The effects of social network and environmental risk perception on farmers' willingness to participate in the management of black-smelling water

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Abstract. Based on the field research data in Shaanxi area, the binary logit model and ISM model were organically combined to study the influencing factors and their hierarchical structure affecting farmers' willingness to participate in the management of black-smell water from the perspective of social network and environmental risk perception. The results of the study show that: blood relationship network, karma relationship network, geographic relationship network, environmental risk factual perception, environmental risk cause perception and environmental risk loss perception have positive influence on farmers' willingness to participate, geographic relationship network, blood relationship network and karma relationship network are the most direct and superficial influencing factors, and environmental risk cause perception is located in the second tier, environmental risk factual perception is located in the third tier, and environmental risk loss perception is the most direct and superficial influencing factor, while environmental risk cause perception is located in the third tier, and environmental risk loss perception is located in the third tier. Perceived environmental risk loss is the lowest and most fundamental influence factor, which will act on the upper-level factors. We empirically analyze the influence of social network and environmental risk perception on farmers' willingness to participate in the management of black-smell water. At the same time, based on the results of ISM model, the hypothesis that social network may play a mediating role is proposed, and the hypothesis is verified. In view of this, it is necessary to establish a governance system with the collaboration of the whole society and the participation of the whole public, and to enhance the willingness of farmers to participate by strengthening the social network and farmers' perception of environmental pollution.

Keywords: social network, environmental risk perception, black-smelling water, willingness.

1. Introduction

Clean water starts a new journey, and the countryside is revitalized." Solving the problem of black smelly water pollution in rural areas is an indispensable and important component of the rural revitalization strategy, which is related to the well-being of 600 million rural residents as well as the effectiveness of the construction of eco-livability.In 2015, the State Council issued the "Action Plan for the Prevention and Control of Water Pollution", which comprehensively deploys the prevention and control of water pollution, including the treatment of black smelly water, and promotes the treatment of black smelly water in various places, which is the important basis for a series of subsequent black smelly water treatment policies.In December 2023, the Ministry of Ecology and Environment, the Ministry of Water Resources, and the Ministry of Agriculture and Rural Development jointly issued the "Guidelines for the Treatment of Rural Black and Odorous Water " to carry out the treatment of rural black and odorous water in the whole county as a unit of county-level administrative districts, insisting on controlling the source of pollution as the fundamental, and advancing the work according to the basic technological line of "controlling and intercepting the pollution, treating the endogenous sources, linking up the water system, and ecological restoration".The basic technical line of "pollution control, internal source treatment, water system connection, ecological restoration" has promoted the work and provided professional guidance for the management of rural black smelly water. However, at present, China's rural black smelly water management method is completely relying on a single environmental governance model led by government departments, there is a typical tendency of "focusing on construction but not on

management, focusing on technology but not on mechanism", which triggers the "can't afford to cure, can't cure problems"[1].

Farmers as an important subject and direct beneficiaries of rural habitat management, their willingness to participate in governance will significantly affect the effectiveness of governance, which in turn affects the rural ecology and habitat, and ultimately affects the farmers' sense of well-being and sense of belonging. However, most farmers are not aware of the above problems, due to the lack of farmers' participation, in the rural black smelly water management mode selection, can not take the most effective measures to "prescribe the right medicine" according to the local conditions, so that the "anti-black and anti-odor" phenomenon occurs frequently, and some of them are not able to take the most effective measures. Some grassroots government workers have turned the implementation of rural black-odor water management into a formality and a "face-saving project" for the grass-roots government [2]. Therefore, to completely solve the problem of black-smelling water pollution in rural areas, it is necessary to fundamentally find an effective way of sustainable management for farmers, which is a key measure for building "ecologically livable" beautiful homes and realizing the strategy of rural revitalization, and also an important guarantee for the construction of a harmonious and beautiful countryside and the promotion of comprehensive development of the countryside.

Summarizing the current research of scholars at home and abroad on the willingness of farmers to participate, mainly from the agricultural infrastructure construction [3], separate treatment of domestic waste [4], green production technology adoption behavior [5], rural cooperative [6] and other aspects have been explored, with relatively few studies focusing on rural wastewater management. The participation of farmers in the management of black-smell water means that farmers can take the initiative to participate in cleaning up the garbage, weeds and silt in rivers and ditches to enhance the self-purification ability of the water, and at the same time, take the initiative to pay attention to the sewage discharge behaviors of neighboring enterprises, farms and other possible sources of pollution to ensure the effective advancement of management work.

