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Heterogeneity Impacts of Farmers' Participation in Payment for Ecosystem Services Based on the Collective Action Framework

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Abstract: Payments for ecosystem services (PES) are designed to reduce the impact of human activities on eco-sensitive areas. PES programs often adopt economic-incentive and command-control strategies. Increasing the enthusiasm of farmers' participation is crucial for the sustainability of PES programs and ecosystem restoration. The watershed ecological compensation in Xin'an River Basin is the first horizontal ecological compensation pilot in China. In this study, economic-incentive strategy and command-control strategies in living and farming are implemented simultaneously to improve water quality. Under the collective action framework, we analyze the drivers of farmers' participation in three concurrent strategies using hierarchical linear models (HLM). The results show: (1) Overall, 81.79%, 76.26%, and 79.11% of farmers are willing to participate in economic-incentive strategy, command-control strategy in living, and command-control strategy in farming, respectively, while 18.21%, 23.74%, and 20.89% are from the village level. (2) Among statistically significant ($p < 0.01$) factors at the farmer level, social trust ($\beta = 0.305$), and social participation ($\beta = 0.134$) have positive effects on the economic-incentive strategy; the number of communication and entertainment equipment has a positive effect on the willingness to participate in command-control strategy in living ($\beta = 0.287$) and command-control strategy in farming ($\beta = 0.336$). (3) At the village level, village characteristics have a direct impact on the farmers' willingness to participate in strategies. Village woodland area is positively correlated with strategies participation. In addition, village characteristics play a moderating role by influencing farmers' sustainable livelihood capital. We conclude that different concurrent strategies and collective actions need to be considered in the design of PES programs, particularly in ecologically sensitive areas, which can enrich the theory of collective action and the connotation of PES.

Keywords: collective action; hierarchical linear model; payment for ecosystem services; watershed ecological compensation

1. Introduction

Eco-sensitive areas provide human beings with vital means of production and living, such as water, food, and climate regulation. These areas are also among the most vulnerable places that easily be affected by human activities [1], but the rehabilitation of the impacted areas can be arduous and lengthy [2]. To reduce the undesirable impacts of human activities on eco-sensitive areas and secure the sustainable utilization of high-quality resources, governments and non-governmental organizations have taken numerous intervention measures [3], such as formulating legal provisions [4], promoting national co-operation in the field of environmental protection [5], and subsidizing landholders for conserving ecosystem services [6].

Over the past few decades, payments for ecosystem services (PES) as an innovative approach in policy have become increasingly attractive to environmental managers, academic researchers, and various practitioners [7]. This attraction has a clear economic rationale, as PES is an institutional arrangement that internalizes external costs associated with environmental protection and mobilizes the enthusiasm of protectors by providing economic-incentive such as cash or in-kind compensation [8,9].

A paradox emerges during the evaluation of the effectiveness of PES programs. Such an incentive is not always as practically successful as envisaged in theory since many programs face sustainability challenges. An evaluation of 40 programs implemented in Latin America [10] found that the success rate of long-term PES programs was 58%, and the success rate of short-term PES programs was even lower, only 50%. A study of 56 PES programs implemented across three continents (Latin America, Asia, and Africa) found that only 54% of the programs achieved both economic development (poverty reduction) and environmental protection goals, and only 26 (46%) were efficient in land work activities [11]. There are several reasons explaining the outcomes mixed with both successes and failures. First, the startup cost is often too high, and recurrent costs are needed to support the PES programs [12]. Second, whether livelihoods can be improved while ensuring the availability of quality resources remains uncertain [10]. Third, lacking an intermediary organization with supervision mechanisms can be critically disadvantageous [13]. Since community engagement often reduces supervision costs and improves the efficiency of the PES program [14]. These factors can lead to the termination of the PES programs and the exit of participants, making it difficult to continue the conservation practices or even further deteriorating the restoration of eco-sensitive areas with soil erosion, land degradation, water pollution, and biodiversity reduction.

The theoretical explanation of this paradox has become the difficulty in expanding existing and designing new PES programs [15,16]. The theory of collective action may shed light on understanding this phenomenon [17]. PES provides a platform for the protectors (sellers) and beneficiaries (buyers) to trade high-quality natural resources such as fresh air and clean water [18]. Protectors need to provide such quasi-public goods to make a deal happen. The externality of the quasi-public goods necessitates collective action taken by the protectors to achieve the conservation goals. Olson [19] pointed out that when personal benefit and common interests are in a collective conflict, collective action will fail. Only through certain means can individual interests be elevated to meet the common interests and hence promote the success of collective action. In other words, the lack of attention to collective action and environment may lead to the lack of motivation to fulfill PES program requirements.

In the PES programs, as individuals who take collective action, farmers' willingness to participate is an important index to effectively measure the sustainability of the PES program [20]. Specifically, the willingness of individuals to participate in the PES program would not only affect their own behavioral decisions [21] but also affect the individual decisions of surrounding farmers through the neighborhood (peer) effect [22]. It is more sensitive in the provision of public goods than substantialized commodities. The effectiveness and protective behavior of these products are difficult to measure, and the crisis of confidence is more likely to be generated or even amplified, resulting in a prisoner's dilemma [23].

Research on farmers' participation in PES programs worldwide has accumulated fruitful results in theory and practice. In theoretical analysis, a reflection is that the nature of shared problems depends on the complex co-operation mechanism arrangement of human society, the "benefit enhancing" collective action system design and test [24,25]. In the empirical study, farmers are the main stakeholders, and the variables are expounded using Ostrom's institutional analysis and development framework (IAD) or Chris Ansell and Alison Gash's cooperative governance analysis framework [26,27]. Relevant studies found that factors affecting rural collective action include, in addition to economic development, institutional change [28], labor mobility [29], economic geography change [20], villager heterogeneity, and land fragmentation [30].

Another theoretical viewpoint is strategy heterogeneity. That is, differences in farmers' preferences for different strategies within the same PES program [31,32]. Although PES programs with blood transfusion, industrial development, and professional employment of the labor force are more durable than those with cash compensation [33,34], farmers are inclined to choose the latter, cash compensation [35]. Hence, many scholars have researched compensation standards and indicated that reasonable compensation standards mobilized farmers to participate in PES programs [36,37]. This type of research tends to focus on economic incentive strategies but ignores command-control strategies in PES schemes [38].

