to two generated choice sets. See Table 2 for an example of a choice set. In the case of "Do not choose any of the above options", the value of the attribute variable is 0. The 36 choice sets were randomly divided into six groups, and each group included six choice sets. In the survey, the six choice sets were randomly assigned to different respondent farmers, and each respondent was required to complete a set of choice sets.

Table 2. Example of a choice set.

Scheme	Contract Length (Years)	Land Area (%)	Fertilizer Reduction (%)	Annual Cash Subsidy (CNY/ha/Year)	Choice
Scheme 1	5	20	30	4500	
Scheme 2	1	20	10	1500	
Scheme 3	Do not choose any of the above options				

4. Study Area and Data Sources

4.1. Overview of the Study Area

The study area included farmers' land around Poyang Lake. Poyang Lake is located in the north of Jiangxi Province and the south bank of the middle and lower reaches of the Yangtze River. It is the largest freshwater lake in China. Poyang Lake is of great value for migratory birds and is on the list of wetlands of international importance maintained by the Convention on Wetlands. However, the quality of Poyang Lake's water environment is still poor. According to the Jiangxi Provincial Ecological and Environmental Status Bulletin, from 2010 to 2021, the water of Poyang Lake was consistently in a state of mild or moderate eutrophication, and the main pollutants were total phosphorus and/or total nitrogen. In 2021, the proportion of excellent water quality in Poyang Lake monitoring sites was only 16.7%. At the same time, Jiangxi province is one of the 13 major grain producing provinces in China, and Poyang Lake Plain, where Poyang Lake is located, is one of the four major grain producing areas in Jiangxi Province. According to the Jiangxi Statistical Yearbook 2022, in 2021, the grain output of Nanchang, Jiujiang, and Shangrao, which are situated around Poyang Lake, accounted for 31.46% of the province's total output, while the fertilizer application accounted for 47.78%. The large amount of chemical fertilizer application has led to the excessive nitrogen and phosphorus content in Poyang Lake. Reducing the amount of chemical fertilizer used around Poyang Lake is an important way to improve the water quality. Therefore, to conduct a survey on the WTA value for chemical fertilizer reduction, we sampled 31 villages located in Xinjian District, Yongxiu County, Lushan City, Yugan County, and Duchang County around Poyang Lake.

4.2. Survey of Farmers and Descriptive Statistics

The farmer questionnaire included three parts. The first part collected the basic information and production activities of farmers, including the household population, age, education level, household income and expenditure, and the status of farmers' farmland management (particularly the amount of chemical fertilizer used). The second part was farmers' cognition of wetland protection and fertilizer application. The third part was the fertilizer reduction choice experiment.

The survey was carried out in July 2021. We randomly sampled 15 farmers from each village, and collected 367 questionnaires in total. After excluding the farmers with no farmland, those who did not complete the choice experiment, and those with abnormal data, a total of 142 sample farmers were obtained for further analysis.

The variables of the choice experiment method included explained variables and explanatory variables, as shown in Table 3. The explained variables are the results of farmers' choices of a specific scheme. The explanatory variables include the attribute variables and the individual characteristics of the respondents. The attribute variables are the four attributes of the designed schemes, and the individual characteristic variables are further divided into three parts: the personal characteristics of the farmers, the household characteristics, and the ecological protection cognition variables.

First, the individual characteristic variables of the farmers mainly included age, gender, education level, and whether they were village leaders. The individual characteristics of farmers affect their cognition of agricultural chemical fertilizer application behavior as well as their willingness to participate in the chemical fertilizer reduction program. The average age of the respondents was 55.2 years old, and the average for years of education was 7.0 years. Finally, 28.2% of the respondents were village leaders. The sampled farmers were generally older and less educated.

Secondly, the household characteristics of the farmers mainly included the household population burden, the proportion of household non-agricultural income, the distance between the farmland and Poyang Lake, and the average amount of fertilizer applied per ha. The smaller the farm household burden, the higher the proportion of non-agricultural income, the lower the dependence of farmers on agricultural land, and the lower the WTA for fertilizer reduction. The average dependency burden of the farmers in the survey area was 27.6%, and the average proportion of non-agricultural income in terms of total income was 62.3%, indicating that the household dependency burden was relatively low, and the source of household income mainly depended on non-agricultural work.

Thirdly, the farmers' cognitions of ecological protection mainly included their cognition of the harm caused by chemical fertilizers and the importance of wetland. These cognitions were expressed on a five-point Likert scale, with higher scores indicating that the respondents thought that chemical fertilizers were more harmful or that wetlands were more important. Among them, the farmers' cognitions of chemical fertilizer hazards included two questions: "Do you think chemical fertilizer is harmful to water?" and "Do you think chemical fertilizer is harmful to migratory birds?" The farmers' cognition on the importance of wetlands included four questions: "Do you think Poyang Lake wetland has ecological benefits?", "Do you pay attention to the change of wetland water quality?", "Do you think wetland protection has important long term benefits?" and "Do you think migratory birds are friends of human beings?" The higher a farmer's cognition of ecological protection was, the more likely they were to participate in the fertilizer reduction program with a lower WTA. The average score of wetland importance cognition was 3.84, indicating a high degree of cognition. However, the average score of the respondents on the hazards of chemical fertilizer use was only 1.66, indicating that the respondents did not think that the hazard was very high.