Cognitive psychology theory suggests that the willingness of economic agents to participate is based on cognition [7], Farmers' willingness to participate in the treatment of black-smelling water is also based on their perception of the risk of black-smelling water. Therefore, farmers' perception of the fact of pollution caused by black smelly water, such as foul smell, flies and insects, death of organisms, and deterioration of water quality, the cause of pollution, such as the lack of wastewater treatment facilities in the village and the lack of funds for sewage treatment, as well as the loss of crop yields and health hazards to farmers caused by water pollution, will directly affect the willingness of farmers to participate in the management of black smelly water. It has been shown that risk perception enhances farmers' willingness to pay for waste disposal [8], enhances pro-environmental behaviors of farmers[9], and farmers' willingness to participate in latrine reform [10]. However, the relationship between farmers' risk perception of black smelly water and their willingness to participate in the management of black smelly water needs to be studied in depth. In addition, farmers are not only "economic beings" but also "social beings"[11]. It has been shown that social networks significantly affect the willingness of farmers to participate in rural habitat management. [12-14] Whether farmers will make decisions to participate in the management of black-smelling water is therefore influenced not only by risk perceptions but also by rural social networks. Especially in China, a country characterized by significant social networks and closely intertwined relationships of blood, kinship, geography, and karma, the complex structure of social networks has a significant impact on the way farmers participate in production and life and their willingness to participate [15]. Communication between farmers can obtain relevant knowledge and methods of black smelly water management, popularize the size of the loss caused by black smelly water pollution, and then change the behavioral intention of farmers and enhance their willingness to manage. At present, most farmers do not perceive the risk of black smelly water pollution deeply and comprehensively, only focusing on the fact that the water is polluted, and do not have a deep understanding of the reasons for the ineffectiveness of black smelly water pollution control and the

losses that black smelly water pollution will bring to the farmers. This in-depth and incomplete perception affects the perception and opinion of the whole village residents through the social network, which in turn reduces the motivation of farmers to participate in the governance and affects their willingness to participate.

The above research results provide a solid theoretical foundation for this paper, but there is still room for expansion: in terms of research perspectives, most scholars chose the willingness of rural human settlements governance as the explanatory variable, or from the garbage disposal [16], publicinfrastructure development [3] The willingness to participate in such segmented areas has been researched, but fewer scholars explored in depth the willingness of farmers to participate in the segmented area of black smelly water management. In addition, many of the existing articles related to rural habitat improvement have chosen to set social network as the core independent variable, and some of these studies include: the complementary and substitution relationship between social network and Internet use in influencing the technology adoption behavior of farm households [5], the moderating role of social networks in the impact of aging agricultural labor force on farmers' green production technology adoption behavior [17], the use of Internet [5], In terms of research methodology, most of the existing studies were modeled through Probit [18-20]or Logit [8, 21, 22], However, the hierarchical relationship between multiple explanatory variables is neglected, and decomposition of the hierarchical relationship can help to clarify the interrelationships among the variables to find the intrinsic linkages among them [7]. Given this, this paper takes the location of rural black-smelling water in Shaanxi Province as the scope of the study, based on the survey data of 327 farmers, from the willingness of farmers to participate in the management of black-smelling water, we use the binary logit model to study the influence of environmental risk perception and social network on the willingness of farmers to participate in the management of black-smelling water. Based on this, we explore the relationship between the explanatory variables with the help of the Interpretive Structural Modeling (ISM), to put forward relevant suggestions for the government to formulate corresponding environmental behavior guidance strategies.

