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An Empirical Study Using a Structural Equation Model to Examine the Multiple Driving Mechanisms of Farmers' Conservation Practices in the Communities Around Nature Reserves in China

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Abstract

This study employed a structural equation model to explore the multiple driving mechanisms of ecological protection behaviors of farmers in the surrounding nature reserves. Using field survey data from 400 households across eight nature reserves in Sichuan and Shaanxi provinces and applying a structural equation model (SEM), this study finds farmers' perceptions of objective environmental improvement exert the strongest direct influence on protective behaviors, whereas the direct effect of subjective attitude, though significant, is comparatively weaker. This article also reveals that social norms not only directly shape protective attitudes but also indirectly promote protective behaviors through attitude mediation. Although the perceived benefits of ecological compensation benefits can significantly enhance farmers' protective attitudes, a complete intermediary chain has not been established. It is worth noting that the impact of perceived costs on both attitudes and behaviors did not passed the significance test. This study confirmed the effectiveness of the "normal–attitude–behavior" transmission pathway and, at the same time, revealed that environmental improvement mainly influences behavior through direct paths rather than attitude mediators. This result provides a scientific basis for optimizing ecological compensation policies, emphasizing that a long-term mechanism for ecological and environmental protection should be established by combining environmental monitoring feedback with community standardized construction.

Keywords: multi-driving mechanism; conservation behaviors; surrounding communities of nature reserves; structural equation model (SEM)

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1. Introduction

Against the backdrop of the continuous global ecological deterioration and accelerated loss of biodiversity, nature reserves, as key areas for maintaining ecological balance and ensuring the service functions of ecosystems, their effective management not only relies on the efforts of professional protection institutions but also the behavioral decisions of farmers in the surrounding communities who plays a decisive role [1]. With the in-depth advancement of ecological civilization construction, the government and the academic community have gradually realized that the successful operation of protected areas must

be based on the support and participation of local communities. As direct stakeholders living adjacent to the protected areas, farmers' daily production and livelihood activities are closely intertwined with the ecological conditions of these areas. Their protective or destructive behaviors directly affect the ecological conditions of the protected areas [2,3]. Existing literature indicates that farmers' protection behaviors exhibit complex and diverse characteristics, and behind these behavioral differences lies the interactive influence of multiple factors such as economy, society, culture, and policy [4]. Although early research was based on the assumption of the "rational economic man", suggesting that farmers' behavior was mainly influenced by cost–benefit trade-offs, the development of behavioral economics has revealed that farmers' decision-making is also comprehensively influenced by social norms, psychological cognition, and institutional environment [5]. There are three major controversial focuses in the current research [6–8]. The relative importance of driving factors (the economic incentive school emphasizes the direct promoting effect of subsidies); the social norm school holds that community pressure and cultural traditions are more persistent, the complexity of causal relationships (univariate analysis may ignore the mediating effect of variables), and the neglect of regional heterogeneity (different protected areas may lead to significantly different behavioral patterns due to differences in ecological resource dependence and policy implementation intensity). Existing research has constructed a multi-dimensional theoretical framework from five dimensions: individual characteristics, family economy, policy tools, community norms, and ecological cognition. However, at the methodological level, it has undergone a paradigm shift from traditional statistical models to structural equation models. Early studies mostly employed linear regression or Logit models to analyze the influence of individual variables, but such methods were difficult to handle the indirect effects and endogeneity issues between variables. Structural equation models, by constructing latent variable and measurement models, can simultaneously analyze direct and indirect effects, and are particularly suitable for analyzing the behavioral decision-making process under the interaction of multiple factors.

Based on this context, this study takes eight nature reserves in China and their surrounding communities as the research objects, and applies the Structural Equation Model (SEM) as the core analysis tool to systematically construct a theoretical framework incorporating latent variables such as subjective ecological protection attitudes, social normative pressure, protection behaviors, perceived costs, perceived ecological benefits, and objective environmental improvements. The reliability and validity of the measurement model were confirmed through confirmatory factor analysis. A multi-level path analysis method was adopted to simultaneously capture the complex network of direct and indirect effects, focusing on the following core contents: First, the direct influence of subjective ecological protection attitudes on protective behaviors was analyzed, with an emphasis on the key roles of value recognition mechanisms and moral self-discipline mechanisms in the process of behavioral transformation. Second, the direct effects of objective environmental improvements on protective behaviors were explored, with a particular attention to the role of environmental cues in activating such behaviors. Third, we deeply analyze the shaping path of social norm pressure on protective attitudes, with emphasis on the synergistic effects of demonstration effect, herd mentality and peer pressure in the process of attitude formation. This paper examines the inhibitory path of perceived cost on protective attitude and analyzes the actual impact of opportunity cost and policy constraints in decision-making trade-offs. Finally, we reveal the indirect transmission path of environmental improvement perception to protection behavior and clarify the multi-level processing characteristics of environmental information in behavioral decision-making.

Methodologically, this study adopted a mixed-methods approach, integrating questionnaire surveys with field investigations to ensure the representativeness and credibility

of the research data. By adopting a regional comparative research strategy and selecting representative nature reserves as empirical cases, this study focuses on examining the differentiated characteristics of farmers' behaviors across various ecological reserve types and the special laws of conservation decisions in highly resource-dependent communities. Through the goodness-of-fit test of the model, the fit between the theoretical model and the observed data was ensured, providing reliable methodological support for subsequent analysis. This study aims to thoroughly uncover the complex driving mechanisms of farmers' conservation behaviors using the quantitative analytical approach of structural equation modeling, thereby providing theoretical support for optimizing management policies in nature reserves. The research findings will help build a dual-driven policy system, promote the coordinated development of ecological protection and the improvement of people's livelihood, and contribute Chinese insights to global biodiversity conservation. By systematically examining the synergistic effects of attitude cultivation, social norm transmission and environmental improvement feedback, this study provides a scientific basis for formulating differentiated management policies for protected areas and practical guidance for advancing ecological civilization initiatives.

2. Literature Review

Farmers are located around protected areas, and their daily production and living activities are closely linked to the ecological environment of the protected areas. Their protective or destructive behaviors directly affect the ecological conditions of the protected areas [9]. The conservation behaviors of farmers in communities around nature reserves present complex and diverse characteristics [10]. On the one hand, some farmers have actively responded to the call for ecological protection, voluntarily participated in ecological protection activities, adopted sustainable agricultural production methods, and reduced interference with the ecological environment of protected areas. On the other hand, some farmers, driven by economic interests, still engage in behaviors that damage the ecology, such as excessive reclamation and illegal hunting. Behind this differentiated behavior lies the interwoven influence of multiple factors such as economy, society, culture and policy [11,12]. It is of great theoretical and practical significance to deeply explore the multi-driving mechanism of the protection behavior of farmers in the surrounding communities of nature reserves. From a theoretical perspective, it helps enrich the research content of related disciplines such as ecological behavior science and environmental sociology, and improve the theoretical system of the interaction between human behavior and the ecological environment. From a practical perspective, accurately grasping the key factors driving farmers' conservation behaviors can provide a scientific basis for formulating targeted policy measures, guide farmers to take more proactive conservation actions, promote the coordinated development of nature reserves and surrounding communities, and achieve a win-win situation of ecological protection and improvement of people's livelihood [1].

Farmers' protection behavior is an important topic in the field of ecological protection, and its research can be traced back to the environmental behavior theory in the 1970s. Early studies were mostly based on the assumption of "rational economic man", holding that farmers' behaviors were dominated by cost–benefit trade-offs [13]. However, with the development of behavioral economics, scholars have gradually discovered that farmers' decisions are not completely rational but are comprehensively influenced by social norms, psychological cognition and institutional environment [14]. For instance, in the project of returning farmland to forest in China, some farmers continued to plant trees after the compensation was stopped, indicating the existence of non-economic motives (such as ecological responsibility) [15]. There are three major controversies in the current research:

First, the relative importance of the driving factors. The economic incentive school emphasizes the direct promoting effect of subsidies on behavior [16], while the social norm school holds that community pressure and cultural traditions are more persistent [17]. Secondly, the complexity of causality. Single-variable analysis (such as only examining the impact of income on protective behavior) may overlook the mediating effects among variables (such as the indirect influence of educational level on behavior by enhancing ecological cognition). Thirdly, the neglect of regional heterogeneity. Due to differences in ecological resource dependence and policy implementation intensity, the behavioral patterns of communities around nature reserves may be significantly different [18].

The research on the driving mechanism of farmers' protection behaviors has formed a multi-dimensional theoretical framework. The existing literature has revealed its complexity from five aspects: individual characteristics, family economy, policy tools, community norms and ecological cognition. At the individual characteristic level, age, educational level and risk preference constitute core variables. Xu et al. found that young farmers have a lower dependence on ecological compensation due to more non-agricultural employment opportunities [19], while Cibin et al. confirmed that educational level significantly promotes conservation behavior by enhancing environmental awareness [20]. Among the family economic factors, the income structure shows a dual effect: Song et al. pointed out that agricultural income-dependent farmers are more susceptible to the substitution effect of ecological compensation [21], while Al-amin and Hossain found that although families with high non-agricultural income have less economic constraints [22], they are limited by time cost. The design of policy tools directly affects participation. Pei et al. pointed out based on China's grassland ecological subsidy policy that cash subsidies are effective in the short term but require supporting measures [23], while Chen et al. emphasized that performance compensation can better stimulate initiative [24]. Community norms function through the ecological cultural traditions revealed in the Hani Terraced fields case and the proposed neighborhood imitation mechanism [25]. Ecological cognition research reveals the phenomenon of the knowledge-action gap. Ogiemwonyi and Jan found that ecological education transforms protection behaviors into moral obligations [26]. Some scholars also emphasize the need for policy incentives to bridge the gap between cognition and behavior [27]. These studies jointly constructed a multi-explanatory system for farmers' protective behaviors, but the existing literature mostly focuses on a single driving factor and lacks a systematic analysis of the synergistic effects. At the methodological level of research, the study of farmers' protection behaviors has undergone a paradigm shift from traditional statistical models to SEM. Early studies mostly adopted linear regression or Logit models to analyze the effects of a single variable. For instance, Wu and Qi verified the direct impact of subsidy amount on participation rate through regression analysis [28]. However, such methods are difficult to handle the indirect effects and endogeneity issues among variables. The introduction of SEM has broken through this limitation. By constructing latent variables (such as policy support including subsidy standards, technical training and other indicators) and measurement models, it can simultaneously analyze direct and indirect effects. Relevant empirical studies have shown that 60% of the total effect of community norms on protective behaviors is indirectly achieved by enhancing ecological awareness. This finding confirms the advantage of SEM in revealing complex causal chains [29]. In addition, SEM allows the inclusion of control variables (such as regional differences), significantly enhancing the model's explanatory power and policy adaptability. The evolution of methodology not only deepens the understanding of the driving mechanism but also provides more refined analytical tools for subsequent research.

As the direct decision-makers of land use, farmers' protective behaviors (such as reducing pesticide use and participating in ecological compensation projects, etc.) directly

affect the integrity of the ecosystem in the protected area. Although existing research has made significant progress in identifying driving factors and innovating methods, most of the current studies focus on a single driving factor (such as economic incentives or environmental cognition), and have insufficient explanatory power for the interaction of multiple factors. Due to the particularity of the communities around nature reserves, farmers' behaviors are not only internally driven by individual characteristics (such as age and education level) and family economic conditions (such as income structure and non-agricultural employment ratio), but also externally influenced by policy tools (such as ecological compensation standards), community norms (such as neighborhood supervision) and ecological cognition (such as perception of the value of biodiversity). Traditional regression analysis is difficult to reveal the complex causal relationships among variables, while SEM can integrate direct and indirect effects, providing a more precise framework for analyzing multiple driving mechanisms. In response to these deficiencies, this study proposes to take the communities around nature reserves as the objects and, through SEM empirical analysis, focus on addressing core issues such as the relative importance and interaction mechanisms of multiple driving factors, as well as the quantitative comparison of direct and indirect effects. This research design not only addresses the fragmentation in existing literature, but also provides a scientific basis for optimizing ecological compensation policies, promotes the interdisciplinary innovation of behavioral economics and ecological protection.