Table 3. Variable assignment and descriptive statistics.

Variable	Variable Meaning and Assignment	Mean	Standard Deviation
Explained variables			
Whether the scheme is chosen or not	1 = the scheme is chosen; 0 = the scheme is not chosen	0.333	0.471
Explanatory variables			
Attribute variables			
Contract length	1, 5, 10	3.391	3.879
Land area	0.2, 0.5, 1	0.366	0.375
Fertilizer reduction	0.1, 0.2, 0.3	0.136	0.117
Annual cash subsidy	1.5, 4.5, 7.5	3.080	0.198
Characteristic variables			
Age	Continuous variable (year)	55.155	10.919
Gender	1 = male; 0 = female	0.775	0.418
Education level	Continuous variable (year)	6.965	4.049
Whether respondents are village leaders	1 = respondents are village leaders; 0 = respondents are not.	0.282	0.45
Household support burden	Number of persons under the age of 6 and over the age of 60 as a proportion of the total number of persons in a household	0.276	0.34
Proportion of non-agricultural income	Share of household non-agricultural income in total household income	0.623	0.498
Distance of farmland from Poyang Lake	Continuous variable (kilometers)	4.402	7.044
Average fertilizer application per ha	Fertilizer application/area under crops (kg/ha)	793.920	32.475
Cognition of fertilizer hazards	1 = barely any, 2 = low, 3 = medium, 4 = high, 5 = quite high	1.662	0.757
Cognition of the wetland importance	1 = barely any, 2 = low, 3 = medium, 4 = high, 5 = quite high	3.840	0.717

5. Analysis of Empirical Results

The empirical results included the following three parts: the analysis of the farmers' preferences and WTA for participating in the fertilizer reduction program, the heterogeneity analysis of farmers' preference, and the potential classification of farmers.

5.1. Farmers' Preference for Chemical Fertilizer Reduction Programs

We used Stata 16.0 to conduct an empirical analysis of the farmers' choice experiment data with the random parameter logit model. The coefficients of the annual cash subsidy in the fertilizer reduction scheme were set as random parameters with normal distribution, and the coefficients of other attribute variables were set as fixed parameters. Then, 1000 Halton sampling was used for estimation. The estimation results are shown in Table 4, where Model (1) only includes attribute variables, and Model (2) includes attribute variables and household characteristic variables. The coefficients of the farmers' characteristic variables in Model (2) are based on the "status quo" scheme. Since these two schemes are designed and randomly set, the coefficients and significance obtained by regression are basically the same. We reported a set of coefficients that shows the influence of the farmers' characteristics on their participation in the fertilizer reduction scheme.

Table 4. Estimation results of the random parameter logit model.

	Model (1)		Model (2)	
	Coefficient	Standard Error	Coefficient	Standard Error
Attribute variables				
Fixed parameters				
Contract length	−0.051 **	0.024	−0.051 **	0.024
Land area	−0.620 ***	0.231	−0.591 **	0.236
Fertilizer reduction	−3.356 ***	0.944	−3.308 ***	0.983
Random parameter mean				
Annual cash subsidy	0.862 ***	0.131	0.824 ***	0.125
Random parameter standard deviation				
Annual cash subsidy	0.877 ***	0.181	0.801 ***	0.171
Characteristic variables				
Age			0.982 *	0.545
Gender			−0.037	0.031
Education level			−0.022	0.069
Whether respondents are village leaders			−0.167	0.541
Household support burden			−1.501	0.947
Proportion of non-agricultural income			−2.645 ***	0.685
Average fertilizer application per ha			−0.001 ***	0.000
Distance of farmland from Poyang Lake			−0.049 *	0.028
Cognition of fertilizer hazards			0.576 *	0.300
Cognition of the wetland importance			−0.061	0.288
Constant	1.390 ***	−0.425	5.503 **	2.243
Log likelihood	−660.455		−634.765	
LR chi2	75.96		59.74	
Prob > chi2	0.000		0.000	
Number of obs	2556		2556	

Note: ***, **, * → significant at the 1%, 5%, and 10% levels.

It can be seen from Table 4 that the results of Model (1) and Model (2) show that the coefficients of the attribute variables of contract length, land area, and fertilizer use are significantly negative, indicating that the longer the program implementation period, the more the increase in the proportion of participating land area and the increase in the proportion of reducing fertilizer will reduce the willingness of farmers to participate. The coefficient of the attribute variable of the annual cash subsidy is significantly positive, indicating that providing cash compensation can improve farmers' willingness to participate.