2. Theoretical model and hypotheses development

2.1. Hypotheses Development

2.1.1. The Influence of Social Networks on Farmers' Willingness to Participate in the Management of Black-Smelling Water

The theory of social embeddedness shows that the behavior of economic agents is embedded in social relations and social structures, so economic phenomena cannot be understood only from the logic of the economy itself. Chinese rural society has always been characterized by its rural nature, with a special network of rural social relations. Whether a farmer takes positive behavioral measures to manage the environment will largely influence the behavior of the surrounding farmers when they are in a relatively close social network [23]. These include the blood ties of predisposition, the karmic ties of self-inflicted causes, and the "geographic ties" formed through geographic location. [24, 25] Blood ties mean that farmers are close to each other and have a high degree of familiarity with each other, which is manifested in the form of relatives who are in constant contact with each other. The "internal and external differentiation" strategy that farmers follow in the blood relationship network will make them psychologically favor their "own family" in collective affairs and emotionally reluctant to cooperate with their "own family."When one of the more powerful members of their own family comes forward to call for participation in the management of black-smelling water, other people will participate in the management of water even if they do not want to create conflicts; Contemporary part of the countryside already has a large-scale township enterprises and a wide range of karmic relations, this kind of karmic relations from the employment of labor, strengthened by the daily interaction, the factory owner's behavior of the leading role will also be amplified, as long as the owner of the factory ordered to prohibit the pollution of the water, the workers will also protect

the water [26]. In addition, the skills and techniques related to the management of black stinky water learned through the business relationship will also enhance the willingness of farmers to participate; geo-relationships are mainly through the "internalization mechanism" to establish the "identity of one's people", which makes the "favor" and "face" become the key factors affecting the communication of farmers. The "favor" and "face" become the key factors influencing the farmers' communication. When others are caring for the environment, even if they are in the position of "maintaining face" individual farmers will not carry out the pollution of the water but actively participate in it together. Water pollution, but actively participate in the management together. The embeddedness and closed nature of the social network makes the behavioral decisions of individual farmers not completely independent, but influenced by other members of the network, and often manifests itself as a group decision-making of the herd [27, 28].

In summary, this closely interconnected network of social relations can limit individual actions while also enabling farmers to implement mutually beneficial behaviors more smoothly, and at the same time, factors such as face and human feelings can, to a certain extent, promote the recognition of mutually beneficial behaviors in the collective farmers, i.e., change the internal perception of farmers on the problem of black-smelling water. As long as individual farmers get enough feedback on the collective benefits of managing black-smelling water or the influence of others' actions through their blood, business, and geographic networks, it is possible to generate the idea of participating in the management of black-smelling water and then put it into action. The social network can promote the active participation of farmers in the management of black-smelling water to a certain extent. Most of the existing studies take social network as a whole variable, this paper mainly from the perspective of farmers' social relationship network, divided into two dimensions: acquaintance society and social network, and categorized the relationship network in a more detailed way, to study the role of social relationship network in the willingness to participate in the governance of farmers. In summary, this paper proposes hypothesis H1:

H1: Social network has a positive effect on the willingness of farmers to participate in the management of black-odor water;

H1a: The blood relationship network has a positive effect on the willingness of farmers to participate in the management of black-odor water;

H1b: The geographic network has a positive effect on the willingness of farmers to participate in the management of black-odor water;

H1c: The business relationship network on the willingness of farmers to participate in the management of black-odor water ;

2.1.2. The Effect of Environmental Risk Perception on Farmers' Willingness to Participate in the Management of Black-Smelling Water

Environmental risk perception is derived from the concept of risk perception. Risk perception is the degree of subjective awareness of the losses and hazards that may be caused by uncertain events [29]. The concept of "environmental risk perception" has yet to be defined accurately and uniformly in the academic community. However, through combing domestic and international literature, most researchers believe that "environmental risk perception" is the subjective judgment and direct feeling of the public facing environmental risks. [30] Environmental risks are usually accompanied by the occurrence of damage or destruction of the natural environment and are mainly governed by both situational and individual factors. Therefore, farmers' risk perception of black stinky water pollution directly affects their attitudinal decision-making, i.e., their willingness to participate in the treatment. It has been shown that the key element influencing farmers' participation in habitat governance is environmental risk perception, which is positively related to the willingness to participate in environmental governance [31]. And farmers' willingness is governed by the perception of risk, "risk means different things to different people." Therefore, each person's risk perception may be higher or lower than the objective reality, thus affecting individuals or groups; that is to say, farmers judge the rural environmental pollution problem according to their perceptions, evaluate the risks and

consequences brought about by it, and then make a decision on whether they want to participate in the management of black-smelling water.