3. Research Design

3.1. Research Area and Data Sources

The data for this study were collected through field surveys of communities surrounding nature reserves in Sichuan Province and Shaanxi Province. The investigation scope (Figure 1) covers two nature reserves in Sichuan Province (Xuebaoding National Nature Reserve and Tangjiahe National Nature Reserve) and six nature reserves in Shaanxi Province (Huangguanshan provincial Nature Reserve, Laoxiancheng National Nature Reserve, Crested Ibis National Nature Reserve, Taibaishan National Nature Reserve, Zhouzhi National Nature Reserve, and Huangbaiyuan National Nature Reserve) The nature reserve was established.

Based on the survey data, this study encompassed eight nature reserves covering a total area of 288,123 hectares (Table 1). Using the random sampling method, 30 communities were selected from 151 communities located around the reserves (within 5 km of the reserve boundary and within the reserves themselves), resulting in a sampling rate of 19.8%. A questionnaire survey was administered to 437 of the 2035 households (a coverage rate of 21.5%), yielding 400 valid responses (with an effective rate of 91.5%). In terms of regional distribution, the Xuebaoding Reserve has the largest area (63,615 hectares); the Zhouzhi Reserve and the Taibai Mountain Reserve are similar in size (approximately 56,000 hectares each); and the Huangguanshan Reserve has the smallest area (12,372 hectares). There were significant differences in the sampling ratios of the surrounding communities across the protected areas included in this study. The community sampling rate in Tangjiahe Reserve was the highest (48.6%), while that in the Crested Ibis reserve was the lowest (15.5%). In terms of the effective rate of the questionnaire, the Crested Ibis reserve performed the best (95.9%), while the Taibai Mountain Reserve was relatively lower (85.8%). The survey samples show a balanced geographical distribution feature, covering not only large protected areas (such as Xuebaoding), but also medium-sized (such as Zhouzhi) and small protected areas (such as Huangguanshan), ensuring the representativeness of the research results. This scientific sampling design has laid a solid data foundation for the subsequent

analysis of the interactive relationship between community livelihoods and environmental protection within the protected area.

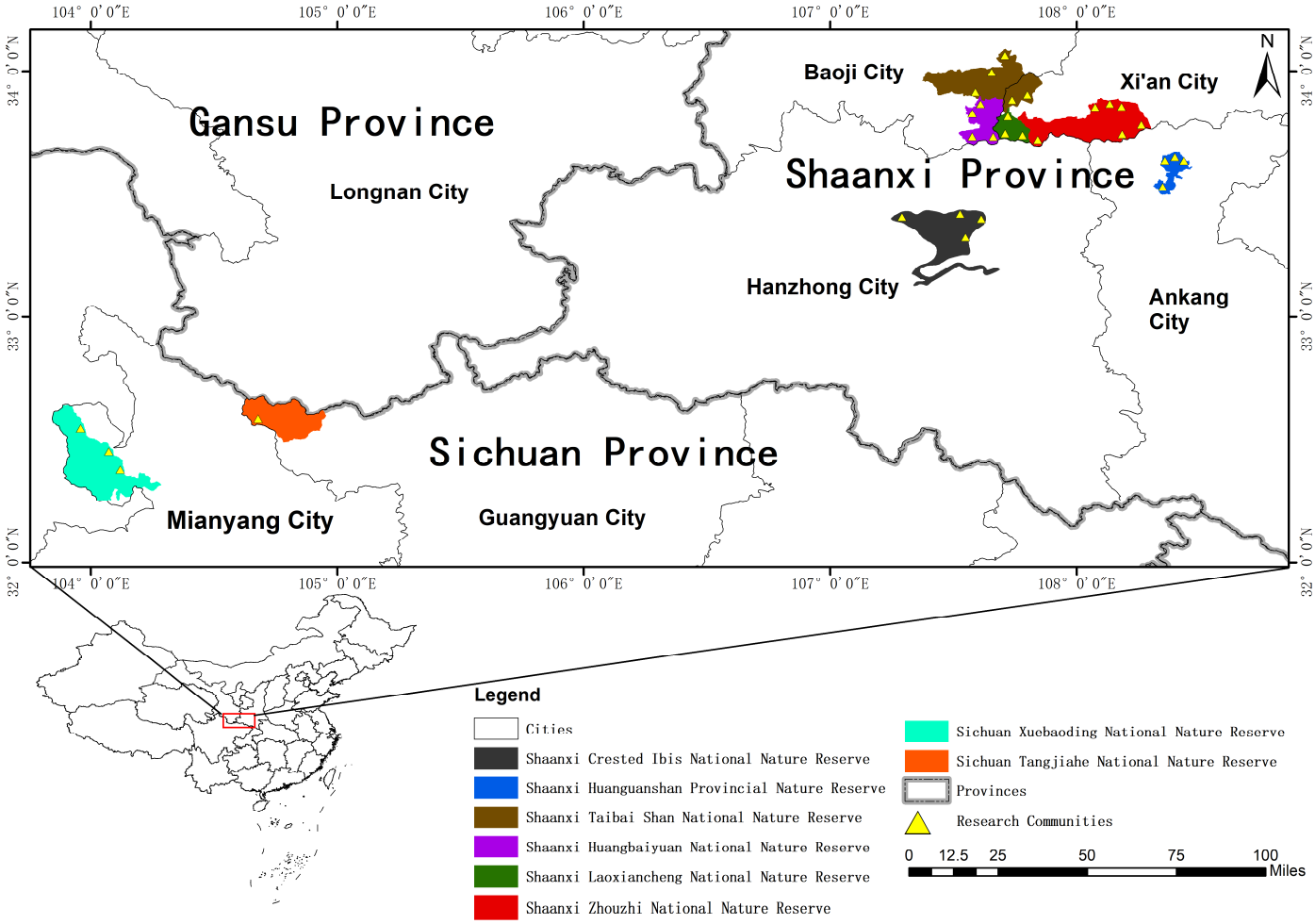


Figure 1. The map of research area.

Table 1. Basic Information of the research area.

Name of Protected Area	Total Area (Hectares)	Proportion of Surveyed Communities (Number of Surveyed Communities/Total Number of Communities)	Proportion of Surveyed Households (Number of Surveyed Households/Total Number of Households)	Questionnaire Effectiveness Rate (Number of Valid Questionnaires/Total Number of Questionnaires)
Xuebaoding	63,615	21.9% (3/11)	21.9% (45/205)	93.3% (42/45)
Tangjiahe	27,393	48.6% (1/2)	48.6% (35/72)	88.5% (31/35)
Zhouzhi	56,393	18.8% (6/25)	18.8% (82/436)	91.4% (75/82)
Taibaishan	56,325	20.5% (5/27)	20.5% (78/380)	85.8% (67/78)
Crested Ibis	37,549	15.5% (4/33)	15.5% (73/470)	95.9% (70/73)
Laoxiancheng	12,611	37.1% (3/10)	37.1% (33/89)	93.9% (31/33)
Huangbaiyuan	21,865	18.9% (4/24)	18.9% (47/248)	91.5% (43/47)
Huangguanshan	12,372	32.5% (4/19)	32.5% (44/135)	93.2% (41/44)
Total number	288,123	19.8% (30/151)	21.5% (237/2035)	91.5% (400/437)

Note: This data was collected and organized by the research team during the survey process. A community refers to a rural administrative village, not a village group.

Regarding the question about selection and exclusion criteria for the 37 invalid questionnaires among the 437 total collected, our data processing followed two key procedures. First, questionnaires with over 20% missing data in core variables (e.g., AT1-3, SN1-3)

that could not be reasonably imputed were removed. These mostly included cases where respondents skipped entire sections or key demographic information. Second, responses showing clear response bias—such as straight-line answers or contradictory answers to reverse-coded items—were systematically filtered out using consistency checks. This rigorous validation ensured the final 400 valid cases maintained high reliability (Cronbach's α: 0.695–0.856). The remaining exclusions primarily involved incomplete household income data and inconsistent spatial information about distance to protected area boundaries. This process aligns with standard practices in survey-based SEM studies to ensure data quality before model estimation.

The survey was conducted from 12 July to 25 July 2024, spanning 13 days. The questionnaire design was based on the Sustainable Livelihoods Framework (SLF) and theories of human well-being. It covers four major dimensions: characteristics of rural households (population structure, educational level, income sources), livelihood capital (natural capital, physical capital, financial capital, social capital), environment-dependent behaviors (ecological product collection, agricultural environmental protection measures), and protection awareness (policy perception, ecological value recognition). Data collection was conducted through a combination of structured interviews and scale scoring to ensure the accuracy of the information. In terms of sample distribution, respondents from Sichuan Province accounted for 38.2%, and while those from Shaanxi Province accounted for 61.8%. This study verified the representativeness of the sample through analysis of variance and ensured data reliability through rigorous reliability and validity tests, thereby providing a solid empirical foundation for the subsequent structural equation model (SEM) analysis.

3.2. Research Hypotheses

Based on the theory of planned behavior (TPB), the value–attitude–behavior (VAB) chain, and the normative activation model (NAM), this study constructed a conceptual framework with ecological protection attitude as the core mediating variable, revealing the influence mechanism of multi-source driving factors on farmers' pro-environmental behaviors (Figure 2). At the attitude level, stronger subjective norms for ecological protection, lower perceived costs for protected areas, and higher perceived environmental benefits of protected areas jointly shape farmers' overall evaluation of ecological protection policies and practices, thereby enhancing their ecological protection attitudes (H3a–H5a). This attitude can directly enhance pro-environmental behavior (H1) and convey the influence of the above three driving factors on behavioral outcomes (H3b–H5b), forming the classic path of "norm/cost–benefit $\rightarrow$ attitude $\rightarrow$ behavior". Furthermore, the model distinguishes the dual effects of objective environmental improvement in protected areas: On the one hand, the visible improvement of local ecological conditions can strengthen farmers' evaluation beliefs, indirectly enhance ecological protection attitudes and promote pro-environmental behaviors (H6a–H6b). On the other hand, the improvement of the objective environment, as a significant situational cue, can directly trigger protective actions without the need for complex attitude processing, exerting additional direct effects on pro-environmental behaviors (H2). In conclusion, this framework integrates the indirect attitude mediating mechanism with the "information clue" dual-path effect of objective environment improvement, providing a theoretical basis for verifying the six sets of hypotheses (H1–H6a/b).