The Xin'an River Basin is a pilot area under watershed ecological compensation in China. A command-incentive compatible ecological compensation program is implemented by the local government throughout a decade-long pilot program [39]. Among the "Ten Strategies in Xin'an River Basin", about seven strategies are directly related to farmers' farming livelihoods, such as the limited use of chemical fertilizers and pesticides, improvement of the rural environment, and the application of biological pesticides. Farmers are limited to the use of water for farming and living to reduce non-point source pollution and provide high-quality water in the basin. Several economic-incentive strategies were also being implemented simultaneously. These measures adjusted the scope of economic activities of coastal farmers through fundraising and distribution to achieve water quality protection. For example, raising funds deliver direct subsidies to farmers in the reservoir area below the 108-m watermark and fishermen who have retired from fishing.

Through the relevant review of the literature [19,20,31,33,40,41] and based on the background of PES program in Xin'an River, the following contents can be helpful. First, village characteristics and peasant household characteristics should be equally important. Most studies analyzed the influencing factors from the farmer-level perspective [32]. Even if village-level data are available, they were mostly taken as background variables, ignoring the moderating effect that village characteristics may have on farmers' decisions and attitudes. However, village characteristics can be crucial for collective actions, particularly in rural China [42]. The differences in a social system and natural endowments reflected at the village level are often the environments on which individual farmers rely when making decisions. Second, the participation of farmers in different strategies may be different, and it is necessary to conduct PES program classification and heterogeneity analysis according to the situation of current strategies. Finally, it is significant to use the hierarchical structure model to distinguish the influence of cross-level interactions on participation in PES programs. Accordingly, the objective of this paper is the ecological compensation in the Xin'an River Basin. According to the type of strategy implemented in this PES program of Xin'an River Basin, we divide the program into economic-incentive strategy, command-control strategy in living, and command-control strategy in farming. In addition, considering the differences in the effects of PES programs at the farmer and village levels, we use Hierarchical Linear Modeling (HLM) to separate the influencing factors at these two levels.

Based on the collective action theory, this study applies an IAD framework and provides new insight to understand the contradiction between PES program design and the lack of efficiency in the implementation process. The HLM is used to estimate the different contributions of village-level and individual farmer factors, aiming to provide evidence that the village-level factors can support the implementation of PES. In addition, comparing the difference in participation factors in different strategies can provide new insights on how to adjust measures to the different strategies of participators. In addition to the theoretical significance, the research has policy implications for the implementation of PES programs in developing countries. Exploring the differences in farmers' participation in China's pilot horizontal PES program and its sustainability measures can be informative to design future PES programs both in China and other developing countries.

This paper is structured as follows. Section 2 reviews the relevant literature and proposes research hypotheses. The empirical method and data are presented in Section 3. There are results and discussion in Sections 4 and 5. Section 6 summarizes the conclusion.

2. Research Hypotheses and Framework

2.1. PES Program

PES is defined as the existence of voluntary transactions between at least one buyer and provider of ecosystem services, subject to established rules of natural resource management, to achieve specific ecological service functions [9,43]. It is a specific type of environmental regulation program [44]. According to the types of environmental regulation policy, PES programs can be divided into economic-incentive strategy and command-control strategy [45–47]. The economic-incentive strategy is developed using the Coase Theorem as a theoretical basis [48,49]. The system is designed to facilitate transactions between the government, enterprises, industrial associations, and other parties, and it can be applied to mature market economic conditions [50,51]. The command-control strategy is guided by Pigouvian taxation and emphasizes intensive control by the government as the principal agent [52,53]. Many studies focus on the economic-incentive of PES programs [34,54], ignoring the fact that PES programs are implemented with incentive-command compatibility based on local economic and social conditions. The watershed ecological compensation of the Xin'an River Basin is the typical PES program with both economic-incentive and command-control compatibility. Local farmers are required to abandon chemical fertilizers, pesticides, and fishing to reduce water pollution. There are also measures to encourage them to participate in job training and compensation incentives. Additionally, the government expects to establish a principal-agent relationship with local farmers through villagers' organizations. Therefore, farmers' willingness to participate in the PES program should not be a response to a single strategy but multiple responses to the command-incentive compatible strategies. To distinguish the differences in farmers' willingness to participate in different strategies in the same PES program, we measure the willingness to accept compensation of farmers (*WTA*) for participation in the economic-incentive strategy. This is expressed as the logarithm of the amount of compensation, which is a continuous variable. The research also measures whether farmers are willing to participate in command-control strategy in living and command-control strategy in farming, which are binary variables.

2.2. The Influence of Sustainable Livelihood Capital on Farmers' Willingness to Participate in PES Programs

The sustainable livelihood framework guides analyzing the livelihood activities and behavioral choices of farmers [55–57]. Under this analytical framework, farmers in the context of vulnerability will change their livelihood choices in the face of policy shocks [58]. Their behavioral decisions are affected by natural capital, physical capital, human capital, financial capital, and social capital [59,60]. Farmers have different utility functions, which affect their resource allocation [61]. Therefore, the characteristics of farmers must be combined when analyzing their willingness to participate in the command-incentive compatible PES program. Based on this, we propose:

H1. *The sustainable livelihood capital affects farmers' willingness to participate in the command-incentive compatible program.*

H2. *Under the impact of different sustainable livelihood capital, the influencing factors of farmers' participation in the economic-incentive strategy and command-control strategies are different.*

2.3. The Influence of Collective Action Theory on Farmers' Willingness to Participate in PES Programs

According to Ostrom's collective action theory [62], the value of collective action lies in enhancing the interests of its members. Therefore, the realization of collective action needs to consider the group characteristics embedded in individual decision-making, namely the villages' environmental characteristics. In the same village environment, a "society of acquaintances" is formed by kinship or consanguinity [63]. The geographical characteristics, natural-social-economic characteristics, and characteristics of program implementation reflect villages' organizational advantages and differential patterns. A beneficial villagepeople relationship would encourage farmers to seek collective shelter and may form path dependence. Therefore, village characteristics would form norms or risks through interaction with the sustainable livelihood capital, and the impact willingness to participate. Based on this, the hypothesis is:

H3. *Village characteristics such as geographical characteristics, natural-social-economic characteristics, and characteristics of program implementation affect the willingness to participate through interactions with farmers' variables.*

2.4. Research Framework

This paper constructs an IAD framework (Figure 1). Farmers' multiple types of capital interact with village characteristics and affect their willingness to participate in environmental protection. For farmers, the economic-incentive strategy encourages them to participate by setting compensation standards, and the command-control strategies force them to participate in environmental protection activities related to farming and living. Constrained by their livelihood level, the influencing factors of farmers' participation in the economic-incentive strategy and command-control strategies may be different.