Regarding Wang Yuan's scholars, this paper categorizes environmental risk perception into three types: risk fact perception, risk loss perception, and risk cause perception [32]. Perceived environmental risk fact refers to the farmers for the black odor water pollution fact recognition, farmers for the black odor water pollution this fact of the higher the degree of recognition, participation in the management of the stronger will; environmental risk cause perception refers to the farmers for the cause of the current black odor water pollution causes the understanding of the cause of the black odor water pollution, farmers for the cause of the black odor water pollution the more understanding of the cause of the black odor water pollution, more aware of how to manage the pollution, the participation in the management of the perceived environmental risk loss refers to the loss of farmers' interests due to environmental pollution, for example, when farmers realize that black-smelling water are harmful to their health, farmers will participate in the management of black-smelling water out of the protection of their health. Based on this, the following research hypotheses are proposed:

H2: Environmental risk perception has a positive effect on the willingness of farmers to participate in the management of black-odor water;

H2a: Environmental risk fact perception has a positive effect on farmers' willingness to participate in the management of black-odor water;

H2b: Environmental risk cause perception has a positive effect on farmers' willingness to participate in the management of black-odor water;

H2c: Environmental risk loss perception has a positive effect on farmers' willingness to participate in the management of black-odor water;

2.1.3. The Mediating Role of Social Networks in Environmental Risk Perception and Farmers' Willingness to Participate in the Management of Black-smelling Water

As one of the important channels for farmers to obtain information, social network plays a key role in the process of farmers' participation in the management of black-smelling water. On the one hand, the social network can effectively alleviate the information asymmetry problem caused by farmers' incomplete knowledge of the environment, and farmers with strong environmental risk perception ability can transfer reliable information related to environmental governance through blood, geographic, and business relationship networks, thus enhancing the willingness of other farmers to participate; on the other hand, the social learning effect points out that individuals will imitate and learn from others' behaviors, according to others' behavioral experience to adjust their behavior [33]. When farmers observe that those farmers with a strong perception of environmental risks have improved their water after participating in the treatment of black-smelling water, their willingness to participate will also increase. In addition, the willingness to participate will also increase when farmers observe that farmers with strong influence in the network of blood, geographic, and business relations are involved in the management of water. In this paper, the mediating role is firstly identified by the ISM model and then tested by Bootstrap.

Based on the above, the hypothesis is formulated:

H3: Social networks play a mediating role in environmental risk perception and farmers' willingness to participate in the management of black-smelling water.

3. Methodology

3.1. Data Sources

This research location was selected as the main research site based on the "Public Announcement of Black Odor Water Control in Shaanxi Province in 2023" issued by the Department of Urban and Rural Housing and Construction of Shaanxi Province and the Department of Ecology and Environment of Shaanxi Province in March 2024, which selected the Dafu, Banqiao, and Songzhuang

villages of Xingping City, Xianyang City, as the main research site.And in July and August 2024, household surveys were conducted in areas with problems related to black-odor water pollution in Shaanxi Province.The research area included Xingping City, Xianyang City and Yangling District, Xianyang City.A total of 350 questionnaires were distributed, and after excluding incomplete information and unrecovered questionnaires, there were 327 valid questionnaires, with an effective rate of 93.43%.

3.2. Variable measurement

3.2.1. Implicit Variable

The dependent variable in this paper refers to the willingness of farmers to participate in the management of black-smelling water .In terms of measuring the willingness of farmers to participate in the management of black-smelling water , this paper chooses to use the question "Are you willing to participate in the management of black-smelling water ?"to measure the dependent variable, i.e., the dependent variable is divided into dichotomous variables, "1=willing" means that farmers are willing to participate in black smelly water management; "0=unwilling" means that farmers are unwilling to participate in black smelly water management.

3.2.2. Independent Variable

This paper focuses on the influence of social network and environmental risk perception on farmers' willingness to participate in the management of black-smelling water, so social network and environmental risk perception are taken as core independent variables. The willingness of farmers to participate in the management of black-smelling water is taken as the fixed dependent variable. In addition to environmental risk perception and social network, there are other uncertain factors. Therefore, farm household characteristics and others were included as control variables.