The influence of farmers' characteristics on their participation in the fertilizer reduction program was represented by the results of Model (2). In terms of individual characteristics, male farmers were more willing to participate in the fertilizer reduction program. Age, education level, and whether they were village leaders did not affect the willingness to participate. In terms of household characteristics, the coefficient of the proportion of non-agricultural income of farmers was significantly negative, indicating that the higher the proportion of non-agricultural income of farmers, the lower the willingness of farmers to participate. In terms of farmers' farmland management, the higher the amount of fertilizer per ha, the lower the willingness of farmers to participate in the fertilizer reduction program. Farmers may think that a higher amount of fertilizer can maintain a greater crop yield, making them less willing to participate in the fertilizer reduction program. The shorter the land distance from Poyang Lake, the higher the farmers' attention to Poyang Lake, and the higher their willingness to participate. In terms of cognition, the higher the farmers' cognition of the harm of chemical fertilizer was, the more willing they were to participate. However, farmers' cognition of the importance of wetland did not significantly affect their willingness to participate in the fertilizer reduction program.

In order to ensure the accuracy of the benchmark regression results, we switched to the conditional logit model and the multiple logit model to test the robustness of the experimental data regarding the farmers' selection. Models (3) and (4) in Table 5 represent the conditional logit regression and multiple logit regression, respectively, and the regression results are shown below. It can be seen that the regression results of the conditional logit and multiple logit are not much different from the benchmark regression results, especially for the annual cash subsidy attribute variable that we focused on.

Table 5. Robustness test.

	Model (3)		Model (4)	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**
Attribute variables				
Contract length	−0.02	−0.014	−0.017	−0.014
Land area	−0.174	−0.15	−0.149	−0.154
Fertilizer reduction	−0.972 *	−0.57	−1.003 *	−0.554
Annual cash subsidy	0.395 ***	−0.023	0.400 ***	−0.022
Characteristic variables				
Age			−0.006	−0.13
Gender			0.001	−0.006
Education level			0.008	−0.016
Whether respondents are village leaders			−0.036	−0.126
Household support burden			0.103	−0.19
Proportion of non-agricultural income			−0.018	−0.109
Average fertilizer application per ha			0	0
Distance of farmland from Poyang Lake			−0.004	−0.007
Cognition of fertilizer hazards			0.012	−0.066
Cognition of the wetland importance			0.018	−0.07
Constant	1.390 ***	−0.425	−2.010 ***	−0.437
Log likelihood	−1117.68		−1341.584	
LR chi2	556.07		590.69	
Prob>chi2	0		0	
Number of obs	2556		2556	

Note: ***, * → significant at the 1% and 10% levels.

According to the parameter estimation results of the regressions and Formula (9), farmers' willingness to accept the attributes of the fertilizer reduction program were calculated, as shown in Table 6. Taking the results of Model (2) as an example, regarding the implementation years of the fertilizer reduction program, for each additional year, the farmers' WTA was 63.75 CNY/ha/year. For every 10% increase in the proportion of farmers participating in the land area, the WTA was 73.875 CNY/ha/year. For every 10% reduction in fertilizer application, the WTA was 413.505 CNY/ha/year.

Table 6. Farmers' WTA for the attributes of the fertilizer reduction scheme.

	Model (1)	Model (2)	Model (3)	Model (4)
Contract length (1 year)	58.845	63.75	-	-
Land area (10%)	71.535	73.875	-	-
Fertilizer reduction (10%)	387.225	413.505	246.076	250.75

The results of this study were compared with those of the related literature, as shown in Table 7. It can be seen that the WTA calculated in this paper is close to the calculated results of Li [18] and Zhu [22], which indicates that the results of this paper are reliable to some extent.

Table 7. Comparison with similar research results.

Literature	Research Time	Research Location	Research Methodology	Number of obs.	Fertilizer Reduction (%)	Annual Cash Subsidy (CNY/ha/Year)
Yu Liangliang [23]	2013	Jingshan County, Hubei Province	Contingent valuation method	170	50	7737
Li Xiaoping [18]	2016	Ankang, Shaanxi Province; Hanzhong City	Choice experiment method	632	10	227.85
Lyu [21]	2019	Nanjing, Jiangsu Province	Contingent valuation method	205	14	882.45
Zhu Kening [22]	2020	Shiyan City, Hubei Province	Contingent valuation method	500	20	980.1
This article	2021	Nanchang City, Jiangxi Province, Jiujiang, and Shangrao	Choice experiment method	142	10	413.4

5.2. Individual Characteristics of Farmers and Preferences

We further analyzed the heterogeneity of farmers' preferences to participate in fertilizer reduction programs with respect to individual characteristics. On the basis of Model (2), the interaction terms of the attribute variables and individual characteristic variables were added, in which the individual characteristics were household support burden, proportion of non-agricultural income, average amount of chemical fertilizer per ha, farmers' cognition of chemical fertilizer harm, and farmers' cognition of wetland importance. The regression results are shown in Tables 8 and 9. In general, only a few of the coefficients of the interaction terms between the individual characteristic variables and the attribute variables were significant; that is, some of the characteristic variables of the farmers showed heterogeneity in the WTA values for the attributes of the program.

Table 8. Heterogeneity of household characteristics of farmers.