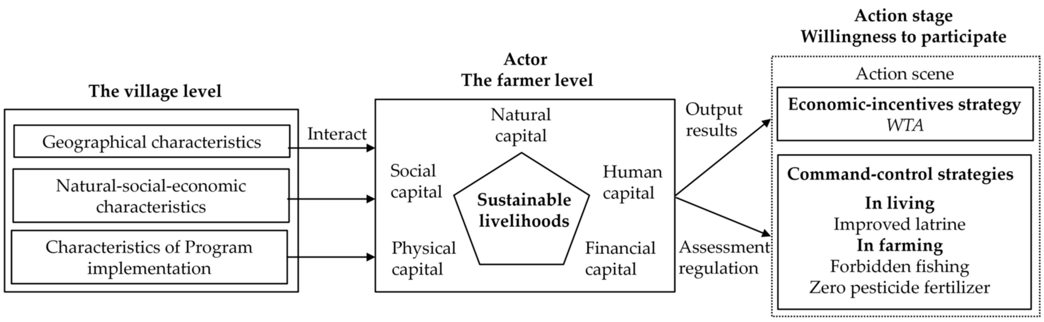

Figure 1. Schematic diagram of the simplified IAD framework.

3. Methods and Data Sources

3.1. HLM

This paper analyzes the influence of the characteristics of farm households and village levels on the willingness of farmers. Ordinary linear models, such as OLS, only consider a single level of data and cannot simultaneously capture the characteristics of explanatory variables embedded in each cluster [64]. In contrast, HLM provides hierarchical data analysis methods, which have advantages in model parameter calculation and data requirements [65,66]. This is composed of the following three models.

3.1.1. Model 1: Null Model

A null model does not include any explanatory variables, also known as a one-way analysis of variance (ANOVA). It divides the total variance into intra-class variance (farm-level variance σ^2, Formula (3)) and inter-class variance (village-level variance $\tau_{00}{}^2$, Formula (3)). The intra-group Correlation, known as Intra-class Correlation or ICC (Formula (4)), is calculated to determine whether to conduct further partitioning analysis. The model form is as follows:

$$\text{Level} - 1: \ Y_{ij} = \beta_{0j} + r_{ij} \tag{1}$$

$$\text{Level} - 2: \ \beta_{0j} = \gamma_{00} + u_{0j} \tag{2}$$

When the dependent variable is binary, we use the logit link function to transform ordinary logit into a linear model: $Y_{ij} = \log(\frac{P_{ij}}{1 - P_{ij}})$. P_{ij} is the probability of being willing to participate in command-control strategies.

The intra-class (farmer level) variance $Var(r_{ij})$ and inter-class (village level) variance $Var(u_{0j})$, as shown in Formula (3):

$$Var(r_{ij}) = \sigma^2;\ Var(u_{0j}) = \tau_{00}{}^2 \tag{3}$$

ICC can be expressed as:

$$ICC = \frac{\tau_{00}{}^2}{\sigma^2 + \tau_{00}{}^2} \tag{4}$$

where Y_{ij} represents the willingness of the i^{th} farmer in the j^{th} village. β_{0j} represents the average Y_{ij} of the j^{th} two-layer unit; r_{ij} is the variation of Y_{ij} in the j bilevel unit; γ_{00} represents the total average of Y_{ij} in the second-level units; u_{0j} denotes the random effect term of the second equation.

When the ICC value is close to 0, there is little difference at the village level, and it is not necessary to carry out HLM. When the ICC value is sufficiently large, it is necessary to add the differences within the group, namely the characteristics at the farmer level, and perform random intercept model regression [67].

3.1.2. Model 2: Random-Effects Regression Model

Based on Model 1, we add the first level variables (farmer level). It reflects the degree and direction of the influence of the first-level variables on the willingness of the dependent variable. Secondly, according to whether the random effect of the independent variable passes the significance test, the model of introducing the village variable is determined. Finally, focus on whether the first-level intercept and regression coefficients are significantly different at the second level. If so, it indicates that the village variable plays a moderating effect; otherwise, it indicates that there is no difference at the village level. Therefore, the factors affecting willingness at the farmer level were selected to construct a regression model, as shown in Formulae (5)–(7), to determine whether village characteristics should be added.

$$Y_{ij} = \beta_{0j} + \sum \beta_{nj} X_n + r_{ij} \tag{5}$$

$$\beta_{0j} = \gamma_{00} + u_{0j} \tag{6}$$

$$\beta_{nj} = \gamma_{n0} + u_{nj} \tag{7}$$

where X_n represents the n^{th} independent variable of the first layer; β_{nj} represents the regression slope of the n^{th} independent variable in the first layer; γ_{n0} is the average value of β_{nj}; u_{nj} is the random component of β_{nj}.

3.1.3. Model 3: Full Model

Following Model 2, we introduced the second-level variable village characteristics to establish a complete model. It can reflect the influence of single-level variables on the willingness to participate in the strategies and the mutual relationship of two-level variables. Therefore, the full model (Formulae (8)–(10)) introduces variables at the farmer level and village level to explore the influence degree and mutual relationship between the two levels on willingness.

$$Y_{ij} = \beta_{0j} + \sum \beta_{nj} X_n + r_{ij} \tag{8}$$

$$\beta_{0j} = \gamma_{00} + \sum \gamma_{0m} Z_m + u_{0j} \tag{9}$$

$$\beta_{nj} = \gamma_{n0} + \sum \gamma_{nm} Z_m + u_{nj} \tag{10}$$

where Z_m represents the m^{th} independent variable of the second layer; γ_{0m} represents the regression slope of the m^{th} independent variable in the second layer; γ_{nm} is the slope explained by the m^{th} variable in the second layer to the slope of the respective variable in the first layer, reflecting the cross-level interaction effect.

3.2. Study Area

The PES program involved in the study was launched in 2011 by Anhui Province in the upper and middle reaches and Zhejiang Province in the lower reaches to protect the water quality of the Xin'an River Basin (Figure 2). The Xin'an River covers 373 km. The upper reaches are located in Xiuning County, Huangshan City, Anhui Province. There are two main tributaries, Hengjiang River and Shuaishui River, with a length of 40.2 km and 124.2 km, and 18 townships. The middle reaches are in She County, Huangshan City, Anhui Province. The mainstream is 76.75 km, and there are nine townships along the river.