3.3. Model setup

3.3.1. Binary logit model

In analyzing the influence of social network and interpersonal trust on the willingness of farmers to participate in habitat improvement, willingness to participate is the explanatory variable. Since this variable is dichotomous, this paper constructs a Logit model to analyze it. The setup equation is:

$$Logit(P) = \ln(\frac{P}{1-P}) = \alpha + \Sigma\beta_j X_j + \varepsilon$$

P indicates the probability that a farmer is willing to participate in the management of a black-smelling water, 1-P indicates the probability that a farmer isn't willing to participate in the management of a black-smelling water,α is a constant term, βj (j=1,2,…,n) is the parameter to be estimated, ε is the random error term. Xj denotes the jth explanatory variable that affects the willingness of farmers to participate in the management of black-smelling water.

3.3.2. ISM models identify mediating effects

The Interpretive Structural Model(ISM), as a system analysis tool, can transform the complex relationships among elements in a complex system into an intuitive multilevel recursive order structure [34]. Describe the direct relationship of elements through the adjacency matrix, and then get the reachability matrix by matrix operation, clarify the direct and indirect relationship between elements, and then divide the hierarchy to construct the hierarchical structure model to reveal the hierarchy of the system and the intrinsic connection [7] This paper intends to use explanatory structural modeling to analyze the hierarchical structure and interrelationships affecting farmers' willingness to participate in the management of black-smelling water.

The construction steps include:

Step 1: Construct the adjacency matrix, considering whether there is a direct link between the elements represented by the matrix elements;

$$S_{ij}\begin{cases}1, & S_i \text{directly affects } S_j \\ 0, & S_i \text{don't direct affects } S_j\end{cases} \quad i=0,1,2,...,6;\ j=0,1,2,...,6 \tag{1}$$

Step 2: Boolean operation is then performed on the adjacency matrix to obtain the reachable matrix. Assuming that the adjacency matrix is R and the unit array is I, the reachable matrix is M, we have:

$$M=(R+I)^{\lambda}=(R+I)^{(\lambda-1)}\neq...\neq(R+I)^{2}\neq(R+I) \tag{2}$$

Step 3: Divide the elements into tiers based on the reachability matrix M.Calculate the reachable set and the prior set of each element, find the element that satisfies the specific conditions as the highest tier element, and then divide the other tiers by analogy.

Step 4: Draw a recursive hierarchical directed graph according to the hierarchical relationship, using nodes to represent the elements and directed edges to represent the relationship, to get the surface, direct, intermediate, and fundamental factors affecting the willingness of farmers to participate in the management of black-smelling water.

3.3.3. Bootstrap method to test the role of mediation

Bootstrap method is considered to be a better method to directly test the mediating role. When analyzing the mediating effect, its significant advantages are mainly reflected in: (1) the traditional causal stepwise regression method requires the data to obey the normal distribution, while the Bootstrap method does not have this prerequisite, and the scope of application is much wider; (2) the traditional mediating effect test method often presupposes that the independent variable has a direct and significant effect on the dependent variable, which is the prerequisite for its application. In contrast, the Bootstrap method does not need to rely on the establishment of this preset path, it can directly test the significance of the mediating effect, thus more effectively avoiding the "masking effect" caused by the existence of two mediating paths in the opposite direction, cancel each other's effects, showing the superiority of its methodology [35]. (3) Bootstrap method is suitable for small samples and its statistical efficacy is strong. Therefore, it is highly applicable to test the mediating role of social networks using the Bootstrap method. Based on this, the specific conceptual model of this paper is designed as:

$Y=cX+e_1$, X and Y perform regression modeling.

$M=aX+e_2$, X and M perform regression modeling.

$Y=c'X+bM+e_3$, X and M with Y for regression modeling.

X denotes environmental risk perception, including three dimensions of environmental risk fact perception, environmental risk cause perception, and environmental risk loss perception; Y denotes farmers' willingness to participate in the management of black-smell water; M denotes the mediating variable social network; and e1, e2, e3 denote the error terms.