		Model (5)		Model (6)		Model (7)	
		Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Attribute variables							
Fixed parameters							
Contract length		−0.043	0.029	−0.033	0.035	−0.059	0.042
Land area		−0.265	0.286	−0.835 **	0.340	−0.331	0.411
Fertilizer reduction		−3.019 ***	1.125	0.444	1.363	−1.306	1.476
Contract length	×Household support burden	−0.023	0.059				
Land area	×Household support burden	−1.129 *	0.604				
Fertilizer reduction	×Household support burden	−1.005	2.458				
Contract length	×Proportion of non-agricultural income			−0.023	0.041		
Land area	×Proportion of non-agricultural income			0.464	0.408		
Fertilizer reduction	×Proportion of non-agricultural income			−5.664 ***	1.590		
Contract length	×Average fertilizer application per ha					0.000	0.001
Land area	×Average fertilizer application per ha					−0.000	0.006
Fertilizer reduction	×Average fertilizer application per ha					−0.037	0.022
Random parameter mean							
Annual cash subsidy		0.812 ***	0.122	0.785 ***	0.112	0.812 ***	0.124
Random parameter standard deviation							
Annual cash subsidy		0.785 ***	0.167	0.746 ***	0.152	0.783 ***	0.170
Characteristic variables		√		√		√	
Log likelihood		−634.107		−637.886		−636.778	
LR chi2		58.06		56.37		57.62	
Prob > chi2		0.000		0.000		0.000	
Number of obs.		2556		2556		2556	

Note: ***, **, * → significant at the 1%, 5%, and 10% levels.

Table 9. Heterogeneity of farmers' cognition on ecological protection.

		Model (8)		Model (9)	
		Coefficient	Standard Error	Coefficient	Standard Error
Attribute variables					
Fixed parameters					
Contract length		−0.060	0.049	0.140	0.110
Land area		−1.199 **	0.492	−2.507 **	1.116
Fertilizer reduction		−5.035 ***	1.917	0.994	4.057
Contract length	×Cognition of fertilizer hazards	0.007	0.024		
Land area	×Cognition of fertilizer hazards	0.367	0.253		
Fertilizer reduction	×Cognition of fertilizer hazards	1.076	0.977		
Contract length	×Cognition of the wetland importance			−0.048 *	0.027
Land area	×Cognition of the wetland importance			0.497 *	0.281
Fertilizer reduction	×Cognition of the wetland importance			−1.121	1.035
Random parameter mean					
Annual cash subsidy		0.810 ***	0.124	0.818 ***	0.124
Random parameter standard deviation					
Annual cash subsidy		0.794 ***	0.171	0.799 ***	0.169
Characteristic variables		√		√	
Log likelihood		−635.329		−632.153	
LR chi2		58.74		60.35	
Prob > chi2		0.000		0.000	
Number of obs.		2556		2556	

Note: ***, **, * → significant at the 1%, 5%, and 10% levels.

In Model (5), which included the interaction terms between the household support burden and attribute variables, only the interaction term between household support burden and land area was significant and negative at the level of 10%. Based on Model (3), the farmers' WTA values for the attributes of the fertilizer reduction program were calculated. The calculations are as follows: First, the interaction coefficient between the land area and household support burden was multiplied by the sample mean of the household support burden, plus the coefficient of land area (if significant), and then divided by the coefficient of the annual cash subsidy, and finally, the absolute value of the result is the farmers' WTA for the attributes of the fertilizer reduction program. The results showed that, for every 10% increase in the proportion of farmers' participated land area, the WTA was 39 CNY/ha/year, while the WTA increased by 14.145 CNY/ha/year for every 10% increase in the support burden of the farmers.

In Model (6), which includes the interaction terms between the proportion of non-agricultural income and the attribute variables, only the interaction term between the proportion of non-agricultural income and the proportion of fertilizer reduction is significant and negative; that is, the higher the proportion of non-agricultural income, the higher the WTA value for fertilizer reduction. Even if farmers can obtain higher non-agricultural income, they still hope to maintain the current agricultural income and are not willing to reduce the amount of chemical fertilizer used. Based on Model (4), we calculated the farmers' WTA for reducing the usage of chemical fertilizers. It can be seen that for every 10% reduction in fertilizer use, the WTA is 441.15 CNY/ha/year, and for every 10% increase in the ratio of non-agricultural income of the household, the WTA rises by 70.8 CNY/ha/year.

In Model (7), which includes the interaction terms of average fertilizer use per hectare and attribute variables, the coefficients of the three interaction terms were not significant. In other words, the amount of chemical fertilizer per ha did not affect the WTA of farmers in terms of contract length, land area, or fertilizer reduction.

In Model (8), which includes the interaction terms between farmers' cognition of wetland importance and attribute variables, the regression coefficients of two interaction terms are significant. Among them, the coefficient of the interaction term between the farmers' cognition of the importance of wetland and the contract length is significantly negative, which indicates that the higher the farmers' cognition of wetland importance, the higher their WTA value for the implementation period of the program. That is, although the farmers recognize the importance of wetland protection, they still believe that the implementation period of the program will have a negative impact on their agricultural yield. Therefore, they hope to obtain a higher level of economic compensation. The coefficient of the interaction term between the farmers' cognition of wetland importance and the proportion of participating land area was significantly positive, indicating that the higher the farmers' cognition of wetland importance, the lower their WTA value for the proportion of participating land area; that is, they are more willing to invest a larger proportion of land in the fertilizer reduction program to strengthen wetland protection. In addition, Model (9) included the interaction terms of farmers' cognition of fertilizer hazards and the attribute variables, and the regression coefficients of the three interaction terms were not significant, indicating that farmers' cognition of fertilizer hazards did not significantly affect the WTA value for the fertilizer reduction program. However, the regression coefficients were insignificantly positive, and the WTA value for the program may be reduced to some extent.