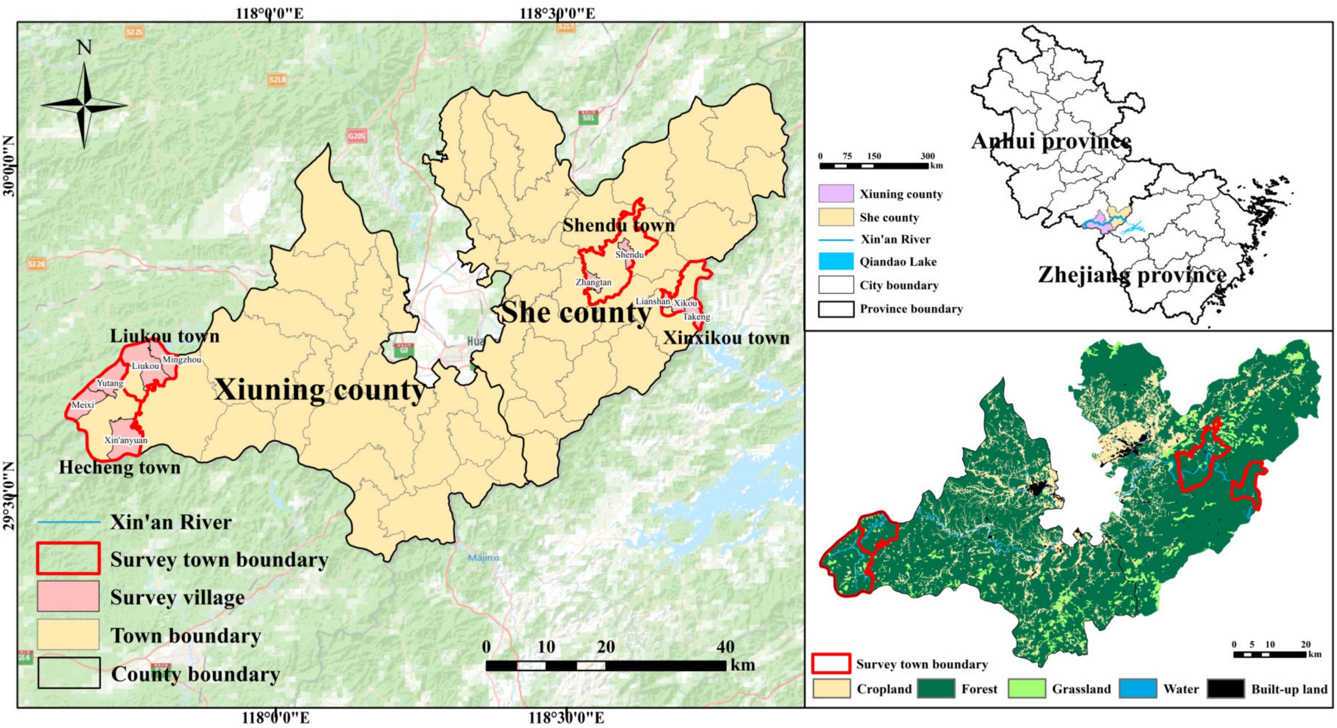

Figure 2. Study area and sample distribution.

The hilly area in Xiuning County and She County accounts for 76.7% and 95%, respectively. In terms of planting crops, Xiuning County and She County own more planting areas of economic fruit forests, such as tea gardens, which are 10,745 ha and 23,310 ha in 2020, respectively. Due to limited land conditions and inland locations, local farmers often go out to work.

After the implementation of the ecological compensation in the Xin'an River Basin, the economic-incentive strategy and the command-control strategy was implemented in Xiuning County and She County. The economic-incentive strategies include the compensation of public welfare forests, the establishment of public welfare posts, and the exchange of garbage for goods, while the command-control strategies in farming restrict the use of pesticides and fertilizers.

3.3. Data and Descriptive Statistics

3.3.1. Data

We surveyed farmers in Xiuning County and She County, located in the upper and middle reaches of the Xin'an River Basin. The survey was conducted in 2020 in two rounds.

The first round was the focus group interview. The second round was the household survey using stratified random sampling. First, we selected two towns in Xiuning County and She County, each of which randomly selected 2–3 villages (Figure 2). We interviewed 30–50 farmers in 10 villages. Finally, of the 400 questionnaires collected, 349 were valid after post-survey evaluation, with an effective rate of 87.25%. In Xiuning County, we selected Hecheng Town and Liukou Town and collected 166 valid questionnaires, accounting for 47.56% of the sample. From Shendu Town and Xinxikou Township of She County, we obtained 183 valid questionnaires, accounting for 52.44% of the sample size. The interview topics include the farmer-level characteristics (e.g., capital endowment) and farmers' willingness to participate in the PES program. The village-level features include village geographical characteristics, natural-social-economic characteristics, and the characteristics of program implementation.

3.3.2. Variable Definitions

(1) Dependent variables

Here are the three dependent variables. Y_1 is the willingness to accept compensation (WTA). Y_2 is the willingness to participate in the command-control strategy in living.Y_3 is the willingness to participate in the command-control strategy in farming. Among them, Y_2 and Y_3 are binary variables, which are represented by the farmers' willingness to participate in command-control strategies. The questionnaire was used to measure Y_1 by the conditional value method. By setting the question, "How much are you willing to participate in the PES program in the Xin'an River Basin (yuan/person/year)", the farmers' willingness to receive compensation was directly measured. When the value exceeds 10,000 or falls below 100, we confirmed the answer again and recorded the reason to reduce data entry and subjective willingness bias.

The final amount of compensation standard was determined by the price and interval frequency that all the interviewed farmers were willing to accept, as shown in Formula (11):

$$E(WTA) = \sum_{i=1}^{n} p_i b_i \quad (11)$$

where $E(WTA)$ is the expected compensation of the interviewed farmers; p_i is the compensation amount that the interviewed farmers hope each person can accept every year; b_i is the probability of the compensation amount in all samples; n is the number of farmers investigated. Specific results can be seen in Table 1.

(2) Independent variables

Independent variables include farmer characteristics and village characteristics.

At the farmer level, based on the existing research [68–71], this study incorporates the sustainable livelihood capital and program cognition of farmers. We measure human capital using respondent age, level of education, and the number of the labor force. We chose the forest land slope as natural capital and set the question, "where is most of the woodland located", to judge forest land slope. The reason is that the forest land in the mountainous area is relatively scattered, so it is difficult to measure the specific number and area. Forest land slope can affect agricultural incomes and the time of farmers engaged in agroforestry. Annual household income, non-farm income, and forestry income measure financial capital. The physical capital includes the living conditions of farmers and the number of communication and recreational facilities. Social capital chooses social trust and social norms, which reflect the ability of farmers to access information and communicate externally. Program cognition refers to farmers' understanding of the PES program. The descriptive statistics are shown in Table 1.