4. Analysis and Results

4.1. Benchmark Regression Analysis

4.1.1. Analysis of the Impact of Social Networks

Industry-related social networks, geographical social networks, and kinship social networks all exhibit a positive impact on farmers' willingness to participate in black-odor water governance at the 1% significance level, supporting hypotheses H1a, H1b, and H1c. This indicates that the closer the kinship, geographical, and industry-related social ties among farmers, the stronger their willingness to engage in black-odor water governance. Specifically, (1) Tighter kinship networks enhance mutual care and influence among family members. When a family member recognizes the health risks (e.g., pollution threatening physical health) posed by black-odor water, others are more likely to participate in governance under their influence. (2) Closer geographical networks, characterized by frequent interactions and shared use of public resources, facilitate information exchange and common interest

alignment among neighbors, thereby strengthening collective participation willingness. (3) Tight industry-related networks provide platforms for communication and collaboration. Farmers exposed to governance experiences and methods through these networks enhance their participation willingness. Additionally, industry-related networks are economically intertwined; when black-odor water pollution threatens shared economic interests (e.g., agricultural production), farmers within the same industrial chain exhibit stronger governance willingness driven by collective economic incentives.

4.1.2. Analysis of the Impact of Environmental Risk Perception

Table 1 shows that environmental risk loss perception exerts a significant positive impact on farmers' participation willingness at the 1% significance level (hypothesis H2c supported). This suggests that farmers perceiving higher potential losses (e.g., crop yield reduction from contaminated irrigation water, disease transmission from mosquito breeding) are more motivated to engage in governance. Environmental risk fact perception demonstrates a positive effect at the 5% significance level (hypothesis H2a supported), indicating that awareness of the existence of local black-odor water directly increases participation willingness. Environmental risk cause perception shows a marginally significant positive effect at the 10% level (hypothesis H2b supported), implying that understanding pollution causes (facilitating targeted solutions) weakly but positively influences participation willingness.

Table 1. Model Regression Results

Item	Regression Coefficient	Standard Error
The blood relationship network	2.403*** (3.046)	0.789
The geographic relationship network	1.559* (1.954)	0.798
The industry - related relationship network	4.101*** (3.079)	1.332
Environmental risk fact perception	6.380** (2.265)	2.817
Environmental risk cause perception	2.645* (1.693)	1.562
Environmental risk loss perception	3.018*** (3.546)	0.851
Age	-0.311 (-0.823)	1.213
Educational Background	-0.627 (-1.303)	0.481
Whether a Party Member/Village Cadre	-0.771 (-0.636)	0.378
Intercept	-43.253*** (-3.941)	10.976

4.2. Mediating Effect

4.2.1. Identification of the Mediating Effect

Based on the analysis results of the influencing factors of farmers' participation in black - odor water governance mentioned earlier, the following settings are given: S0 represents the explained variable, that is, farmers' willingness to participate in black - odor water governance. S1, S2, S3, S4, S5, and S6 respectively represent six key influencing factors: environmental risk fact perception, environmental risk loss perception, environmental risk cause perception, blood network, geographical network, and industry - related network. Through theoretical analysis and expert scoring, the logical relationship of the influencing factors of farmers' willingness to participate in black - odor water

governance is finally drawn. Among them, A indicates that the row factor will have a direct impact on the column factor; V indicates that the column factor will have a direct impact on the row factor; O indicates that there is no direct impact between the row factor and the column factor.

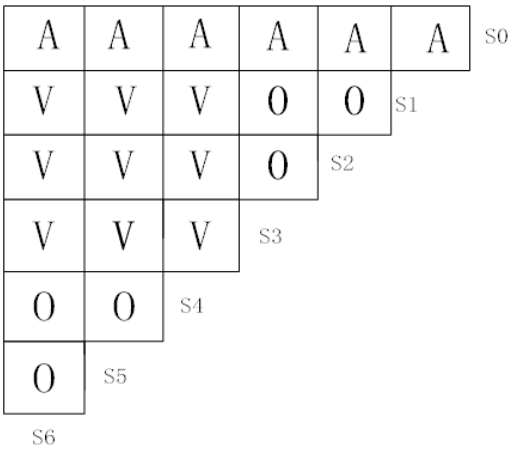

Figure 1. logical relationship diagram

According to Figure 1 and Equation (1), the adjacent matrix R can be obtained, and further, the reachability matrix M can be calculated according to Equation (2). For the reachability matrix M, first determine the highest - level elements according to the Boolean operation rules $L_1 = \{S_0\}$, and then determine them one by one $L_2 = \{S_4, S_5, S_6\}$, $L_3 = \{S_1, S_2, S_3\}$ to obtain the sorted reachability matrix B.