5.3. Individual Characteristics and Preferences for Fertilizer Reduction Programs

The latent-class logit model was used to analyze the heterogeneity of the sampled farmers in terms of categories. The latent-class logit model can divide the sampled farmers into several potential categories and estimate the coefficients of the attribute variables for each category. In order to test the suitability of the number of sample categories, the Bayesian information criterion (BIC) and Akaike information criterion (AIC) are used to measure the model's goodness-of-fit. The Bayesian information criterion can effectively prevent the model from overfitting and is the main basis for the latent classification. We classified the sampled farmers into from two to five categories, with AIC values of 942.8227, 886.0922, 849.9880, and 855.4841, and BIC values of 969.4251, 927.4738, 906.1487, and 926.4239. When the farmers were divided into four categories, the AIC value and BIC value were the lowest, and the goodness-of-fit of the model was the best. Therefore, we divided the farmers into four categories and regressed. The estimated results of the latent-class logit model are shown in Table 10. The basic characteristics of the four types of farmers were further statistically analyzed, and the results are shown in Table 11. The latent-class logit regression results and the descriptive statistics of the four types of farmers were used to analyze the main characteristics of each category.

Table 10. Regression results of the latent-class logit.

	"Farm-Oriented Hybrid"		**"Farm"**		**"Off-Farm"**		**"Off-Farm-Oriented Hybrid"**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Attribute variables								
Contract length	0.106 ***	0.027	12.250	45.970	−1.262	0.843	−0.087	0.092
Land area	−0.001	0.291	65.430	249.000	10.523 *	6.129	−14.454 **	6.130
Fertilizer reduction	−0.457	1.013	−38.580	153.300	−32.900	24.160	−60.680 **	25.540
Annual cash subsidy	0.4 ***	0.067	18.867	71.533	−0.467	0.733	58.667	4903.000
Constant	0.161	0.276	−0.924 **	0.380	−0.985 ***	0.296	-	-

Note: ***, **, * → significant at the 1%, 5%, and 10% levels.

There were 45 households in the first category, accounting for 31.69% of the total sample. The regression results showed that, among the attribute variables of the fertilizer reduction program, only the contract length and the annual cash subsidy coefficients were significant, and they were both positive. According to the farmer characteristic statistics, the non-agricultural income for farmers in the first category is in third place, but is close to the sample mean. These farmers also own a certain amount of agricultural land (second place) and agricultural income (second place), the proportion of non-agricultural income is relatively high, and the proportion of agricultural income is relatively low. Therefore, this category can be referred to as the "farm-oriented hybrid type". This category of farmers is more dependent on labor income, but also has a certain dependence on agricultural income, so these farmers prefer a higher subsidy amount and a long-term fertilizer reduction program.

Table 11. Characteristics of the four types of farmers.

Farmer Category	Farm-Oriented Hybrid	Farm	Off-Farm	Off-Farm-Oriented Hybrid	All
Number of obs.	45	14	18	65	142
Education level (year)	7	5.7	6.2	7.4	7
Household non-agricultural income (CNY)	71,827	46,986	84,400	92,831	80,586
Household agricultural income (CNY)	22,651	76,188	7083	17,806	23,738
Farmland area (ha)	1.81	2.23	0.58	1.79	1.69
Average fertilizer application per ha (kg/ha)	828	711	922.5	751.5	793.5
Cognition of fertilizer hazards (point 1–5)	1.84	1.46	1.42	1.65	1.66
Cognition of wetland importance (point 1–5)	3.87	3.75	3.92	3.82	3.84

There were 14 households in the second category, accounting for 9.86% of the total sample. The regression results showed that none of the four coefficients of attribute variables were significant, that is, the farmers were not interested in the fertilizer reduction program. This type of farmer has the lowest mean non-agricultural income, the highest agricultural income, the most farmland area, and the lowest level of education, so this category can be called " farm type". These farmers mainly rely on agricultural income and are not interested in participating in the fertilizer reduction program, which may imply that they are not willing to participate in any form of fertilizer reduction program.

There were 18 households in the third category, accounting for 12.68% of the total sample. The regression results showed that only the coefficient of the proportion of participating land area was significant and positive, that is, the larger the proportion of participating land area, the higher the willingness of the farmers to participate in the fertilizer reduction program. According to the characteristics of the third category of farmers, the non-agricultural income is in second place, the agricultural income is the lowest, and the agricultural land area of the farmers is generally the smallest, implying that they may prefer to put more land into the fertilizer reduction program. Hence, they can be called "off-farm workers". This category of farmer has the smallest land area, mainly relies on labor income, and prefers a fertilizer reduction program with a larger proportion of land area.