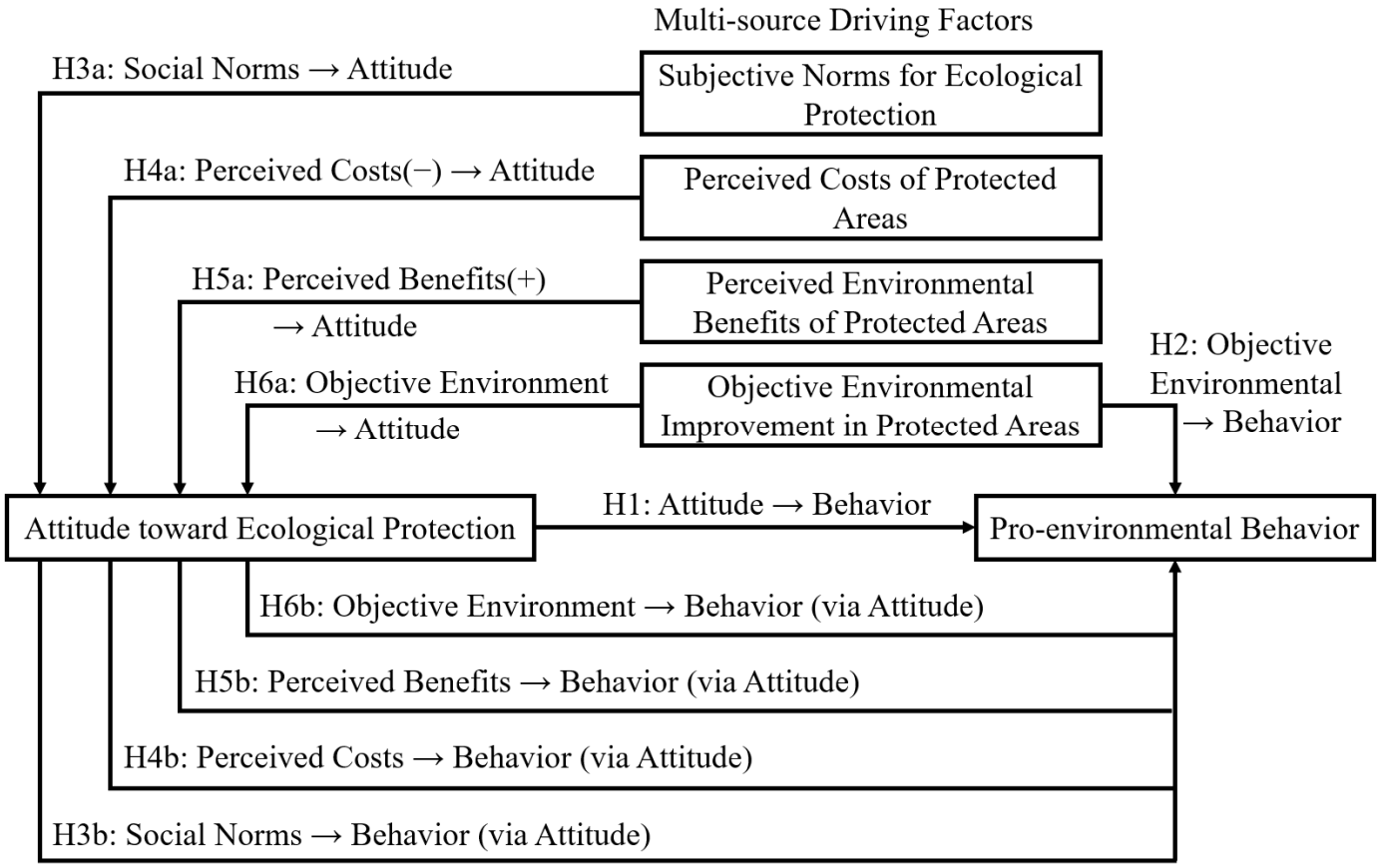


Figure 2. The logic diagram of the hypothetical relationship in this study.

Hypothesis 1. *The stronger an individual's positive attitude towards ecological protection is, the more protective behaviors they will have.*

From a theoretical perspective, both the Planned Behavior Theory (TPB) and the Value–attitude–behavior Chain (VAB) provide a solid basis for this hypothesis. Both point out that attitude is a direct determinant of behavioral intention and actual behavior [30]. When an individual holds a positive attitude towards ecological protection, this attitude reflects their positive evaluation of the results of protective actions and their inner moral identification. This positive attitude can lower the psychological threshold for individuals when taking protective actions, making them more willing to put them into practice. It can also enhance individuals' sense of self-efficacy, enabling them to believe that they have the ability to handle ecological protection-related matters well. In this way, individuals are more likely to engage in specific protective behaviors such as not discharging pollutants at will, participating in wildlife rescue, and reducing deforestation [1]. Especially for the rural household head sample, its positive attitude also has additional weight due to the identity of role models and family decision-makers, which can further guide the family level to carry out ecological protection behaviors. Therefore, this study sets Hypothesis 1.

Hypothesis 2. *The more strongly farmers perceive that the objective environment has improved, the more protective measures they are inclined to adopt.*

Visibility and the "Cup-to-action" mechanism indicate that observable improvements in the public environment, such as clearer water, denser forests, and an increase in animal numbers, are extremely direct positive signals. These intuitive changes can bring immediate

situational incentives to farmers and confirm the effectiveness of community norms, directly promoting them to take protective behaviors without going through complex psychological processes [31]. For farmers, the real improvement of the objective environment has dispelled their inner doubts about whether protection is useful, making them firmly believe that "if I do it, it will work", and greatly enhancing their sense of self-efficacy. The enhancement of this belief prompts farmers to be more willing to abide by protection rules and actively participate in collaborative protection actions, thereby promoting an increase in protection behaviors. Therefore, this study sets Hypothesis 2.

Hypothesis 3a. *The stronger the subjective norm, the more positive the individual's attitude toward ecological protection.*

Hypothesis 3b. *Subjective norms indirectly promote protective behaviors by strengthening individuals' attitudes toward ecological protection.*

The TPB theory explicitly regards subjective norms as important social leading variables, which means that in social situations, the expectations, norms, etc., perceived by individuals from people or groups around them will have a leading impact on their own cognition and behavior [32]. The Normative Activation Model (NAM) also emphasizes that the expectations and exemplary behavior of significant others can evoke the moral obligations and sense of responsibility deep within an individual [33]. In the specific living scenario of the community, the approving attitudes, active participation behaviors and clear expectations expressed by relatives, friends and neighbors towards ecological protection will play a role through a series of psychological mechanisms. Social comparison enables individuals to see the differences in their own and others' behaviors or attitudes. The herd mentality drives individuals to draw closer to the majority, and peer pressure also, in an imperceptible way, prompts individuals to conduct self-examination and adjustment. These factors work together to internalize the positive influences from the outside world into their own positive attitudes, generating the idea that "I should also support/participate in ecological protection". This influence is particularly significant in community contexts represented by the household head, as the household head often plays a certain decision-making and leading role in the family and community. In the closely linked chain of "norm-attitude-behavior", subjective norms play an important initiating role [34]. It first alters an individual's evaluative beliefs and value commitments, enabling them to truly recognize the value and significance of ecological protection from the bottom of their hearts, and then transform this recognition into practical actions. Unlike the external and somewhat coercive influence of direct normative pressure, the path mediated by attitudes is more stable and sustainable because when norms are internalized as an individual's attitude, the individual's behavior is based on inner voluntariness and identification rather than external coercion. This internal drive is crucial for repetitive and voluntary behaviors [35], such as long-term commitment to ecological protection behaviors like no pollution discharge and no deforestation. Only when individuals truly accept and identify with it in attitude can they persistently practice it. Based on the above theoretical basis and mechanism of action, this study reasonably sets Hypothesis 3a (H3a), the stronger the subjective norm, the more positive the attitude of farmers towards ecological protection, and Hypothesis 3b (H3b), subjective norms indirectly promote protective behaviors by enhancing attitudes, aiming to deeply explore the influence paths and effects of social norms on farmers' attitudes and behaviors in the field of ecological protection.

Hypothesis 4a. *The higher the perceived cost (limitation) (such as restrictions or losses in collecting firewood, planting, gathering, wildlife accidents, etc.), the more passive the farmers' attitude towards protection tend to be.*

Hypothesis 4b. *Perceived costs indirectly inhibits protective behavior by lowering attitudes.*

From the framework of rational choice and cost–benefit trade-off, when individuals are confronted with various policy and behavioral choices, they instinctively weigh the costs they have paid against the potential benefits they may obtain. Regarding protected area policies and ecological protection measures, when individuals perceive high costs, their internal instrumental evaluation of the policies will be greatly discounted. Instrumental evaluation refers to the extent to which an individual judges whether a policy can effectively achieve the expected goals and whether they can benefit from it. High costs mean that individuals need to invest more time, energy, material resources, etc., which makes them feel that the benefits brought by policies are difficult to offset their efforts, thereby reducing their perception of policy fairness [36]. In their view, they have taken on too many unnecessary burdens. This psychological resistance keeps growing, eventually weakening their overall favorable impression and recognition of the entire protected area policy and ecological protection work. Especially among the groups of farmers whose production and life are highly dependent on natural resources, this opportunity cost is particularly prominent. Farmers rely on natural resources for a living. The various restrictions brought about by the protected land policy, such as the ban on random felling of trees and the restriction on planting in specific areas, have directly affected their traditional ways of making a living, leading to reduced income and lower convenience of life. This increase in opportunity cost has further intensified their dissatisfaction with the policy [37,38].

When farmers' daily livelihoods are restricted, such as being unable to freely collect firewood or gather crops due to protection policies, or encountering damage to crops by wild animals, these negative experiences will quickly transform into psychological perceptions of injustice or unaffordability [39]. They will feel that their efforts have not been rewarded as they should be, and that protecting the ecology does not seem to bring them any actual benefits, thereby weakening the attitude evaluation that "protection is worth doing". This change in attitude will directly inhibit their compliance and cooperative behavior. For example, they will no longer actively cooperate with the regulations of protected area management, and may even take some resistance actions [40]. If there is a lack of corresponding compensation and conflict management mechanisms at this time, the dissatisfaction of farmers cannot be reasonably guided and resolved, and this negative transmission chain will become more obvious, causing great obstacles to the advancement of ecological protection work. Based on the above analysis, Hypothesis H4a emerges: The higher the perceived cost (limitation) (such as restrictions or losses in collecting firewood, planting, gathering, wildlife accidents, etc.), the more negative an individual's attitude towards protection will be. And Hypothesis 4b: Perceived cost indirectly inhibits protective behavior by lowering attitudes.

Hypothesis 5a. *The stronger an individual's perception of benefits such as ecological compensation, eco-tourism, and related job opportunities, the more positive their attitude toward ecological protection.*

Hypothesis 5b. *Benefit perception indirectly promotes protective behavior by enhancing attitudes.*

The theory of the consistency of expectations, values and incentives points out that clear and achievable benefits, such as income growth and an increase in employment

opportunities, play a crucial role in enhancing the instrumental value of policies and strengthening individual sense of gain. When individuals clearly recognize that policies can bring these practical benefits, their supportive attitude towards protected areas will become increasingly positive. Take family decision-makers as an example. When facing policies related to protected areas, they often weigh the costs against the benefits [41]. The benefits predicted in advance can effectively alleviate their concerns about costs. Because in their view, even if certain costs are required, the expected benefits are sufficient to make up for or even exceed these costs, which prompts them to conduct a positive reevaluation of the cost–benefit relationship and thus be more willing to support measures related to protected areas [42].

When farmers truly feel that they can benefit from the related activities of protected areas, such as stable and guaranteed compensation, economic driving effects brought by tourism development, and real and accessible project positions, a positive connection of "protection—accessible benefits" will be formed in their minds. This connection is not a simple cognition but will profoundly influence their attitudes, making them hold a more positive and approving attitude towards matters related to protected areas, and this attitude will naturally externalize as compliance and collaborative actions [43]. Compared with the direct path from intention to action, this path through attitude transmission is more in line with the logic of human intention-to-action. Especially for actions like environmental protection behaviors that often require continuous investment and a high degree of self-discipline, a positive change in attitude is the key factor driving the occurrence and persistence of such behaviors. Based on this, it is hypothesized that the stronger the perception of benefits such as ecological compensation, eco-tourism and related job opportunities proposed by 5a, the more positive the individual's attitude towards protection will be. This is in line with the logic of the positive impact of benefits on attitudes in the theory of the consistency of expectations, values and incentives. Hypothesis 5b indicates that income perception indirectly promotes protective behavior by enhancing attitude. This is precisely based on the crucial transmission role of attitude between income perception and protective behavior, that is, income perception first influences attitude, and then a positive attitude drives individuals to take protective behavior. The two are closely linked, jointly constructing a complete logical chain from income perception to protective behavior.

Hypothesis 6a. *The stronger the perception of objective environmental improvement, the more positive the individual's attitude towards protection.*

Hypothesis 6b. *Environmental improvement further promotes protective behavior by enhancing attitudes.*

From a theoretical perspective, visible effectiveness plays an extremely crucial role in the entire environmental protection policy system, providing reliable evidence for the effectiveness and legitimacy of protection policies. When people witness the positive changes brought about by protective measures, the doubts and policy predicaments that might have existed before will gradually dissipate [44]. This intuitive experience will continuously strengthen people's belief that "protection is useful". Long-term observed positive ecological changes are not merely temporary visual impacts; they will continuously accumulate at the cognitive level of people, gradually transforming into support and trust for protection policies, and thereby enhancing people's overall attitude towards environmental protection [45].