	S0	S1	S2	S3	S4	S5	S6
S0	1	0	0	0	0	0	0
S1	1	1	0	0	1	1	1
S2	1	0	1	0	1	1	1
M =S3	1	0	0	1	1	1	1
S4	1	0	0	0	1	0	0
S5	1	0	0	0	0	1	0
S6	1	0	0	0	0	0	1

The sorted reachability matrix:

	S0	S4	S5	S6	S3	S1	S2
S0	1	0	0	0	0	0	0
S4	1	1	0	0	0	0	0
S5	1	0	1	0	0	0	0
B=S6	1	0	0	1	0	0	0
S3	1	1	1	1	1	0	0
S1	1	1	1	1	0	1	0
S2	1	1	1	1	0	0	1

Construct a hierarchical structure directed graph according to the sorted reachability matrix B. As can be seen from Figure 2, among the numerous factors influencing farmers' willingness to participate in the governance of black-odor water, geographical relationship networks, kinship relationship networks, and industry relationship networks are the most direct and superficial influencing factors. The perception of environmental risk causes is at the second level; the perception of environmental risk facts is at the third level, directly acting on the perception of environmental risk causes; the perception of environmental risk losses, as the most fundamental factor at the bottom level, will act on the upper-level factors. Combining with the regression results of the previous binary logit model, it can be known that each key factor influencing farmers' willingness to participate can not only directly act on the willingness to participate but also indirectly act on it through interconnections. Through the analysis of the interpretative structural model, we find that the influences of environmental risk perception are all

located at relatively deeper and more fundamental positions, while the influences of social networks are all located at relatively more direct and superficial positions. Therefore, Hypothesis H3 is preliminarily verified.

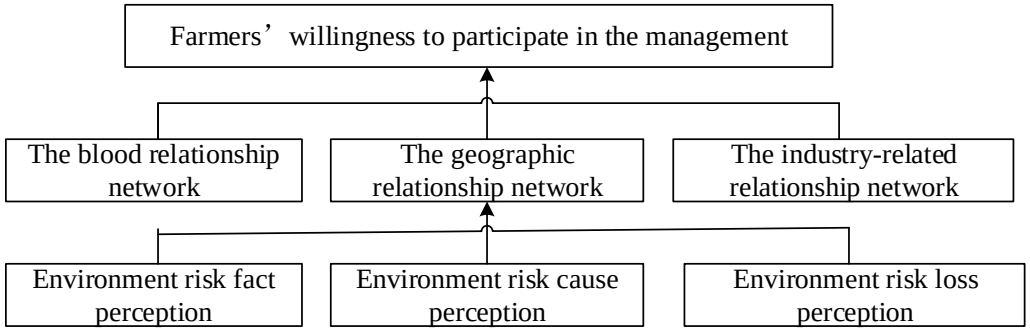

Figure 2. Hierarchical Structure Directed Graph

4.2.2. Test of Mediating Effect

The following Table 2 shows the verification process of the mediating effect. Model 1 shows that environmental risk perception has a significant impact on farmers' willingness to participate in black - odor water governance at the 1% level. Model 2 shows that environmental risk perception also has a positive impact on the closeness of farmers' social networks at the 15% significance level. Model 3 shows that when both environmental risk perception and social networks are used as explanatory variables, their impacts on the explained variable are both positively significant at the 1% level. When farmers' environmental risk perception of black - odor water increases, they will be more active in communicating relevant information in social networks. Farmers may take the initiative to organize or participate in discussions, meetings, and other activities related to black - odor water , further consolidating and expanding their social network connections regarding environmental issues. Specifically, when a farmer learns that black - odor water may lead to a decline in the quality of agricultural products, he will share this information with members of his social network such as relatives and neighbors. The intensification of such information exchange will make social networks more active regarding black - odor water issues. In addition, social networks provide villagers with access to governance resources. When farmers with a stronger environmental risk perception realize that they can obtain these resources through social networks, their willingness to participate in black - odor water governance will increase.