There were 65 households in the fourth category, accounting for 45.77% of the total sample, which was the highest proportion among the four categories. The regression results showed that the coefficients of the proportion of participating land area and the proportion of reducing fertilizer were significantly negative; the coefficient of contract length was negative, but not significant; and the coefficient of annual cash subsidy was positive and not significant. In terms of the characteristics of this category, the level of education is the highest, the household non-agricultural income is the highest, the household agricultural income is relatively low (ranking third), the agricultural land area is relatively small (ranking third), and the per ha fertilizer consumption is in the middle level of the sampled farmers (ranking third). Therefore, this category can be called "off-farm-oriented hybrid type". This category of farmer mainly earns income from non-agricultural work, but also has certain income from agriculture, so they are not willing to participate in the fertilizer reduction program.

In general, the "farm type" farmers seemed to be uninterested in participating in the fertilizer reduction program; the "off-farm workers" had the lowest agricultural income and preferred to put more land into the fertilizer reduction program. The "farm-oriented hybrid type" and "off-farm-oriented hybrid type" farmers accounted for the highest proportion, and their regression results were the closest in terms of the benchmark regression results, indicating that these two types of farmers are the most typical.

6. Conclusions and Policy Implications

The use of chemical fertilizers in agricultural production is an important factor causing water pollution and eutrophication. China has already reduced the amounts of chemical fertilizers being used to a certain extent through the widespread introduction of fertilizer application technology, but it is still necessary to further reduce fertilizer application in some areas, especially in areas with large-scale agricultural production and higher requirements for ecological environment quality, which enhances the necessity of establishing an ecological compensation mechanism for fertilizer reduction. Taking the farmers located around Poyang Lake as an example, we used the choice experiment method to study the farmers' preferences for the key attributes of the chemical fertilizer reduction program, namely, the WTA, and we explored the heterogeneity of the preference of farmers.

Based on the study of 142 farmers around Poyang Lake, it was found that cash compensation had a significant incentive effect on farmers' participation in the fertilizer reduction program. The implementation period of the program, the proportion of participating land area, and the proportion of fertilizer reduction were the key attributes to be considered in the design of the ecological compensation program. For each additional year of the fertilizer reduction program, the farmers' WTA was 63.75 CNY/ha/year. For every 10 percent increase in the proportion of participating land area, the WTA was 73.875 CNY/ha/year, and for every 10 percent decrease in the amount of chemical fertilizer being applied, the WTA was 413.505 CNY/ha/year. The farmers' characteristics and cognitions also affect the WTA value. The household support burden, the proportion of non-agricultural income, and farmers' cognition of wetland importance have a significant impact on their willingness. Different types of farmers preferred different fertilizer reduction schemes. Based on the latent-class logit model, the surveyed farmers were divided into four types: farm-oriented hybrid type, farm type, off-farm type, and off-farm-oriented hybrid type. There were considerable differences in the preferences for fertilizer reduction scheme attributes among these four types of farmers, implying that differentiated fertilizer reduction programs for different types of farmers may increase the overall willingness to participate in these programs.

These conclusions, combined with the current situation and the policies associated with chemical fertilizer application in planting agriculture around Poyang Lake, lead to several policy implications. First, the monetary compensation required for chemical fertilizer reduction is significant, so it is suggested that the current priority should be to advance the progress of fertilizer application technology in order to reduce the use of chemical fertilizers and mitigate the loss of fertilizer into the soil and waterways. Secondly, when exploring an ecological compensation mechanism for chemical fertilizer reduction, the implementation period of the program should be more flexible, and it is not necessary to set a fixed long period, so the ecological compensation mechanism is more easily accepted by farmers. Third, strengthening publicity and education to improve farmers' cognition of the importance of wetland and the harm caused by the excessive application of chemical fertilizers can improve farmers' willingness to accept the ecological compensation mechanism. Fourth, the policies should be tailored for different types of farmers. On the one hand, for farmers who rely more on agriculture, the subsidy is the most important attribute, while contract length, land area, and fertilizer reduction are less important, so the policy could include a higher subsidy and stricter requirements. On the other hand, for farmers who rely less on agriculture, the subsidy is not so important, but land area and fertilizer reduction are more important; therefore, the policy could include a lower subsidy and fewer requirements. In practice, policymakers may formulate these two types of fertilizer reduction incentive programs to enroll more farmers and a greater proportion of land area so as to reduce the use of chemical fertilizers and improve the water quality.

Author Contributions: Conceptualization, H.W.; methodology, H.W.; software, Q.L.; survey, H.W., Q.L. and T.L.; writing—original draft preparation, T.L.; writing—review and editing, H.W. and Q.L.; funding acquisition, H.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Jiangxi Provincial Department of Forestry, grant number 2020-07.

Data Availability Statement: Due to the privacy of the respondents, we are unable to provide raw data, but we can share methods and results.

Acknowledgments: Thanks go to Wen Yali, Jiang Xuemei and Wang Weidong for their help with the research ideas and methods. Thanks also go to Xie Liyu, Wen Zhaojie, Gong Leiqiang, Hu Binhua, Zhang Zonghua, Li Jianxin, Mei Yong, Wu Yanliang, Zhong Xinghua, and all of the surveyed farmers for their help and support during the research. Thanks go to MDPI for polishing this paper and for the suggestions on the manuscript from the reviewers and editors.

Conflicts of Interest: No potential conflict of interest were reported by the authors.