Table 1. Descriptive statistics of variables.

Categories	Variable	Variable Definition and Assignment	Mean	S.D.	Min.	Max.
Dependent variable	*WTA*	Logarithmic form of willingness to accept compensation	6.523	1.299	2.996	11.184
	Willingness to participate in command-control strategy in living	Volunteer to participate in village cleaning activities such as improved toilets (0 = no, 1 = yes)	0.699	0.459	0.000	1.000
	Willingness to participate in command-control strategy in farming	Whether to voluntarily participate in the development of green agriculture and cultivate regional public brands (0 = no, 1 = yes)	0.287	0.453	0.000	1.000
Independent variable						
Farmer level	Sample size = 349					
Human capital	Age	Continuous variable (age)	61.355	11.085	18.000	89.000
	Level of education	0 = no schooling, 6 = primary school, 9 = Junior high school, 12 = Technical secondary school and high school, 15 = junior college or above	6.713	3.425	0.000	16.000
	Quantity of labor force	Number of family members (except students and soldiers) with complete working ability (person)	2.722	1.402	0.000	10.000
Natural capital	Forest land slope	Woodland location: 0 = not clear, 1 = flat, 2 = steep, 3 = very steep	2.003	0.693	0.000	3.000
Financial capital	Annual gross household income	Total household income, including farming and operation income, transfer income. (10^3 yuan)	44.547	52.216	0.500	509.600
	Non-farm income share	The proportion of non-farm income in total annual household income (%)	0.576	0.361	0.000	1.000
	Cost of forestry	Forestry production and operation cost (thousand yuan)	1.286	1.723	0.000	10.300
Physical capital	The housing situation	Number of houses owned by farmers (buildings)	1.117	0.364	1.000	3.000
	Communication and entertainment equipment	The number of communication and entertainment equipment (fixed telephone, mobile phone, computer) owned by the household (unit)	3.384	1.596	1.000	9.000
Social capital	Social trust	Degree of trust in neighbors and relatives: 1 = very distrust, 2 = relatively distrust, 3 = average, 4 = relatively trust, 5 = very trust	4.135	0.736	2.000	5.000
	Social participation	Frequency of communication with farmers in the same village: 1 = almost no, 2 = rarely, 3 = average, 4 = more, 5 = a lot	2.530	1.136	1.000	5.000
Program cognition	Understanding of program	The degree of understanding of ecological compensation program: 1 = very unfamiliar, 2 = relatively unfamiliar, 3 = fair, 4 = relatively familiar, 5 = very familiar	2.963	0.977	1.000	5.000
Village level	Sample size = 10					
Geographical characteristics	Distance from county government	Distance of the village from the county government of the county to which it belongs (km)	59.300	20.205	24.000	85.000
	Mean village elevation	The average elevation of the village is/m	359.800	186.097	100.000	634.000
Natural-social-economic characteristics	Village environmental assessment	The overall evaluation (mean) of the village environment by the resident farmers: 1 = poor, 2 = relatively poor, 3 = average, 4 = relatively good, 5 = good	3.948	0.415	2.890	4.400
	Per capita forestland area	Village per capita forestland area (mu/person)	13.813	9.870	4.150	27.680
Characteristics of program implementation	Degree of program implementation	The implementation intensity of village ecological compensation program is calculated by the implementation status of six major strategies: pesticide and chemical fertilizer replacement, village garbage cleaning, fishermen's withdrawal from fishing, farmland conversion, ecological migration, and compensation for public welfare forest (value: 0–6).	4.300	1.418	3.000	6.000

Note: 1 mu = 1/15 hectare.

At the village level, the village characteristics include geographical characteristics, natural-social-economic characteristics, and characteristics of program implementation [72]. Specifically, geographical features, including distance from county government and altitude, reflect transportation accessibility and can affect the availability of off-farm employment opportunities and information reception channels for farmers [73]. This study selects village environmental assessment and per capita woodland area to measure natural-social-economic characteristics. In addition, we measured the number of farmers participating in PES programs to reflect the degree of program implementation. In Table 1, we present the definitions and descriptive statistics of the variables.

(3) Descriptive statistics and *t*-test

To investigate whether farmers in the upper and middle reaches of the villages are significantly different, we divided the sample villages into upstream and downstream villages. As can be seen from Table 2, there are significant differences in human capital, financial capital, and social capital among farmers in the upper and middle reaches of the villages, and there are no significant differences in physical capital, natural capital, and program cognition. It indicates that there is heterogeneity between villages, and this heterogeneity may lead to differences in the willingness of farmers to participate.

Table 2. Individual characteristics of farmers in upstream and midstream villages.

The Farmer Level	Farmers in Upstream Villages (N = 166)		Farmers in Midstream Villages (N = 183)		Difference in Means
	Mean	S.D.	Mean	S.D.	
Human capital					
Age	61.620	12.123	61.115	10.078	0.506 **
Years of education	5.867	3.789	7.481	2.859	−1.613 **
Quantity of labor force	3.078	1.549	2.399	1.167	0.679 ***
Natural capital					
Forest land slope	1.964	0.622	2.038	0.751	−0.074
Financial capital					
Annual gross household income	57.077	64.542	33.180	34.113	23.897 ***
Non-farm income share	0.710	0.279	0.455	0.383	0.255 ***
Cost of forestry	0.442	0.482	2.052	2.056	−1.610 ***
Physical capital					
The housing situation	1.114	0.388	1.120	0.343	−0.006
Communication and entertainment equipment	3.452	1.567	3.322	1.624	0.129
Social capital					
Social trust	4.127	0.698	4.142	0.771	−0.016 **
Social participation	2.277	0.806	2.760	1.329	−0.482 ***
Program cognition					
Understanding of program	2.681	0.908	3.219	0.970	−0.538

Note: ** $p < 0.05$; *** $p < 0.01$.

4. Results

4.1. Results of Null Models

The null models manifest the contribution degrees of individual and village characteristics to the difference in farmers' willingness to participate in the three strategies. The null model results (Table 3) show that: (1) The random and fixed effects of the three dependent variables passed the significance tests ($p < 0.01$); (2) In the decomposition of total score difference, the intra-group and inter-group variances of the three dependent variables were 1.419 and 0.316, $\pi^2/3$ and 1.023, $\pi^2/3$ and 0.868, respectively. According to Formula (4), the ICC values of three dependent variables were 18.21%, 23.74%, and 20.89%. It means that 18.21%, 23.74%, and 20.89% of the differences in farmers' participation in the three strategies of programs come from the village level, and the remaining (81.79%, 76.26%, and 79.11%) come from the farmer level. ICC values were all greater than 0.138 [74]. Moreover, it means that there is a hierarchical effect on willingness, which needs to be further analyzed by the HLM.