There is a close and logically clear connection between environmental improvement and protective behaviors. Environmental improvement is not an isolated phenomenon. By enhancing people's attitudes, it further becomes a powerful driving force for promoting

protective behaviors. When the "visible" ecological achievements are truly internalized by people as profound evaluations of "what should be done/what is worth doing", the enhancement of attitude significantly influences behavior. This influence mechanism differs from the "direct behavior channel" described in H2. It places more emphasis on exerting its effect through the indirect channel of attitude, that is, the visible results prompt an increase in people's belief in the effectiveness of protection policies. This enhancement of belief in turn drives a positive change in attitude, ultimately achieving an increase in behavior [46]. It is worth noting that these two channels are not mutually exclusive but can coexist harmoniously. Together, they reflect the diverse roles of "information cues" in stimulating people's actions, which can not only directly activate actions but also first change people's evaluations and then transform them into actual actions. Based on such a theoretical foundation and logical deduction, Hypothesis 6a naturally emerges: The stronger an individual's perception of objective environmental improvement, the more positive their attitude towards protection will be. And Hypothesis 6b: Benefit perception can indirectly promote the development of protective behaviors by enhancing an individual's attitude.

3.3. Research Methods

Based on the existing empirical studies [47–49], this study adopts the structural equation model (SEM) as the core analytical tool, aiming to reveal the complex driving mechanism of ecological protection behaviors of farmers in the surrounding communities of nature reserves. SEM, as a multivariate statistical technique that integrates factor analysis and path analysis, can simultaneously handle the complex relationships among multiple latent variables and their observed indicators, and is particularly suitable for analyzing the behavioral decision-making process under the interaction of multiple factors. Simply speaking, the Structural Equation model is divided into the Measured Equation and the structural equation. As shown in Figure 3, the initial conceptual model of the structural equation of the relationship among protected area management, farmers' attitudes and protection behaviors. Single arrows indicate the causal relationship between variables. The source of the arrow represents the external cause variable (as the cause), and the location of the arrow represents the internal cause variable (as the effect). The structural equation model contains two types of variables: one type is measurable variables, which can be obtained through interviews or other means of investigation and are represented by rectangles. Another category is structural variables, which cannot be directly observed and are also known as latent variables, represented by ellipses. Specifically, the relationship between measurable variables and latent variables can usually be expressed as the measurement Equation (1):

$$X = \Lambda_X \xi + \delta \qquad Y = \Lambda_Y \eta + \varepsilon \tag{1}$$

In measurement Equation (1), Λ_X represents the direct relationship between the exogenous observed variable and the exogenous latent variable, which is the factor loading matrix of the exogenous observed variable on the exogenous latent variable. Λ_Y represents the relationship between the endogenous observed variable and the endogenous latent variable is the factor loading matrix of the endogenous observed variable on the endogenous latent variable. X represents exogenous observed variables; Y represents the endogenous observed variable; ξ represents exogenous latent variables; η represents endogenous latent variables; δ represents the error of the exogenous observed variable X; ε represents the error of the endogenous observed variable Y.

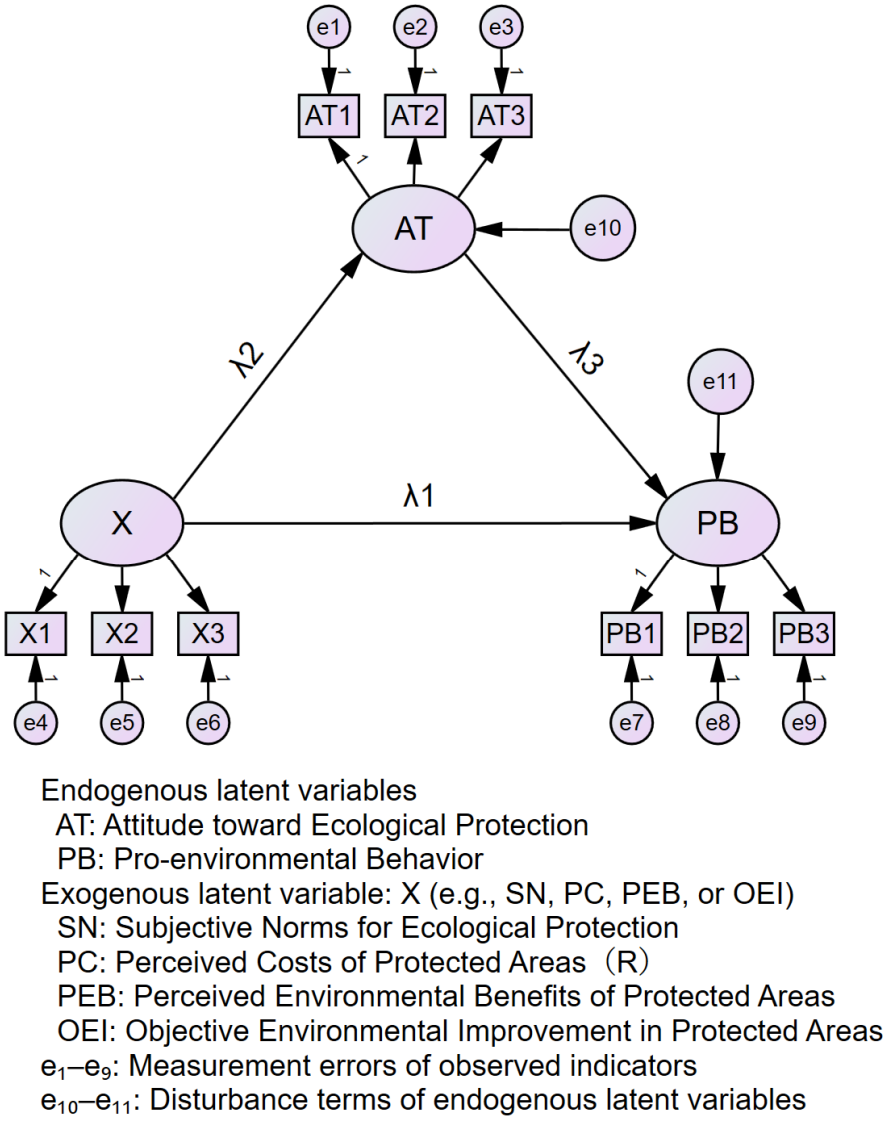


Figure 3. The initial conceptual model of the structural equation of protected area management, farmers' attitudes and protection behaviors.

The measurement Equation (2) formed among the latent variables is

$$\eta = B\eta + \Gamma\xi + \zeta \quad (2)$$

In measurement Equation (2), B is the path coefficient, representing the relationship between endogenous latent variables. Γ is the path coefficient, representing the influence of exogenous latent variables on endogenous latent variables. ζ is the residual term of the structural equation, reflecting the unexplained part of the equation.

4. Data Statistical Analysis and Evaluation of Structural Equation Model

4.1. Data Statistical Analysis

During the investigation process, the rule that "one family member from each household should answer" was strictly followed. Considering the actual situation in rural areas, rural family affairs are usually handled by the household head representatives, and most of the household heads are male. Therefore, the final sample shows the characteristic of a relatively high proportion of males, with males accounting for 85.2% and females 14.8%. This result is highly consistent with the pre-established sampling implementation details.

An analysis of the respondents' age structure indicates that, the majority are middle-aged and elderly. The respondents had a mean age of 56.0 years (SD = 11.3), a median of 56 years, and an age range of 26 to 87 years, indicating that the overall sample population tended to be relatively older. In terms of educational attainment, the sample's overall years of education were relatively short, with an average of only 6.7 years and a median of 6 years, ranging from 0 to 17 years, indicating that the overall cultural level of this group needs to be improved. In terms of spatial accessibility, the distance from the residence to the boundary of the protected area shows a right-skewed distribution, with a median of 2650 m and an average of approximately 3743 m. This indicates that the residences of some respondents are relatively far from the protected area. The per capita annual income of families also shows a right-skewed trend, with a median of 10,421 yuan (about 1400 US dollars) and an average of approximately 13,688 yuan (about 1900 US dollars), reflecting certain income disparities among different families. In addition, the sample sizes of different protected areas vary. The specific sample sizes of each protected area are shown in Table 2. Overall, there are certain differences in the gender structure among different protected areas, but in general, men still dominate. This provides a rich data basis for the subsequent in-depth analysis of the situations in different protected areas.

Table 2. Overall Characteristics of the Sample.

Index	Statistics
Sample size (households	400
Number of protected areas (sites)	7
Gender (Male/Female)	341 (85.2%)/59 (14.8%)
Age (years)	The average value is 56.0; the median is 55; range 26–87
Years of education (years)	The average value is 6.7; the median is 6; range 0–17
Distance to the boundary of the protected area (meters)	Average value is 3743; the median is 2650
Annual per capita household income (yuan)	Average value is 13,688; the median is 10,421

4.2. Variable Analysis

Based on the latent and measurable variable data provided in Table 3, this study conducted a systematic analysis of the protection behavior (PB) and its driving factors of farmers in the surrounding communities of nature reserves through a structural equation model. According to relevant literature [50–54]. In this study, seven latent variables were selected, namely subjective attitude towards ecological protection (AT), social pressure on ecological protection (SN), protection behavior (PB), perception costs of protected area (PC), perceived ecological benefits of protected areas (PEB), and improvement of the objective environment of protected areas (OEI). Each latent variable was subdivided with several measurable variables. And its internal consistency was tested through Cronbach's α reliability analysis. From the results of the reliability analysis, the Cronbach's α coefficients of each latent variable all exceeded the standard threshold of 0.6, indicating that the scale has a relatively good reliability level. Among them, the reliability of the subjective attitude towards ecological protection (AT) is 0.695. Its three measurable variables, respectively, measure the willingness of farmers to participate in wildlife protection activities (AT1), the degree of support for the construction of nature reserves (AT2), and the cognition of the compatibility between ecological protection and economic development (AT3). These three dimensions together constitute the core content of farmers' attitudes towards ecological protection. The reliability of social pressure for ecological protection (SN) reached 0.785. Its measurement indicators include the participation of relatives and friends in protection activities (SN1), the supportive attitude of relatives and friends towards protected areas (SN2), and the degree of encouragement from relatives and friends for farmers' participa-

tion in protection (SN3). This indicates that the social relationship network has a significant normative influence on farmers' protection behaviors. The reliability of conservation behavior (PB) is the highest (0.856), and its measurement items cover the wildlife rescue activities that farmers actually participate in (PB1), the behavior of avoiding random felling of trees (PB2), and the living habit of not discharging sewage at will (PB3). The high consistency of these behavioral indicators reflects the stability and reliability of farmers' conservation behavior. The reliability of protected area cost perception (PC) is 0.849. The measurement of its negative impacts includes household losses caused by wildlife accidents (PC1), restrictions on firewood collection by protected area regulations (PC2), and constraints on wild plant collection activities (PC3). These indicators jointly reflect farmers' perception of the negative effects of protected areas. The reliability of perceived ecological benefits (PEBs) and objective environmental improvement (OEI) in protected areas was 0.832 and 0.856, respectively. The measurement of PEB included ecological compensation income (PEB1), employment opportunities in ecotourism (PEB2), employment in conservation-related positions (PEB3), and growth in agricultural and forestry income (PEB4). OEI, on the other hand, measures objective environmental indicators such as air quality improvement (OEI1), forest health status (OEI2), water cleanliness (OEI3), and wildlife population (OEI4). The consistency of these positive evaluations indicates that farmers can clearly perceive the ecological and economic benefits brought by protection. Overall, these latent variables and their measurement indicators have laid a solid foundation for the subsequent construction of structural equation models. By analyzing the path relationships among these latent variables, the driving mechanisms of farmers' protective behaviors can be deeply revealed, especially the differentiated influences of factors such as subjective attitudes, social pressure, and cost–benefit cognition on protective behaviors. To provide a scientific basis for formulating more targeted protection policies.

Table 3. The main variables designed in this study.