References

1. Ministry of Ecology and Environment of the People's Republic of China. Announcement on the Ecological and Environmental Status of China in 2021. 26 May 2022. Available online: https://www.mee.gov.cn/hjzl/sthjzk/zghjzkgb/202205/P020220608338202870777.pdf (accessed on 10 June 2023).
2. Sun, B.; Zhang, L.; Yang, L.; Zhang, F.; Norse, D.; Zhu, Z. Agricultural Non-Point Source Pollution in China: Causes and Mitigation Measures. *Ambio* **2012**, *41*, 370–379. [CrossRef] [PubMed]
3. Ministry of Ecology and Environment, National Bureau of Statistics, Ministry of Agriculture and Rural Affairs, Announcement of the Second National Pollution Source Census. 8 June 2020. Available online: http://www.gov.cn/xinwen/2020-06/10/content_5518391.htm?tdsourcetag=s_pctim_aiomsg (accessed on 10 June 2023).
4. Shen, Z.; Liao, Q.; Hong, Q.; Gong, Y. An overview of research on agricultural non-point source pollution modelling in China. *Sep. Purif. Technol.* **2011**, *84*, 104–111. [CrossRef]
5. Culbertson, A.M.; Martin, J.F.; Aloysius, N.; Ludsin, S.A. Anticipated impacts of climate change on 21st century Maumee River discharge and nutrient loads. *J. Great Lakes Res.* **2016**, *42*, 1332–1342. [CrossRef]
6. Ongley, E.D.; Xiaolan, Z.; Tao, Y. Current status of agricultural and rural non-point source Pollution assessment in China. *Environ. Pollut.* **2009**, *158*, 1159–1168. [CrossRef]
7. Ma, J.; Gao, H.; Cheng, C.; Fang, Z.; Zhou, Q.; Zhou, H. What influences the behavior of farmers' participation in agricultural nonpoint source pollution control? Evidence from a farmer survey in Huai'an, China. *Agric. Water Manag.* **2023**, *281*, 108248. [CrossRef]
8. Wang, Y.; Liang, J.; Yang, J.; Ma, X.; Li, X.; Wu, J.; Yang, G.; Ren, G.; Feng, Y. Analysis of the environmental behavior of farmers for non-point source pollution control and management: An integration of the theory of planned behavior and the protection motivation theory. *J. Environ. Manag.* **2019**, *237*, 15–23. [CrossRef]
9. Hu, M.Y.; Yan, S.; Cao, T.Q.; Deng, Y.Y.; Wen, G.H. Research on Farmers' Willingness to Participate in Non-Point Source Pollution Control of Cultivated Land. *Res. Soil Water Conserv.* **2021**, *28*, 397–403.
10. Cui, Z.; Zhang, H.; Chen, X.; Zhang, C.; Ma, W.; Huang, C.; Zhang, W.; Mi, G.; Miao, Y.; Li, X.; et al. Pursuing sustainable productivity with millions of smallholder farmers. *Nature* **2018**, *555*, 363–366. [CrossRef] [PubMed]
11. Jun, Q. Influence of Chemical Fertilizer Application on Water Pollution in China and its Control Measures. *Agric. Econ. Probl.* **2007**, *S1*, 75–80.
12. Mäder, P.; Fliessbach, A.; Dubois, D.; Gunst, L.; Fried, P.; Niggli, U. Soil Fertility and Biodiversity in Organic Farming. *Science* **2002**, *296*, 1694–1697. [CrossRef] [PubMed]
13. Song, Z.; Gao, H.; Zhu, P.; Peng, C.; Deng, A.; Zheng, C.; Mannaf, M.A.; Islam, M.N.; Zhang, W. Organic amendments increase corn yield by enhancing soil resilience to climate change. *Crop J.* **2015**, *3*, 110–117. [CrossRef]
14. Laurance, W.F.; Sayer, J.; Cassman, K.G. Agricultural expansion and its impacts on tropical nature. *Trends Ecol. Evol.* **2014**, *29*, 107–116. [CrossRef] [PubMed]
15. Yuan, Y.; Zeng, G.; Liang, J.; Huang, L.; Hua, S.; Li, F.; Zhu, Y.; Wu, H.; Liu, J.; He, X.; et al. Variation of water level in Dongting Lake over a 50-year period: Implications for the impacts of anthropogenic and climatic factors. *J. Hydrol.* **2015**, *525*, 450–456. [CrossRef]
16. Feng, L.; Han, X.; Hu, C.; Chen, X. Four decades of wetland changes of the largest freshwater lake in China: Possible linkage to the Three Gorges Dam. *Remote Sens. Environ.* **2016**, *176*, 43–55. [CrossRef]
17. The Ministry of Ecology and Environment of the People's Republic of China. The Fourth Central Ecological and Environmental Protection Supervision Group Provided Feedback on the Inspection Situation to Jiangxi Province. 17 July 2021. Available online: https://www.mee.gov.cn/ywgz/zysthjbhdc/dcjl/202107/t20210717_847513.shtml (accessed on 10 June 2023).