Table 3. Regression results of the null models.

Variable	Fixed Effect	Coe.	*t*-Test	*p* Value	Random Effect	S.D.	Variance	χ^2	*p* Value
WTA	γ_{00}	6.523	37.643	0.000 ***	u_0	0.562	0.316	75.633	0.000 ***
					r	1.191	1.419		
Willingness to participate in command-control strategy in living	γ_{00}	0.843	3.544	0.001 ***	u_0	1.011	1.023	53.572	0.000 ***
Willingness to participate in command-control strategy in farming	γ_{00}	−0.912	−3.637	0.000 ***	u_0	0.931	0.868	48.855	0.000 ***

Note: (1) *** $p < 0.01$; (2) the dependent variables Y_2 and Y_3 are binary variables, so the intra-group variances of them are the default values, $\pi^2/3$.

4.2. Results of Random-Effect Regression Models

Considering the farmers' variables, we can obtain the results of the random effect model (Table 4).

Table 4. Results of random effect models.

Fixed Effects	*WTA*		Willingness to Participate in Command-Control Strategy in Living		Willingness to Participate in Command-Control Strategy in Farming	
	Coefficient	S.D.	Coefficient	S.D.	Coefficient	S.D.
Intercept	6.477 ***	0.190	0.961 **	0.388	−1.000 **	0.362
Human capital						
Age	0.003	0.006	−0.000	0.012	0.008	0.013
Years of education	−0.004	0.020	0.036	0.040	−0.022	0.040
Quantity of labor force	−0.061	0.059	−0.125	0.123	−0.061	0.115
Natural capital						
Forest land slope	0.223 **	0.096	−0.055	0.189	−0.109	0.192
Financial capital						
Annual gross household income	−0.002	0.002	0.007 *	0.004	−0.000	0.003
Non-farm income share	0.461 **	0.230	0.149	0.460	−0.617	0.464
Cost of forestry	0.020	0.047	0.013	0.096	0.003	0.094
Physical capital						
The housing situation	0.096	0.188	−0.420	0.380	−0.076	0.372
Communication and entertainment equipment	0.062	0.046	0.287 ***	0.095	0.336 ***	0.092
Social capital						
Social trust	0.305 ***	0.088	−0.152	0.174	0.346 *	0.181
Social participation	0.134 ***	0.062	0.338 ***	0.125	0.192	0.125
Program cognition						
Understanding of program	0.085	0.068	0.217	0.134	0.287 **	0.141
Random effect						
Var (u_0)	0.318 ***		1.333 ***		1.137 ***	

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

In the influencing factors of the economic-incentive strategy (*WTA*), natural capital, human capital, and social capital affect farmers' *WTA*. Specifically, Forest land slope has a positive effect on the *WTA* ($\beta = 0.223$, $p < 0.05$). It may be because high slopes are associated with soil and water loss, and farmers expect high compensation cover for losses. In addition, the higher the proportion of non-farm income ($\beta = 0.461$, $p < 0.05$), the higher the opportunity cost of participating in the economic-incentive strategy and the higher *WTA*. Finally, farmers' *WTA* is positively affected by social trust ($\beta = 0.305$, $p < 0.01$) and social participation ($\beta = 0.134$, $p < 0.01$). This may be because a higher degree of social trust and social participation help to understand the economic-incentive strategy of surrounding farmers to participate, such as farmers in reservoir areas and fishermen.

In terms of the influencing factors of command-control strategy in living, the annual household income ($\beta = 0.007$, $p < 0.1$), the number of communication equipment owned by households ($\beta = 0.287$, $p < 0.01$), and the degree of social participation of farmers ($\beta = 0.338$, $p < 0.01$) all have positive and significant impacts on willingness to participate in command-control strategy in living. The results indicate that farmers with higher household income, better economic conditions, and more frequent communication with farmers in the same village have higher participation in the command-control strategy in living.

Regarding the command-control strategy in farming, the number of communication equipment owned ($\beta = 0.336$, $p < 0.01$), social trust ($\beta = 0.346$, $p < 0.1$), and the understanding of the PES program ($\beta = 0.287$, $p < 0.05$) all encourage farmers to participate in the command-control strategy in farming. In general, farmers with a better understanding of the PES program and a higher level of trust in the outside world are more willing to participate in the command-control strategy in farming. The trust relationship between the farmers in the same village and the farmers' understanding of the PES program provide a good organizational environment, reduce the fear of "free riding" behavior of other farmers and encourage them to participate in the strategy of restrictions on pesticides, chemical fertilizers, and fishing bans.

The above results confirm H1 and H2. They indicate that the sustainable livelihood capital of farmers affects their willingness to participate in command-incentive compatible strategies, and there are differences in the willingness to participate in different strategies.

4.3. Results of Full Models

Table 4 shows that the random effect of farmers' participation intention in the three models is at the significance level of 1%, so it should be included in the influencing factors at the village level. After introducing the full model regression of the second layer (village) variable, the model results are shown in Tables 5 and 6. The coefficient sign and significance of the first layer variable do not change significantly. Therefore, this paper analyzes the direct and moderating effects of the village level.

Table 5. The full model result for the economic-incentive strategy.

Fixed Effects	Coefficient	Standard Error
Intercept	6.485 ***	0.114
Per capita forestland area	−0.049 ***	0.012
Human capital		
Age	0.002	0.006
Years of education	−0.018	0.021
Quantity of labor force	−0.039	0.058
Natural capital		
Forest land slope	0.244 ***	0.094
Financial capital		
Annual gross household income	−0.002 *	0.002
Non-farm income share	0.609 ***	0.233
Distance from county government	0.038 **	0.020
Mean altitude	−0.004 **	0.002
Cost of forestry	0.027	0.047
Physical capital		
Housing situation	0.132	0.186
Communication and entertainment equipment	0.041 *	0.045

Table 5. *Cont.*

Fixed Effects	Coefficient	Standard Error
Social capital		
Social trust	0.271 ***	0.087
Distance from county government	−0.011 ***	0.004
Social participation	0.202 ***	0.076
Village environmental assessment	−0.239 *	0.136
Per capita forestland area	−0.026	0.017
Degree of program implementation	−0.277 **	0.130
Program cognition		
Understanding of program	0.081	0.067
Random effect		
Var (u_0)	0.091 ***	
Var (r)	1.298	

Note: (1) * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. (2) The italic variable is the interaction term between the village characteristic variable and the individual characteristic variable.