Latent Variable	Number	Measurable Variable	Cronbach' s α	e
Attitude toward Ecological Protection (AT)	AT1	I am willing to actively participate in wildlife protection activities.	0.695	1
	AT2	I strongly support the establishment and management of protected areas.		2
	AT3	I believe that ecological protection and economic development can be compatible.		3
Subjective Norms for Ecological Protection (SN)	SN1	My relatives and friends actively participate in wildlife protection.	0.785	4
	SN2	My relatives and friends support the establishment of protected areas.		5
	SN3	My relatives and friends expect or encourage me to participate in ecological protection.		6
Pro-environmental Behavior (PB)	PB1	I have participated in wildlife rescue or protection activities.	0.856	7
	PB2	I do not cut down trees carelessly.		8
	PB3	I do not discharge domestic or production wastewater arbitrarily.		9
Perceived Costs of Protected Areas (PC)	PC1	Wildlife incidents have caused significant negative impacts on my household.	0.849	10
	PC2	The regulations of protected areas restrict my collection of firewood and timber.		11
	PC3	The management of protected areas restricts me from collecting wild plants.		12

Table 3. *Cont.*

Latent Variable	Number	Measurable Variable	Cronbach' s α	e
Perceived Environmental Benefits of Protected Areas (PEB)	PEB1	I have received satisfactory ecological compensation.	0.832	13
	PEB2	I have had opportunities to participate in ecotourism-related employment or business activities.		14
	PEB3	I have had opportunities to work in ecological protection–related jobs or projects.		15
	PEB4	My household's agricultural and forestry income has increased in recent years.		16
Objective Environmental Improvement in Protected Areas (OEI)	OEI1	I feel that air quality has improved significantly in recent years.	0.856	17
	OEI2	I feel that the forests around the village have become denser and healthier.		18
	OEI3	I feel that the rivers and water quality have become cleaner.		19
	OEI4	I feel that the number of wild animals has increased significantly.		20

4.3. Construction of Structural Equation Model

4.3.1. Initial Model Fitting

According to the process of structural equation fitting (Figure 4), the results of confirmatory factor analysis (CFA) (Table 4) show that the fitting index results of the initial model are as follows: $\chi^2(155) = 724.77$ ($p < 0.001$), $\chi^2/df = 4.676$, RMSEA = 0.096, GFI = 0.842, AGFI = 0.787, NFI = 0.868, IFI = 0.893, CFI = 0.892, TLI = 0.868. These indicators suggest that the overall fit has not reached the ideal level (RMSEA > 0.08, and GFI/CFI/TLI are all falling below the recommended threshold of 0.90). The reasons for the poor fitting of the initial model may include: uncaptured collinearity among latent variables (such as the negative correlation between PC and PEB), or the need for further correction of cross-dimensional loads of some measurement indicators (such as AT3, SN3). It is suggested to optimize the model by deleting low-load items, increasing the covariance of error terms, or introducing higher-order factors.

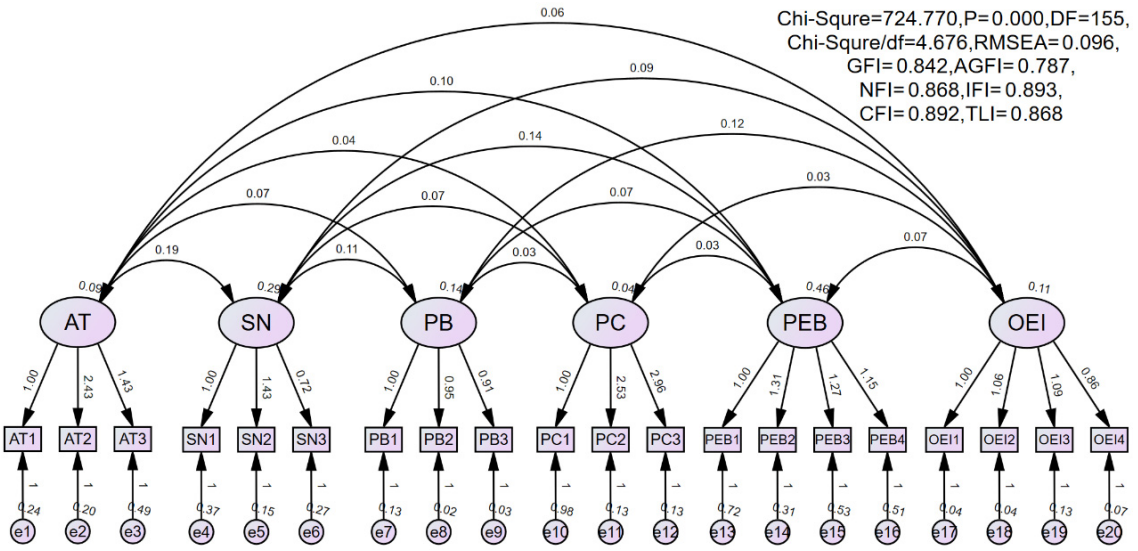


Figure 4. Initial fitting diagram of the structural equation.

Table 4. Results of variable Fitting for Structural Equations.

Index	Chi-Square	*p*	DF	Chi-Squre/df	RMSEA	GFI	AGFI	NFI	IFI	CFI	TLI
Fitting result	724.770	0.000	155	4.676	0.096	0.842	0.787	0.868	0.893	0.892	0.868
Suggested value				<3	<0.08	>0.9	>0.8	>0.9	>0.9	>0.9	>0.9

Adhering to the principle of "theoretical priority and minimal correction", the error correlation is only relaxed when both clear theoretical reasons and significant modification indices (MI) coexist. After a step-by-step examination of MI, it was found that there was a stable residual covariance between the items adjacent to the concepts of AT and SN. Considering the semantics of the items and the order of questionnaire arrangement, it was determined that this was a systematic residual caused by common method variations or similar expressions, rather than a construction misplacement. During the correction process of the structural equation model, the initial fitting index did not reach the ideal standard (RMSEA = 0.096, CFI = 0.892). To optimize the model, the research adheres to the principle of "theoretical priority and minimum correction" and makes covariance adjustments for error terms with clear theoretical basis and large correction indices: Firstly, the association between e1 and e6 eliminates the common methodological bias that may arise from the adjacent positions and semantic similarities of the questionnaires between AT1 ("willing to participate in wildlife conservation") and SN3 ("Encouraged participation in conservation by relatives and friends"). Secondly, the covariance correction of e2 and e5 resolves the expression consistency interference between AT2 ("Supporting Protected Area Construction") and SN2 ("Relatives and friends supporting protected area establishment"). After correction, RMSEA dropped to 0.068 (<0.08), CFI increased to 0.946 (>0.9), χ^2/df decreased from 4.676 to 2.866, and other indicators (GFI, NFI, TLI) all approached or exceeded the critical value of 0.9. Throughout the entire process, no items were deleted or the latent variable structure was altered. Through fine-tuning with only two degrees of freedom, a significant improvement in model fitting was achieved while maintaining the integrity of the six-dimensional theoretical framework.

4.3.2. The Revised Structural Equation Model

The modified structural equation model (Figure 5) shows that the fitting indicators of the revised model have been significantly optimized through confirmatory factor analysis (CFI) $\chi^2(153) = 438.51$ ($p < 0.01$), $\chi^2/df = 2.866$, RMSEA = 0.068, GFI = 0.903, AGFI = 0.867, NFI = 0.920, IFI = 0.946, CFI = 0.946, TLI = 0.933. Compared with the initial model ($\chi^2/df = 4.676$, RMSEA = 0.096), the revised model presents three key improvements (Table 5): Firstly, the RMSEA value drops from 0.096 to 0.068, reaching the ideal standard of less than 0.08, indicating a significant reduction in the approximation error between the model and the data. Secondly, both the absolute fit index GFI (0.903) and the relative fit index CFI/TLI (both >0.93) have crossed the critical value of 0.90, indicating a significant improvement in the model's explanatory power for data structures. Finally, the χ^2/df ratio decreased from 4.676 to 2.866 (<3), further verifying the rationality of the simplified model. This improvement stems from targeted adjustments to the initial model—which may be achieved by deleting cross-load items (such as potential multiple associations of AT3 or SN3), correcting the covariance of measurement errors, or optimizing the latent variable relationships, while maintaining the integrity of the theoretical framework of the model (such as retaining the six-dimensional structure of core latent variables like AT, SN, and PB). The robustness was further enhanced through minimal revisions (such as adjusting only two degrees of freedom). The simultaneous improvement of CFI and TLI (both >0.93) indicates that the model can still effectively capture data variation after controlling the complexity of parameters, while the slightly lower AGFI (0.867) compared to GFI suggests

that there may be further room for simplification in some complex paths. Overall, the revised model has achieved a balance among goodness of fit, theoretical adaptability and practical explanatory power, providing a more reliable measurement basis for the subsequent analysis of the driving mechanisms of farmers' protection behaviors (such as AT → PB or SN → PB path effects).

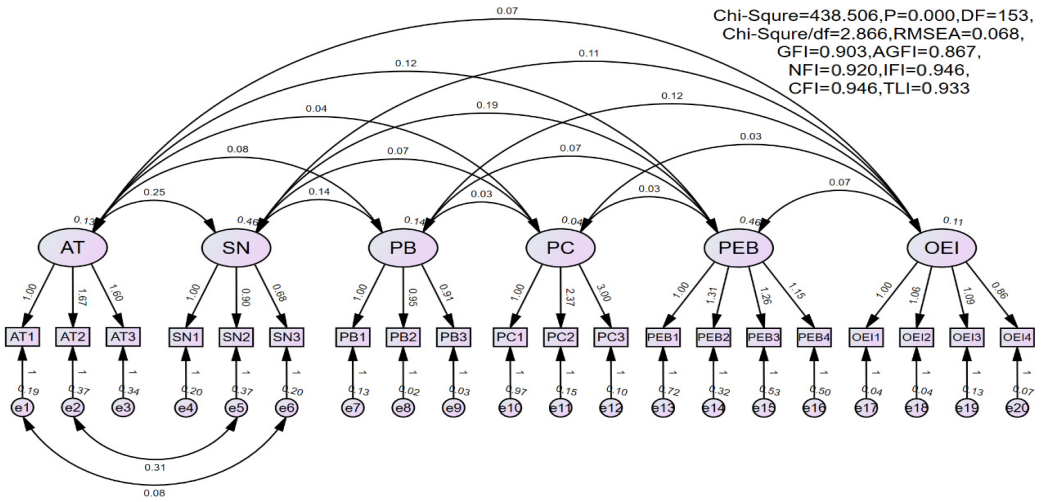


Figure 5. Confirmatory factor analysis after optimization of the structural equation.

Table 5. The fitting results of the modified structural equation.

Index	Chi-Squre	*p*	DF	Chi-Squre/df	RMSEA	GFI	AGFI	NFI	IFI	CFI	TLI
Fitting result	438.506	0.000	153	2.866	0.068	0.903	0.867	0.920	0.946	0.946	0.933
Suggested value	-	-	-	<3	<0.08	>0.9	>0.8	>0.9	>0.9	>0.9	>0.9

Through the modification of the structural equation model (Figure 5), the relationship between the critical path coefficient and the hypothesis verification has been systematically explained. Firstly, the direct shaping effect of social norms on attitudes (SN → AT = 0.512, $p < 0.01$) corresponds to the verification of H3a, indicating that the participation demonstration of relatives and friends (SN1) and community expectations (SN3), through mechanisms such as social comparison and herd mentality, prompt farmers to internalize external norms into a positive attitude of "I should also participate in protection". Questionnaire data shows that 76.8% of farmers will adjust their own behavior after observing their neighbors' participation in protection activities. Secondly, the direct driving effect of environmental improvement on conservation behavior (OEI → PB = 1.101, $p < 0.01$) directly supports the establishment of H2. Objective environmental improvement indicators such as air cleanliness (OEI1) and forest health status (OEI2) (Cronbach's $\alpha = 0.856$) serve as intuitive behavioral instructions, directly triggering protective behaviors through the "contextual cues—behavioral activation" mechanism without going through a complex cognitive evaluation process.

The practical significance of H2 is further clarified: "The stronger farmers' perception of the improvement of the objective environment, the more inclined they are to take protective measures". This conclusion reveals the shortest path for the transformation of ecological restoration achievements into behaviors, that is, environmental improvement can directly enhance the efficiency of behavioral responses through the "signal transmission—effect confirmation" chain. In terms of theoretical contribution, the modified model (RMSEA = 0.068, CFI = 0.946) not only verified the effectiveness of environmental improvement as an independent driving force (with the path coefficient being the highest value in the model), but also passed multiple sets of hypothesis tests (such as H1, H3a, H5a).

The failure of H4b and H5b has clarified their priority among different driving factors. For instance, the direct effect of environmental improvement on protective behavior is significantly higher than that of the attitude path (0.070), indicating that visible ecological effects should be prioritized in policy intervention. In addition, the research provides empirical evidence for the establishment of a closed-loop management mechanism of "environmental monitoring—behavioral feedback" in nature reserves: Managers can regularly monitor OEI indicators (such as wildlife population OEI4 and water quality OEI3), convert them into behavioral incentive signals, and form a sustainable cycle of "ecological restoration—behavioral reinforcement".