18. Li, X.P.; Xie, X.Q.; Zhao, M.J. Compensation Standards for Cultivated Land Non-Point Pollution Control: Incorporating Ecological Benefits. *J. Northwest AF Univ. Soc. Sci. Ed.* **2019**, *19*, 107–114+124.
19. Hansson, H.; Suvi, K. Farmers' mental models of change and implications for farm renewal: A case of restoration of a wetland in Sweden. *J. Rural Stud.* **2018**, *60*, 141–151. [CrossRef]
20. Zhao, X.Y.; Xia, D.; Fan, J.J.; Dai, Q.W. The Selection of Ecological Compensation Model in the Yellow River Water Supply Areas of Gannan, Gansu. *J. Glaclol. Geocryol.* **2010**, *32*, 204–210.
21. Lv, Y.F.; Li, X.; Sun, H.; Wang, S. Ecological compensation standards for paddy fields based on the control of chemical fertilizer application-Lishui District, Nanjing as an example. *Acta Ecol. Sin.* **2019**, *39*, 63–72.
22. Zhu, K.N.; Leshan, J. Study on the compensation of fertilizer reduction in hilly and mountainous areas based on farmers' willingness to accept compensation. *J. Arid Land Resour. Environ.* **2019**, *39*, 63–72.
23. Yu, L.L.; Yinying, C. Ecological compensation based on farmers' willingness: A case study of Jingsan County in Hubei Province, China. *Chin. J. Appl. Ecol.* **2015**, *26*, 215–223.
24. Pang, J.; Leshan, J. Wetland Ecological Compensation Mechanism: A Case Study of the Poyang Lake. *J. Ecol. Rural Environ.* **2021**, *37*, 456–464.
25. Xiong, K.; Kong, F.B.; Chen, S.D. An Analysis of Farmers' Willingness to Accept Ecological Compensation in Poyang Lake Wetland and Its Influencing Factors: Based on the Empirical Study of CVM and Ordinal Logistic Model. *J. Jiangxi Univ. Financ. Econ.* **2016**, *103*, 28–35.
26. Li, F.; Zhen, L.; Huang, H.Q.; Han, P.; Liu, X.L.; Jiang, L.G.; Wei, Y.J. Impacts of Land Use Functional Change on WTA and Economic Compensation for Core Stakeholders: A Case Study in Poyang Lake. *Resour. Sci.* **2009**, *31*, 580–589.
27. Jiang, H.Y.; Yali, W. Study on Peasants' Willingness to Accept its Influential Factor Around Wetland based on WTA. *Resour. Environ. Yangtze Basin* **2011**, *20*, 489–494.
28. Hensher, D.A.; Greene, W.H. The Mixed Logit model: The state of practice. *Transportation* **2003**, *30*, 133–176. [CrossRef]
29. Greene, W.H.; David, A.H. A latent class model for discrete choice analysis: Contrasts with mixed logit. *Transp. Res. Part B* **2003**, *37*, 681–698. [CrossRef]
30. Lancaster, K.J. A New Approach to Consumer Theory. *J. Politic. Econ.* **1976**, *74*, 132–157. [CrossRef]
31. McFadden, D.L. Conditional Logit Analysis of Qualitative Choice Behavior. In *Theory and Mathematical Economics*; Academic Press: Cambridge, MA, USA, 1974; pp. 105–142.
32. Rottinghaus, G.E.; McCullough, W.B. Mixed logit models for random parameters: A review and survey. *Transp. Res. Part B Methodol.* **2007**, *41*, 529–571.
33. Johnson, P.O.; McCullough, W.B.; Ryan, M.E. A latent class logit model for multinomial responses: Theory and application to high-speed rail travel mode choice. *Transp. Res. Part B Methodol.* **2008**, *42*, 506–525.
34. Vermunt, J.K.; Magidson, J. Factor Analysis with Categorical Indicators: A Comparison Between Traditional and Latent Class Approaches. *New Dev. Categ. Data Anal. Soc. Behav. Sci.* **2005**, *3*, 41–62.
35. Li, X.; Liu, W.; Yan, Y.; Fan, G.; Zhao, M. Rural Households' Willingness to Accept Compensation Standards for Controlling Agricultural Non-Point Source Pollution: A Case Study of the Qinba Water Source Area in Northwest China. *Water* **2019**, *11*, 1251. [CrossRef]
36. Wang, N.; Luo, L.; Pan, Y.; Ni, X. Use of discrete choice experiments to facilitate design of effective environmentally friendly agricultural policies. *Environ. Dev. Sustain.* **2019**, *21*, 1543–1559. [CrossRef]
37. Wu, H.X.; Yan, G. Excessive Application of Fertilizer, Agricultural Non-Point Source Pollution, and Farmers' Policy Choice. *Sustainability* **2019**, *11*, 1165. [CrossRef]
38. Yu, Y.H.; Yaosen, C. Farmer Preferences and Its Heterogeneity for Compensation Patterns of Agricultural Chemical Reduction: Evidence from Choice Experimental Analysis of 357 Farmers in Chongqing. *Environ. Manag. China* **2021**, *13*, 98–105.
39. Li, X.P.; Cai, J.; Wang, Q.J.; Wang, X.W. Heterogeneous public preferences for controlling agricultural non-point source pollution based on a choice experiment. *J. Environ. Manag.* **2022**, *305*, 114413. [CrossRef]