Table 6. The full model results of command-control strategies.

Fixed Effects	Willingness to Participate in Command-Control Strategy in Living		Willingness to Participate in Command-Control Strategy in Farming	
	Coefficient	S.D.	Coefficient	S.D.
Intercept	1.197 ***	0.330	−1.158 ***	0.313
Per capita forestland area	0.075 *	0.035	0.072 *	0.033
Human capital				
Age	−0.001	0.014	0.009	0.013
Years of education	−0.001	0.046	−0.035	0.041
Quantity of labor force	−0.095	0.139	−0.093	0.121
Natural capital				
Forest land slope	0.014	0.194	−0.087	0.210
Financial capital				
Annual gross household income	0.011 **	0.005	0.001	0.003
Distance from county government	−0.001 **	0.000	—	
Degree of program implementation	−0.006	0.004	—	
Non-farm income share	0.406	0.511	−0.761	0.503
Cost of forestry	0.018	0.093	−0.032	0.113
Physical capital				
Housing situation	−0.172	0.417	−0.020	0.386
Communication and entertainment equipment	0.276 ***	0.106	0.391 ***	0.100
Per capita forestland area	0.058 **	0.024	—	
Degree of program implementation	0.366 **	0.163	0.109 *	0.066
Social capital				
Social trust	−0.182	0.188	0.423 **	0.201
Mean altitude	—		0.003	0.002
Degree of program implementation	—		0.535 **	0.229
Social participation	0.723 ***	0.185	0.263 *	0.139
Per capita forestland area	0.060 ***	0.020	—	
Program cognition				
Understand of program	0.298 **	0.144	0.249 *	0.150
Per capita forestland area	—		0.026 *	0.015
Random effect				
Var (u_0)	0.838 ***		0.749 ***	

Note: (1) * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. (2) The italic variable is the interaction term between the village characteristic variable and the individual characteristic variable.

4.3.1. Results of Direct Village Effects

In the economic-incentive strategy, the sign of the interaction term between woodland area and intercept term is negative and significant (Tables 5 and 6), indicating that farmers' *WTA* decreases by 4.9% for every unit increase of woodland area in the village. In the participation of command-control strategies (including living and farming), the interaction term of per capita forestland area and intercept term is positive and significant, which suggests that the larger the forestland area is, the higher the enthusiasm for program participation is. Villager organizations (villages) with a richer endowment of agricultural and forestry natural capital have stronger organizational advantages to strive for more compensation when implementing the command-control strategy. Therefore, these villages have stronger participation intention in command-control strategies.

4.3.2. Results of the Moderating Effect of Villages

According to the interaction term between the village variable and farmer variable (Tables 5 and 6), village variables play a moderating role in farmers' participation in the PES program. According to the idea that the interaction effect is consistent with the sign of the farmer's characteristics, the effect is strengthened, and the opposite is weakened. We present the following analysis.

For the economic-incentive strategy, village variables affect farmers' *WTA* by influencing the financial capital and social capital of farmers. In terms of financial capital, the distance from the village to the county government will significantly increase the positive impact of non-farm income on willingness to accept the compensation, while the average altitudes of the villages may decrease the positive impact of non-farm income. The reason hidden in this phenomenon may be that the rural farmers farther away from the county and town are more likely to have a higher opportunity cost to change production and industry, so they have high expectations for the *WTA*. Additionally, the original employment choice of farmers in villages with higher altitudes is non-agricultural employment due to terrain reasons. After the PES program's implementation, farmers' livelihood has not changed, so it would lower expectations for the *WTA*. In terms of social capital, the distance from the village to the county government, the village environmental assessment, and program implementation in the villages can significantly reduce the positive impact of farmers' social participation on their *WTA*. The distance between the county government is often related to diversified information channels, which can strengthen the farmers' understanding of the program, and the *WTA* would be reduced. In addition, the better the village environment, the more trust in collective collections and the less willingness to receive compensation. Finally, the implementation of the PES program increases farmers' understanding, trust, and participation in the PES program, so it can reduce farmers' *WTA*.

For the command-control strategy in living, village characteristics influence farmers' willingness by influencing financial capital, physical capital, and social capital. In terms of financial capital, the closer the village is to the county administrative center, the more diversified the information sources of farmers, which can weaken the positive effect of economic income on farmers' willingness. On physical capital, the larger the woodland area of the village, the more strategies and the richer the related family material capital, and it also improves the willingness of farmers, which has a double additive effect. On social capital, a village with a larger per capita woodland area means more cooperative relations in agriculture (social participation) and is more conducive to the participation of the command-control strategy in living.

For the command-control strategy in farming, village characteristics affect farmers' willingness through physical capital, social capital, and program understanding. In terms of physical and social capital, the program implementation of village characteristics strengthened the positive influence of communication and entertainment equipment and social trust on farmers' willingness, respectively. In terms of program understanding, the area of village woodland increased the willingness of farmers to participate by increasing social participation. This indicates that the villages with richer implementation strategies, richer physical capital, and higher social trust can mobilize farmers' participation intention.

The above results confirm H3. That is, geographical characteristics, natural-social-economic characteristics, and program implementation of villages would affect farmers' willingness to different strategies by interacting with individual features of farmers.

4.4. Comparison of Variance Components among the Three Models

Furthermore, we compared the variance components of the three models to prove the validity and rationality of HLM. As shown in Table 7, with the independent variables from none to only adding variables at the farmer level to adding variables at both levels (village and farmer), the variance at the village level and farmer level decreased. It indicates that with the completion of the model construction, the difference between the village and farmer levels is decreasing.

Table 7. Effect comparison of the three types of models.

Variance	Random Effect	Null Model		Random Effect Model		Full Model	
		S.D.	Variance	S.D.	Variance	S.D.	Variance
WTA	Var (u_0)	0.562	0.316 ***	0.564	0.318 ***	0.301	0.091 ***
	Var (r)	1.191	1.419	1.162	1.349	1.139	1.298
Willingness to participate in command-control strategy in living	Var (u_0)	1.011	1.023 ***	1.154	1.333 ***	0.915	0.838 ***
Willingness to participate in command-control strategy in farming	Var (u_0)	0.931	0.868 ***	1.066	1.137 ***	0.866	0.749 ***

Note: *** $p < 0.01$.