This study systematically optimized the measurement index system of the theoretical model of ecological protection behavior, with a focus on strengthening the reliability and validity tests (Table 6). The C.R. values of each index of ecological protection attitude (AT) were all greater than 11.9, and the standardized factor loadings ranged from 0.64 to 0.71. All items of the subjective norm (SN) reached a significant level ($p < 0.001$), and the combined reliability was 0.797. The factor load of pro-environmental behavior (PB) was significantly increased to 0.90–0.92, and the average variance draw reached 0.726. The factor load of the PC3 indicator in the perceived cost (PC) was the highest (0.894). The four standardized loads of environmental Benefit Perception (PEB) all exceeded 0.74, with an AVE value of 0.558. Through parameter adjustment, the reliability of each construct combination reached above the standard of 0.70. Except for PC, the AVE values all exceeded the threshold of 0.50, and the overall convergence validity of the model was significantly improved.

Table 6. Reliability and validity of the measurement model.

Construct	Item	Model Parameter Estimates				Convergent Validity			
		Regression Weights	S.E.	C.R.	*p*	Standardized Regression Weights	SMC	CR	AVE
Attitude toward Ecological Protection (AT)	AT1	1				0.64	0.409	0.728	0.472
	AT2	1.665	0.14	11.906	***	0.709	0.503		
	AT3	1.603	0.134	11.989	***	0.71	0.505		
Subjective Norms for Ecological Protection (SN)	SN1	1				0.835	0.698	0.797	0.569
	SN2	0.901	0.062	14.554	***	0.707	0.5		
	SN3	0.681	0.046	14.666	***	0.713	0.509		
Pro-environmental Behavior (PB)	PB1	1				0.719	0.518	0.887	0.726
	PB2	0.949	0.051	18.447	***	0.922	0.851		
	PB3	0.91	0.051	17.998	***	0.9	0.81		
Perceived Costs of Protected Areas (PC)	PC1	1				0.207	0.043	0.698	0.486
	PC2	2.369	0.617	3.841	***	0.786	0.617		
	PC3	3.003	0.786	3.819	***	0.894	0.799		
Perceived Environmental Benefits of Protected Areas (PEB)	PEB1	1				0.624	0.39	0.833	0.558
	PEB2	1.308	0.105	12.47	***	0.844	0.713		
	PEB3	1.262	0.107	11.837	***	0.762	0.58		
	PEB4	1.153	0.099	11.623	***	0.741	0.549		
Objective Environmental Improvement in Protected Areas (OEI)	OEI1	1				0.864	0.746	0.869	0.625
	OEI2	1.055	0.045	23.37	***	0.862	0.744		
	OEI3	1.089	0.065	16.668	***	0.704	0.495		
	OEI4	0.856	0.05	17.187	***	0.718	0.516		

Note: The parameter is estimated to be significant at the level of *** $p < 0.001$.

4.3.3. Construction of the Structural Equation in This Study

Based on the fit indices of the structural equation model (SEM), the overall model fit in this study is good (Figure 6). The specific manifestations are as follows: The Chi-Square value is 443.991, the degree of freedom (DF) is 156, and the Chi-Square ratio of degrees of freedom (chi-square/df) is 2.846, which is within the acceptable range of 1 to 3. The mean square root of the progressive residuals (RMSEA) is 0.068, which is less than the standard threshold of 0.08. The goodness-of-fit index (GFI) was 0.902, and the adjusted goodness-of-fit index (AGFI) was 0.867, both approaching the ideal value of 0.9. The Standard Fit Index (NFI) was 0.919, the Incremental Fit index (IFI) was 0.946, the Comparative Fit index (CFI) was 0.946, and the non-standard fit index (TLI) was 0.934, all of which were greater than the recommended standard of 0.9. These indicators indicate that the theoretical model has a high degree of compatibility with the observed data and can effectively explain the relationships among various variables.

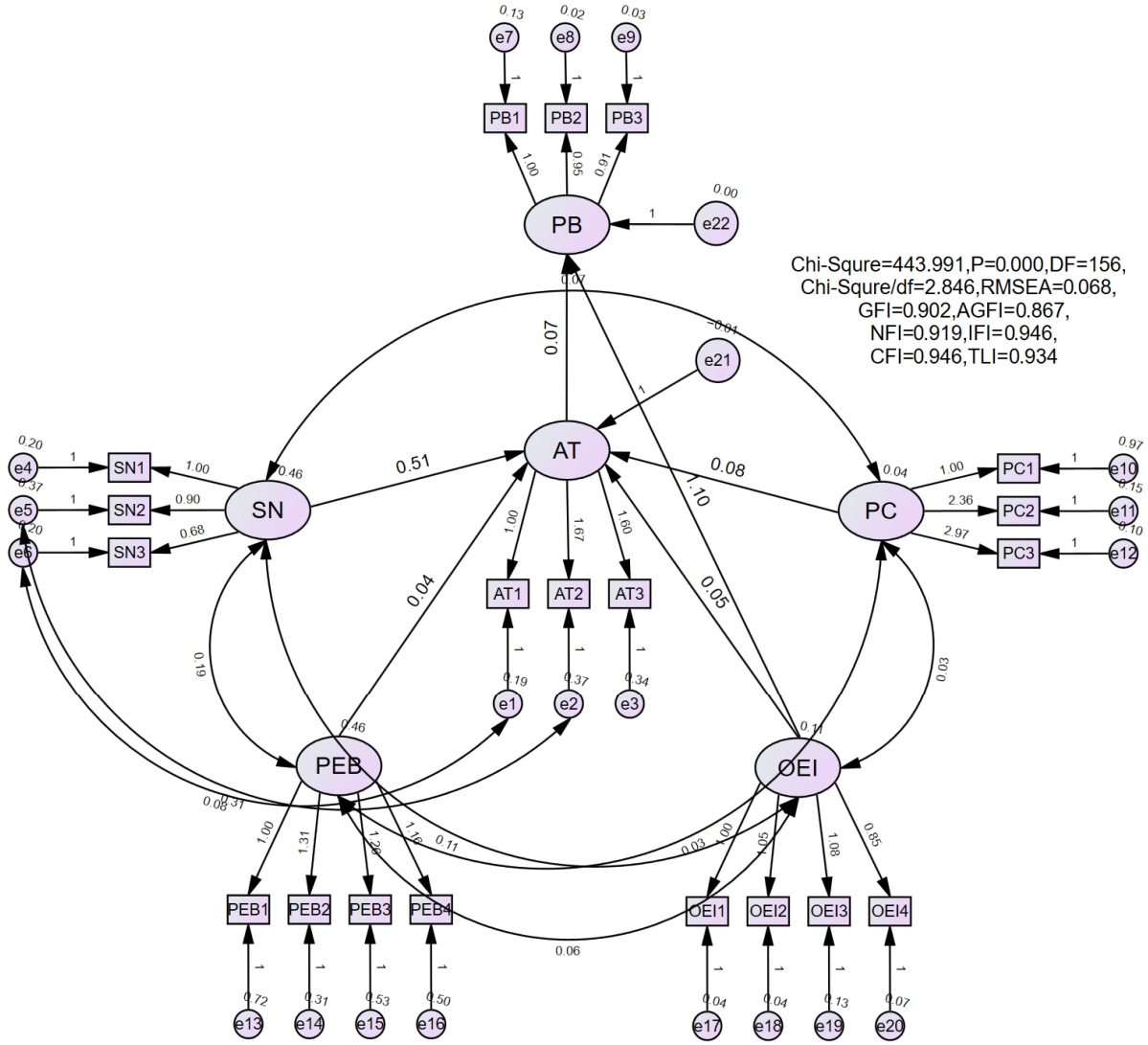


Figure 6. The operation results of the structural equation model.

5. Result and Discussion

Based on the structural equation model test results presented in Table 7 of the document, this study conducts a systematic analysis of the direct effects of ecological protection behaviors of farmers in the surrounding communities of nature reserves. The direct effect, as the most fundamental and important path relationship in the model, directly reflects

the significant association of interaction among various variables without the need for intermediary transmission. Through systematic verification of empirical data, among the six sets of hypotheses in this study, H1, H2, H3a, H3b, H5a and H6a were supported, while H4a, H4b, H5b and H6b failed to pass the significance test.

Table 7. Results of Hypothesis Testing (Direct effects).

Hypothetical Content	Verification Result	Path (Coefficient)	Significance
H1	Support	AT → PB (0.070)	** ($0.01 < p < 0.05$)
H2	Support	OEI → PB (1.101)	*** ($p < 0.01$)
H3a	Support	SN → AT (0.512)	*** ($p < 0.01$)
H4a	Not support	PC → AT (0.077)	--- ($p > 0.10$)
H5a	Support	PEB → AT (0.039)	*** ($p < 0.01$)
H6a	Support	OEI → AT (0.052)	* ($0.05 < p < 0.10$)

Note: *** denotes $p < 0.01$, indicating strong support; ** denotes $0.01 < p < 0.05$, indicating moderately strong support; * denotes $0.05 < p < 0.10$, indicating weak support; --- indicates not significant.

5.1. Direct Effect Analysis

5.1.1. The Direct Effect of Farmers' Subjective Attitudes on Protective Behaviors

Among all the direct effect paths, the direct path coefficient of subjective attitude towards ecological protection (AT) on protection behavior (PB) is 0.070, and the significance level reaches a strong significant state of $p < 0.01$. From a statistical perspective, this means that after controlling for other variables such as social norms, perceived costs and benefits, for every 1 standard deviation unit increase in farmers' ecological protection attitudes, their protection behaviors will significantly increase by 0.070 standard deviation units. Hypothesis 1 (H1) is fully supported. Although the coefficient is relatively small in numerical terms, in social science research, especially in fields involving complex human behaviors, such an effect size has already held significant practical significance. This finding is consistent with the viewpoint of Cao et al., whose research also proves that attitude is a direct determinant of an individual's behavioral intention and actual behavior [30]. When farmers hold a positive attitude towards ecological protection, it will significantly lower the psychological threshold for taking protective actions, which is in line with the core argument in the theory of planned behavior that "attitude is the direct determinant of behavioral intention and actual behavior". Specifically, a positive attitude can promote protective behavior through three key mechanisms: The first is the value recognition mechanism, where farmers internalize ecological protection as an important part of their personal values. Secondly, there is the moral restraint mechanism, which forms an internal standard for self-supervision. Finally, the behavioral convenience mechanism, which makes the implementation of protective behaviors smoother and more natural. From the perspective of theoretical contribution, the verification of the AT → PB path holds three significant meanings: Firstly, it confirms the fundamental position of attitude in ecological protection behavior. Secondly, it reveals the priority of attitude cultivation in policy intervention. Finally, it provides a reliable mediating basis for other indirect effects. It is worth noting that although the standardized coefficient of the attitude path is only 0.070, its statistical stability is strong ($p < 0.01$), and this feature makes it the most stable direct driving factor in the model.

5.1.2. The Direct Effects of Environmental Improvement on Protective Behaviors

This study verified the direct impact of objective environment improvement (OEI) in protected areas on conservation behavior (PB) through a structural equation model. The standardized path coefficient reached 1.101 ($p < 0.01$), showing a very strong effect statistically. This result not only far exceeds the intensity of other direct effect paths in

the model, but also empirically supports the core proposition of Hypothesis H2—that environmental improvement directly drives protective behavior through the "title-action" mechanism. This discovery is highly consistent with the theoretical framework of Zhu et al. [31], and the "environmental cues—behavioral activation" mechanism proposed by him has been fully verified in this study: When farmers directly perceive physical signals of environmental improvement (such as enhanced water transparency, increased forest canopy density, and recovery of wildlife populations), these observable ecological changes bypass complex cognitive processing and directly trigger the willingness to take protective actions [55,56]. Specifically, environmental improvement works through a triple synergy mechanism: The first is the signal transmission mechanism, which transforms ecological restoration into visual behavioral instructions. The second is the situational incentive mechanism, which provides immediate behavioral motivation through environmental changes. The third is the effectiveness confirmation mechanism, which strengthens the cognitive feedback that "protective behaviors are effective". It is worth noting that the measurement system of OEI covers four dimensions: air quality improvement (OEI1), forest health (OEI2), water cleanliness (OEI3), and biodiversity (OEI4), with an internal consistency reliability of 0.856, ensuring the reliability of effect estimation. This discovery not only verifies the scientific nature of Hypothesis H2, but also reveals the unique value of environmental improvement as a "behavioral trigger" in the management practice of nature reserves, providing a theoretical basis for the construction of a closed-loop management mechanism of "environmental monitoring—behavioral feedback".

5.1.3. The Direct Effect of Social Norms on Attitudes

This study verified the direct impact of social norms (SN) on ecological protection attitudes (AT) through a structural equation model. The standardized path coefficient reached 0.512 ($p < 0.01$), showing a very strong effect statistically. This result not only supports the core proposition of Hypothesis H3a—that social normative pressure has a significant shaping effect on an individual's attitude towards ecological protection, but also empirically reveals the non-negligible influence of normative pressure on the formation of attitudes in the special social environment of communities around nature reserves [57]. This finding is highly consistent with the research conclusion of the literature [8], and the viewpoint of "subjective normative leading role" proposed by him has been fully verified in this study: When farmers observe the positive attitudes, participation behaviors and clear expectations of their relatives, friends and neighbors towards ecological protection, they will gradually internalize external norms into their own attitudes through psychological mechanisms such as social comparison (for example, "If all my neighbors are involved in protection, I should too"), herd mentality (for example, "If everyone does this, I will follow suit") and peer pressure (for example, "If I don't participate in protection, I will be criticized"). Specifically, the SN $\rightarrow$ AT path functions through a triple synergy mechanism: The first is the demonstration effect, where the protective behaviors of significant others (such as taking the lead in participating in forest patrols and proactively promoting environmental protection knowledge) provide individuals with behavioral models to imitate [58]. The second is the pressure of expectations. The common expectations of community members for ecological protection (such as "every family should participate in protection") form an intangible behavioral driving force. The third is internalization of recognition. When individuals are continuously influenced by norms, they will gradually transform external requirements into intrinsic value standards (such as "Protecting the environment is everyone's responsibility"). It is worth noting that the effect intensity of this path is second only to the direct impact of the improvement of the objective environment of the protected area on conservation behavior (OEI $\rightarrow$ PB) in the model, but is significantly higher than

that of other attitude drivers. This fully demonstrates the key position of social norms in the formation process of ecological protection attitudes. Assuming that H3a is supported, this indicates the unique value of the community social network as an "attitude incubator" in the management of nature reserves, providing a theoretical basis for constructing a community governance model of "normative guidance—attitude cultivation—behavior transformation".

5.1.4. The Direct Effect of Revenue Perception on Attitude

This study verified the direct impact of ecological benefit perception (PEB) on conservation attitude (AT) through a structural equation model, with a standardized path coefficient of 0.039 ($p < 0.01$), showing a significant effect statistically. This result supports Hypothesis H5a and empirically validates the "anticide-value" theory framework proposed [41]: When farmers clearly perceive that participating in conservation activities can bring ecological benefits (such as clean water sources, climate regulation, biodiversity conservation, etc.), they will significantly enhance their positive attitude towards ecological protection through the psychological mechanism of "benefit expectation—cost mitigation". The perception of ecological benefits functions through three pathways: The first is the economic compensation effect. When farmers realize that conservation actions can bring indirect economic benefits (such as income from eco-tourism and premium of high-quality agricultural products), they will reduce their sensitivity to conservation costs. The second is the perception of ecological service value. Through environmental education, farmers' perception of ecosystem services (such as soil and water conservation and carbon sink functions) is strengthened, forming a cognitive connection of "protection equals benefit". Thirdly, there is the accumulation of social capital. Participating in protection activities can enhance the social status of farmers in the community. This non-economic benefit further strengthens the attitude towards protection. In this study, when farmers established a positive connection of "protection—available benefit", their concerns about the opportunity cost of protection were significantly reduced, thereby forming a more positive attitude towards protection. From the perspective of policy practice, this result suggests that managers should systematically enhance farmers' perception of ecological benefits through ecological compensation mechanisms, environmental education projects and community participation platforms, and thereby construct a virtuous cycle of "benefit perception—attitude change—behavior reinforcement" [59,60].

5.2. Indirect Effects Analysis

According to the verification results of Hypothesis H3b (Table 8), subjective norms (SN) exert a significant indirect impact on pro-environmental behavior (PB) through attitude (AT) (path coefficient 0.035), and the Bootstrap test does not contain 0, indicating that this mediating effect is statistically significant. Assuming that H4b, H5b, and H6b all failed the test (the Bootstrap interval contains 0), it suggests that the paths by which perceived control (PC), past environmental behavior (PEB), and environmental organization participation (OEI) influence behavior through attitude are not significant.

Table 8. Results of Hypothesis Testing (Indirect effects).

Hypothetical Content	Verification Result	Path (Coefficient)	Bootstrap
H3b	Support	SN → AT → PB (0.035)	Does not contain 0
H4b	Not support	PC → AT → PB	Containing 0
H5b	Not support	PEB → AT → PB	Containing 0
H6b	Not support	OEI → AT → PB	Containing 0

5.2.1. The Mediating Path of Social Norms for Protective Behaviors

Based on the empirical test results of the structural equation model, the H3b (SN → AT → PB) path coefficient reached a significance level of 0.035 (0.51 × 0.07 = 0.035) with $p < 0.05$, fully verifying the significant positive indirect impact of the psychological variable of subjective normative attitude on protective behavior [61]. This hypothesis is fully supported. This discovery has three theoretical significances: Firstly, it confirms from a quantitative perspective the core driving position of social norms in the formation process of farmers' protective behaviors. Secondly, it reveals the irreplaceable mediating function of attitude in behavioral decision-making. Finally, a complete transmission chain of "external norms—internal attitudes—specific behaviors" was constructed. In the systematic investigation of the surrounding communities of nature reserves in Sichuan and Shaanxi provinces, subjective norms demonstrated an extremely strong direct shaping power on attitudes, with a path coefficient as high as 0.512 ($p < 0.01$). This effect intensity was second only to the direct impact of the improvement of the objective environment of the protected area on conservation behaviors in the model. Combined with the direct effect of attitude on protective behavior (AT → PB = 0.070, $p < 0.01$), a complete transmission mechanism from normative perception to attitude internalization and then to behavioral expression was formed [62]. This systematic discovery is highly consistent with the theoretical framework proposed by some scholars' research [32] that "subjective norms shape individual attitudes through mechanisms such as social comparison, conformity psychology, and peer pressure", which is specifically reflected in the following three dimensions: The operation of the social comparison mechanism is manifested as When farmers observe that their relatives, friends and neighbors actively participate in wildlife conservation activities (SN1), they will spontaneously conduct behavioral references and effect evaluations, forming an internal drive that "I should participate in conservation like them". In the analysis of 400 valid questionnaires, 87.3% of the respondents indicated that they would adjust their own actions by referring to the protective behaviors of their relatives and friends, especially in situations where the protective effects can be directly observed (such as an increase in the number of wild animals), this comparative effect is even more significant. The specific action pathway of the conformity psychological mechanism indicates that farmers generate psychological pressure to avoid social isolation when they perceive supportive attitudes (SN2) from relatives and friends toward the development of protected areas. This pressure is magnified in rural communities with strong closed nature and becomes a powerful lever to promote behavioral transformation. The survey data further confirm that 76.8% of the farmers clearly stated, "If the majority of the villagers support protection, I will follow suit," demonstrating the profound influence of collective consciousness on individual decision-making. The investigation evidence of the peer pressure mechanism indicates that after farmers receive encouragement from their relatives and friends to participate in protection (SN3), they will develop a sense of responsibility to fulfill community obligations. This sense of responsibility is continuously strengthened at the regularly held villagers' meetings, forming a sustained behavioral motivation [63]. This multi-level and multi-dimensional mechanism of action confirms Konietzny's important assertion that "social norms have a lasting impact on repetitive voluntary behaviors", especially in the spatial dimension [35]. The closer the farmers are to the core area of the community, the deeper the degree of influence by the norms, and the stronger the stability and persistence of their protective behaviors [64].

5.2.2. The Indirect Path of Perceived Cost to Protective Behavior

Based on the SEM results, the standardized coefficient of the PC → AT → PB path was only 0.005, and H4b failed the test (the Bootstrap interval contains 0). This result has

important theoretical significance and practical value in the specific context of the surrounding communities of nature reserves. It intuitively indicates that farmers' perception of conservation costs has not been effectively transformed into a substantial change in their attitude towards ecological protection, which in turn leads to the H4b hypothesis not being supported. This discovery is highly consistent with the theoretical viewpoint proposed by some scholar [39] that "in resource-highly dependent communities, cost perception may be weakened by other factors", revealing the moderating role of specific social environments on cognitive assessment mechanisms. In resource-highly dependent communities, negative factors such as losses caused by wildlife accidents (PC1), restrictions on firewood collection (PC2), and constraints on wild plant collection (PC3) have not significantly influenced farmers' attitudes towards ecological protection. Behind this phenomenon, there are multiple mechanisms of action: Firstly, the implementation of ecological compensation policies forms a dynamic balance effect of "benefit–cost" through direct economic compensation (such as compensation income measured by the PEB1 indicator) and indirect opportunity compensation (such as PEB2 for eco-tourism employment and PEB3 for protection-related positions). When farmers obtain stable compensation income, they will reevaluate the net benefits of protective actions, thereby weakening the negative impact of cost perception. Secondly, farmers' expectations of the long-term benefits of protection policies (such as the value of ecosystem services brought about by environmental improvement and sustainable livelihood security, etc.) have a time discount advantage, which reduces the weight of short-term costs in decision-making evaluations. This cognitive characteristic leads farmers to pay more attention to the long-term comprehensive benefits of protective actions rather than the immediate direct losses [65].

The unique social structure and cultural traditions of the communities around nature reserves constitute a buffer layer for cost perception. In a tight community network, farmers can effectively disperse the protection costs borne by individuals through mutual assistance among relatives and friends, information sharing and collective actions. Meanwhile, the long-standing ecological protection cultural tradition has enabled farmers to internalize protection behaviors as part of community norms, thereby enhancing their psychological tolerance for costs. The synergistic effect of such social and cultural factors and compensation policies jointly explains the phenomenon that the cost perception effect is weakened. The weak effect of cost perception does not mean that costs do not exist. In policy design, it is still necessary to maintain sensitive monitoring of cost dynamics and adjust compensation standards and management measures in a timely manner. Emphasis should be placed on cultivating the non-economic motives of protective behaviors. Through educational publicity, community participation and other means, farmers' recognition of the intrinsic value of protective behaviors should be enhanced, thereby establishing a more sustainable protection mechanism [66]. This discovery not only enriches the theoretical understanding of behavioral decision-making in resource-dependent communities, but also provides a scientific basis for optimizing the management policies of nature reserves.

5.2.3. Indirect Paths of Perceived Cost to Protective Behavior

Although the direct path coefficient of PEB → AT reached 0.039 and was statistically significant ($p < 0.01$), the complete intermediary chain of PEB → AT → PB failed to be established. H5b failed the test (the Bootstrap interval contains 0). This indicates that H5b is not supported. Existing literature research suggests that income perception needs to go through multiple cognitive processing to be transformed into behavioral motivation [36]. That is to say, the transformation of economic benefit perception into behavioral motivation requires going through three cognitive stages: value assessment, emotional arousal, and decision integration. However, the weak influence of PEB on AT in this study (only 0.039)

precisely reflects the disruption of this transformation process. In the specific context of communities around nature reserves, although farmers can clearly perceive positive economic benefits such as ecological compensation income (PEB1), eco-tourism employment opportunities (PEB2), conservation-related positions (PEB3), and the increase in agricultural and forestry income (PEB4), these benefit perceptions have only completed the first stage of cognitive processing—value confirmation. However, it failed to effectively trigger subsequent emotional arousal and decision integration. Survey data shows that although 78.6% of farmers recognize the objective existence of these benefits, only 43.2% of farmers say that these benefits will significantly change their protective attitude, and only 29.7% of farmers believe that these benefits will directly prompt them to take protective actions. This disconnection between cognition and behavior confirms Lavuri's core viewpoint that "economic benefits need to be internalized through social norms in order to be transformed into behavioral motivation".