5. Discussions

5.1. The Comparisons

In this study, the null model results show that there are significant hierarchical characteristics of farmers' willingness in the three strategies of the PES program. In other words, the influencing factors at the village level and the farmer level are considered simultaneously in the PES program design, and the contribution of the village level to the difference in willingness to participate is 18.21%, 23.74%, and 20.89%, respectively. The remaining 81.79%, 76.26%, and 79.11%, respectively, come from the differences among farmers. The existence of such differential values indicates that collective actions should be considered in the implementation of PES programs in eco-sensitive areas [40,75], and it is necessary to include village variables. In addition, farmers' willingness to participate in different strategies and their influencing factors in the same PES program are different [76,77].

Village variables should be considered theimplementation of PES program in eco-sensitive areas [78,79]. Firstly, farmers' participation in the concurrent PES programs is affected by social capital. The social capital of farmers has different directions and dynamics in their willingness to command-incentive compatible strategies, which indicates that trust mechanisms and normative constraints can change farmers' decision-making to affect farmers' willingness to cooperate [24]. As a kind of embedded capital endowment, social capital can weaken the uncertainty of farmers' collective action choices [80]. Secondly, the willingness to participate in PES is directly affected by village-level variables [81]. Villages with rich woodland resources and development potential can promote the participation of farmers in the PES program. Finally, village variables have effects on willingness to participate in the PES program by influencing livelihood capital. For example, the natural economic and social conditions at the village level will also have a regulating effect on the information transmission and trust transmission of farmers, indicating that high-quality "village agents" can guide farmers positively and promote the success of collective action such as the provision of clean water in eco-sensitive areas.

In this situation, we should pay more attention to the heterogeneity of farmers' willingness to participate in different strategies in eco-sensitive areas, which has policy implications for most developing countries to implement PES programs that combine the economic-incentive strategy and command-control strategy [38,39]. For the economic-incentive strategy, the livelihood capital of farmers, such as the slope of family woodland, the proportion of household non-farm income, social trust, and social participation, can significantly enhance farmers' *WTA*. The village variables, such as the distance from the county government, have a positive impact on *WTA* by affecting the opportunity cost of off-farm employment [73]. For the command-control strategy in living, household income, the number of communication and entertainment equipment, and social participation of farmers have significant positive effects on their willingness. For the command-control strategy in farming, the number of communication and entertainment devices, social trust, and program understanding would positively affect their willingness. Village variables such as program implementation and per capita forestland area increased intention to participate in PES program by strengthening physical capital formation and program understanding.

5.2. Policy Implications

Combined with the empirical results and the discussion, it was found that there were differences in the influencing factors of farmers' participation in the same PES program with different strategies. Secondly, variables at the village level can not only directly affect the implementation of PES program but also play a moderating role in the capital endowment of farmers. Based on the above findings, we put forward the relevant suggestions.

First, it is recommended to take into account the differences in resource endowment and natural-social-economic characteristics, consider the program implementation of villages, and adopt differentiated and flexible management strategies. Specifically, villager organizations, village groups, and other village collective units should play their organizational advantages to mobilize farmers' enthusiasm for participation in the PES program. For villages with poor geographical locations and natural conditions, more support should be given, such as increasing ecological public welfare posts, supporting the development of village tourism, and cultivating the village's green characteristic industries. For villages with less participation in the PES program, it is necessary to comprehensively investigate the implementation of the program, solve problems such as weak program implementation, and standardize the situation of program implementation in the local area.

Second, policymakers need to enhance the vitality of the PES program. For the economic-incentive strategy, diversified and differentiated compensation measures should be taken, such as employment training and industrial support, to guide workers to change production and industry. For the command-control strategy, improve infrastructure construction to strengthen physical capital formation and supervision to promote program implementation. For both of them, it is also applicable to enhance social capital and raise awareness of collaborative participation in PES projects by holding villagers' organization and village publicity.

5.3. Limitations

Our study indicates that different strategies in PES and village characteristics will affect the willingness of farmers to participate in PES programs. Yet there are several potential limitations for improvement. Firstly, our research focused on one region and a representative sample, so it is impossible to draw generalizations from this study to all PES regions.

Secondly, our data likely underestimate the influences on all participators for two reasons. First, the characteristics of different counties may also have several strategies under the PES program. For example, the planting industry in Xiuning County and the fishing industry in She County were obviously affected by different strategies. Second, we capture only three strategies. Due to insufficient data, farmers will be subdivided into future studies to explore the differences in their willingness to receive compensation.

Finally, we capture that social capital plays a role in promoting farm household participation in the PES program, and it is still worth exploring its mechanisms and pathways to enrich existing research unceasingly.

6. Conclusions

PES programs are implemented worldwide to address environmental problems, but their results are mixed. One possible reason is the failure of collective actions [82,83]. Another is the lack of consideration of concurrently implemented strategies. More than one strategy is simultaneously implemented targeting the same farmers or in the same areas [76,77]. The PES program in Xin'an River Basin (China) offers a unique opportunity to address these two issues because it requires individual farmers and the villages where farmers live and conduct daily activities to play a role. In this study, we examine how farmers participate in PES programs in collective action and the heterogeneity of the farmers' livelihood capital participation in different strategies. In this study, we built an IAD framework based on the collective action theory. In this framework, the PES program is divided into three strategies for modeling farmers' willingness to participate in PES programs.

Through empirical testing using HLMs, we find that the social capital in the individual livelihood capital of farmers is vital for participation in the PES programs. Specifically, social capital reduces the uncertainty in collective action and promotes farmers to participate in the PES program by enhancing social trust and participation. In addition to the influence of social capital, natural capital, such as forest slope and physical capital, also affects PES participation. Another conclusion is that specific strategies need to be differentiated in PES program. For the economic-incentive strategy, natural capital and social capital affect their willingness to receive compensation, as natural capital affects farmers' agricultural income and labor input, so their *WTA* will be higher. For the command-control strategy, the improvement of physical capital, such as communication equipment and other facilities, can promote farmers' participation in the PES program. Last, we find that villages with a relatively rich endowment of natural capital in agriculture and forestry are more active in implementing the PES program. Village variables indirectly affect the willingness of economic-incentive strategy by influencing financial capital. They also influenced the command-control strategies' participation by strengthening the formation of physical capital.

Given that the PES programs in China and other developing countries may face challenges in the sustainability of the ecosystem services, especially in eco-sensitive areas [84], it is of great significance for grassroots community participation in environmental management and improvement of PES projects in developing countries to integrate the collective action theory into the implementation of PES projects.

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