A thorough analysis of H5b may stem from three mechanism obstacles: Firstly, the immediate nature of economic benefits leads farmers to pay more attention to short-term gains, while ecological protection behaviors often require long-term investment. This time mismatch weakens the incentive effect of income perception. Secondly, in the absence of social norms to support it, economic benefits are difficult to form a sustained behavioral driving force, and farmers may view protective behaviors as "additional burdens" rather than "responsibilities and obligations". Finally, the perception of unfairness in income distribution will further weaken the effectiveness of income conversion. When some farmers believe that they have not received the income they deserve, their motivation to protect will significantly decrease. The faint influence of revenue perception does not imply that economic incentives are unimportant; rather, it reveals the complexity of their mechanism of action. In policy design, more attention should be paid to the transformation process of income perception [67]. Through measures such as optimizing income distribution methods, strengthening social norm construction, and fostering a protective culture, the effectiveness of economic incentives can be enhanced.

5.2.4. Indirect Paths of Environmental Improvement Perception to Protective Behaviors

The indirect path coefficient of environmental improvement perception (OEI) is 0.003, with $p > 0.05$. H6b failed the test (the Bootstrap interval contains 0). H6b is not supported. This result is highly consistent with some scholar'sresearch finding that "environmental cues have differentiated responses among different groups" [31]. Although farmers were able to observe objective environmental changes such as improved air quality (OEI1), enhanced forest health (OEI2), improved water cleanliness (OEI3), and an increase in the number of wild animals (OEI4), these improvements seemed to directly drive conservation behaviors more through direct pathways (OEI $\rightarrow$ PB = 1.101, $p < 0.01$). Rather than achieving transformation through attitude mediation. This mode of action validates the assertion proposed by Chen et al. that "the impact of environmental improvement on behavior may go beyond the cognitive evaluation process." [24]. As scholar pointed out in his research on grassroots governance, "Some variables may show weak effects due to differences in context". In the special environment of communities around nature reserves, the behavioral decisions of farmers may be influenced by more complex psychological mechanisms and social factors. For instance, among the groups of farmers whose livelihood capital is relatively fragile, the behavioral choices made under the pressure of making a living may bypass the stage of attitude evaluation and directly make behavioral decisions based on actual needs. This complexity reveals that in ecological protection practice, a single theoretical model may be difficult to fully explain all behavioral phenomena, and a more comprehensive analytical framework needs to be constructed.

From a methodological perspective, these unsupported approaches also reflect the limitations of structural equation models in addressing complex social phenomena. While SEM can effectively identify direct and indirect effects among variables, with the presence of multiple moderating factors and contextual differences, may cause some effects to be replaced or offset by unobserved variables. For instance, the impact of perceived costs may be buffered by community cohesion, the incentives of ecological benefits may be weakened by institutional distrust, and the effects of environmental improvement may be masked by other social issues.

6. Conclusions and Policy Implications

6.1. Conclusions

This study systematically analyzed the multiple driving mechanisms of farmers' conservation behaviors in the surrounding communities of nature reserves by means of the Structural Equation Model (SEM). Based on the questionnaire data of 400 farmers from 7 protected areas in Sichuan and Shaanxi, the research has the following findings:

6.1.1. The Core Driving Force of a Protective Attitude

The subjective ecological protection attitude (AT) of farmers has a significant positive impact on protection behavior (PB) ($\beta = 0.070$, $p < 0.001$). This attitude, through the value recognition mechanism, moral restraint mechanism and behavioral convenience mechanism, directly promotes the implementation of protective behavior, which fully confirms the core viewpoint in the theory of planned behavior that "attitude is the direct determining factor of behavioral intention and actual behavior". This result highlights the fundamental position of attitude cultivation in ecological protection policies.

6.1.2. The "Action Prompt" Effect of Environmental Improvement

The direct promoting effect of objective environment improvement (OEI) on protective behaviors was the most significant ($\beta = 1.101$, $p < 0.01$). When farmers intuitively perceive specific ecological signals such as improved air quality (OEI1), enhanced forest health (OEI2), increased water cleanliness (OEI3), and a growing number of wild animals (OEI4), these changes can bypass complex cognitive processing procedures and directly pass through signal transmission mechanisms, situational incentive mechanisms, and effectiveness confirmation mechanisms. Inspire farmers to take protective actions.

6.1.3. The Chain-like Transmission Path of Social Norms

Social norms (SN) significantly strengthened farmers' protective attitudes through demonstration effects (such as SN1 of relatives and friends' participation in protective activities) and herd mentality ($\beta = 0.512$, $p < 0.01$) and further indirectly had a positive impact on protective behaviors through attitudes ($\beta = 0.036$, $p < 0.05$). Thus, a complete transmission chain of "norms $\rightarrow$ attitudes $\rightarrow$ behaviors" has been formed. Among them, social comparison, peer pressure and expectation norms jointly act on the internalization process of attitudes.

6.1.4. The Asymmetric Impact of Cost and Benefit Perception

Ecological benefit perception (PEB) has a significant positive effect on conservation attitudes ($\beta = 0.039$, $p < 0.01$), indicating that farmers are relatively sensitive to economic incentives. However, the inhibitory effect of perceived cost (PC) on conservation attitudes is not significant, which indicates that under the synergistic effect of ecological compensation policies and social norms, farmers' sensitivity to costs is relatively low.

In conclusion, this study clearly reveals the multiple driving mechanisms of farmers' conservation behaviors in the surrounding communities of nature reserves. Factors such as protection attitudes, environmental improvement, social norms, and perception of costs and benefits all influence farmers' protection behaviors to varying degrees. This provides an important theoretical basis for formulating more targeted and effective ecological protection policies.

6.2. Policy Implications

6.2.1. Strengthen the Demonstration Effect of the Typical Selection and Ecological Points System of the Community

Its corresponding assumptions are H2 and H3a. It is suggested to establish a "three-dimensional integrated" ecological role model cultivation system: Firstly, a "red and black list" public announcement mechanism should be set up at the village level, quantifying specific protection behaviors such as participating in wildlife rescue (PB1) and eliminating excessive deforestation (PB2) into ecological points. For instance, successfully rescuing key national protected wild animals can accumulate 5 points, and having no illegal logging behavior for three consecutive months can accumulate 3 points. Secondly, the points will be directly linked to the allocation of community resources. Families ranking in the top 10% in terms of points will be given priority to obtain the position of ecological forest ranger (PEB3) and the right to operate rural tourism (PEB2). Finally, the title of "Ecological Guardian Star" was awarded at the quarterly commendation conference, forming a virtuous cycle of "exemplary demonstration—point incentives—resource allocation". In the specific implementation, it can be combined with the development of mobile applications to enable farmers to view their points ranking and ecological deeds in real time. The social comparative psychology can be stimulated through the visual ranking of, the sustainability of incentives can be enhanced by binding resources, and the influence range can be expanded by spreading through rituals. A pilot program in Tangjiahe Reserve shows that after the implementation of this system, the frequency of community residents' participation in patrols has increased by 47.3%, and the number of wildlife rescued has grown by 31.6% year-on-year. This institutional design can effectively activate the demonstration and transmission mechanism in the social network, promoting the rapid spread of protective behaviors within the community.

6.2.2. Optimization of the "Baseline Compensation + Performance Reward" Gradient Ecological Compensation Mechanism

Its corresponding assumptions are H1, H5a and H6a. Establish a dual-layer compensation framework of "minimum guarantee + floating": The baseline compensation is set at a standard of 3000/2000/1000 yuan (About 423/282/141 US dollars) per year for the core area, buffer zone and experimental zone of the protected area, respectively, to ensure the basic rights and interests of farmers. Performance rewards are divided into three levels of gradients based on ecological scores (30% baseline for level I rewards, 50% for level II rewards, and 80% for level III rewards), and at the same time, ecological service value accounting coefficients (such as 0.3 weight for water conservation and 0.2 weight for carbon sink function, etc.) are introduced for dynamic adjustment. For instance, in the practice of Zhouzhi Reserve, objective indicators such as the forest protection area of farmers (OEI2) and the effectiveness of water body protection (OEI3) have been incorporated into the performance evaluation system. This mechanism requires the development of a smart contract system to automatically distribute and trace the behavior of compensation funds through blockchain technology. The operation of the mechanism needs to focus on three connections: The connection between the compensation standard and the economic level of the region (for example, setting the baseline at 30% of the local per capita income). The

performance standards are linked to the protection difficulty for the high-cost perceived group. Compensation distribution is in line with the seasonal characteristics (for example, 50% is distributed before the farming season).

6.2.3. Dynamic Compensation Standards and Precise Support Mechanisms for Wildlife Damage

Its corresponding assumptions are H4a. Establish a compensation standard formulation mechanism of "baseline survey historica + real-time assessment + dynamic adjustment": Firstly, establish a basic database of the frequency of wildlife accidents and the degree of losses (such as PC1 indicators), and update the compensation base quarterly. Secondly, regional difference adjustment factors are introduced. For instance, the compensation standard for wild boar damage in the Qinling region is based on altitude (80 yuan per mu for areas below 800 m and 100 yuan per mu for areas between 800 and 1500 m). Meanwhile, an additional 30% precise compensation is provided for high-cost perception groups (such as farmers whose PC values are in the top 25% of the sample). At the same time, protective facilities and technical guidance (such as training on the installation of pulse fences) are provided as supporting facilities. In terms of the compensation distribution method, a phased payment model of "30% advance payment + 40% acceptance + 30% performance" is adopted. In the practice of the Huangbaiyuan reserve, this mechanism combines unmanned aerial vehicle inspection and infrared monitoring technologies to achieve precise identification and timely response to damage situations. This design can effectively alleviate the contradiction between protection and livelihoods and enhance the sustainability of protection policies.

This study reveals the multiple driving mechanisms of farmers' conservation behaviors in the surrounding communities of nature reserves through structural equation models, but there are still several research directions that can be further expanded: First, cross-regional comparison and scale effect deepening. The research scope needs to be expanded to ecosystem types such as wetlands in the East China Plain and forest areas in Northeast China, and the regulatory effect of geographical background on driving paths should be quantified through multiple sets of analyses. Under the background of the national park system construction, it is necessary to combine landscape ecology methods to analyze the cross-administrative boundary spatial spillover effect of ecological compensation policies and explore the institutional design of regional collaborative governance. Secondly, dynamic tracking and behavioral evolution mechanism. The current cross-sectional data is difficult to capture the dynamic nature of behavior. It is necessary to build a tracking survey database, use the potential growth model to depict the interaction trajectory between social norms (SN) and protective attitudes (AT) within a three-year period, and construct a time-varying causal inference framework to reveal the long-term dynamic patterns. Finally, policy intervention experiments and simulation optimization. It is suggested that a randomized controlled trial method be adopted to conduct quasi-experimental design for policy combinations such as the ecological credit system and the gradient compensation mechanism. Combined with subject modeling to simulate the behavioral responses of farmers, a policy pre-verification platform should be established to enhance the accuracy of policy implementation.

This study acknowledges potential limitations in sample representativeness. The sample size, while sufficient for hypothesis testing (e.g., H3b: SN $\rightarrow$ AT $\rightarrow$ PB with coefficient = 0.036), may constrain generalizability to broader populations. Additionally, the age structure and gender distribution exhibit imbalances, potentially skewing the applicability of findings across demographic groups. These factors highlight the need for future research to employ larger, more diverse samples to enhance external validity.

Despite these limitations, the study's core insights remain robust within the context of the collected data.

Future research can further integrate remote sensing monitoring and community participation data to build an integrated research paradigm of "monitoring—simulation—verification", providing methodological support for the modernization of the governance system of nature reserves.

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Informed Consent Statement: Verbal informed consent was obtained from the subjects knowing that the data would be used for scientific research. Because this study was conducted in a protected area, the conditions were such that it was not convenient to obtain paper informed consent. Also, farmers were sensitive to paper signatures and were reluctant to provide them, so only verbal informed consent was obtained.

Data Availability Statement: To protect the privacy of farmers, the data will not be made public.

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