Table 2. Mediation Effect Test

Variables	Implicit Variable: farmers' willingnss to participate in the governance of black-odor water	Implicit Variable: Social Network	Implicit Variable: farmers' willingness to participate in the governance of black-odor water
--	Model1: Y=cX+e1	Model2: M=aX+e2	Model3: Y=c'X+bM+e3
Constant	-0.668***	1.877***	-1.108***
Age	-0.004	-0.006	-0.003
Education Background	0.003	0.038	-0.006
Whether a Party Member / Village Cadre	0.099**	0.234***	0.044
Environmental- risk perception	0.549***	0.545***	0.421***
Social network	--	--	0.234***
R^2	0.630	0.358	0.704
Adj R^2	0.625	0.350	0.699
F	*F* (4,322)=136.985, *p*=0.000	*F* (4,322)=44.929, *p*=0.000	*F* (5,321)=152.562, *p*=0.000

4.3. Endogeneity Test

Due to the fact that farmers' perception of environmental risks may be affected by subjective cognition, there are measurement errors. Therefore, this paper introduces "whether using a smartphone to access the Internet" as an instrumental variable for environmental risk perception. Suppose a farmer uses a smartphone to access the Internet. In that case, it indicates that he has more channels to obtain information about environmental pollution and more relevant professional knowledge, and thus has a stronger ability to perceive environmental risks, meeting the relevance condition of the instrumental variable. However, whether a farmer uses a smartphone to access the Internet has no direct relationship with the farmer's willingness to participate in black - odor water governance, meeting the exogeneity condition of the instrumental variable. According to the Table 3, in the first stage of the IV (Instrumental Variable) method, the instrumental variable is regressed on the endogenous variable to verify the relevance between the instrumental variable and the endogenous variable. The coefficient is significant at the 1% level, passing the weak-instrument test. In the second stage of the IV method, the predicted value of environmental risk perception obtained in the first stage is used as the core explanatory variable, and the farmer's participation willingness is used as the explained variable for regression. The results show that the estimated coefficient of environmental risk perception is still significantly positive, indicating that after solving the endogeneity problem, environmental risk perception can still significantly promote farmers' willingness to participate in black - odor water governance.

Table 3. Endogeneity Test

Variable	IV Phase I Environmental Risk Perception	IV Phase II Farmers' willingness
Whether or not you will use your smartphone to access the internet	0.583*** (0.056)	--
Predicted environmental risk perception	--	0.303*** (0.059)
Social network	0.222*** (0.0426)	0.175*** (0.0323)
Controls	Controlled	Controlled
Constant	0.666*** (0.129)	-1.085*** (0.083)
N	327	327
AdjR^2	0.5817	0.6913

4.4. Robustness Test

This paper refers to the method of Zhang Jing and other scholars [36] and uses alternative model approaches to test robustness. Both Logit and Probit models are suitable for binary dependent variables, but the Logit model assumes that the error term follows a logistic distribution, while the Probit model assumes that the error term follows a standard normal distribution [37]. Therefore, by comparing the results of Logit and Probit models, we can examine whether the research conclusions are sensitive to model selection. If the results of the two models are consistent, it indicates that the research conclusions are robust to model specification. After conducting regression analysis using alternative models, the influencing factors of farmers' willingness to participate in black and odorous water governance—such as professional networks, kinship networks, and environmental risk loss perception—remain significant at the 1% level. Environmental risk fact perception is significant at the 5% level, while geographical networks and environmental risk cause perception are significant at the 10% level. Moreover, the signs of the coefficients and the significance levels of these variables do not show significant changes. Detailed results of the regression analysis are provided in the table 4. In conclusion, this robustness test is confirmed to be valid.

Table 4. Robustness Test

Item	Regression Coefficient	Standard Error
The industry - related relationship network	1.367*** (3.09)	0.443
The geographic relationship network	0.854* (1.97)	0.434
The blood relationship network	2.327*** (3.14)	0.741
Environmental risk fact perception	3.534** (2.27)	1.555
Environmental risk cause perception	1.539* (1.83)	0.839
Environmental risk loss perception	1.689*** (3.73)	0.453
Age	-0.177 (-0.87)	0.202
Education Background	-0.361 (-1.32)	0.273
Whether a Party Member/Village Cadre	-0.447 (-0.65)	0.689
Intercept	-24.211*** (-3.98)	6.084

5. Conclusions and implications

5.1. Conclusion of the study

Based on the Public Announcement on the Management of Black-smelling Water in Shaanxi Province issued by the Department of Urban and Rural Housing and Construction of Shaanxi Province in March 2024, this study conducts targeted research on towns and cities where black-smelling water exist, and based on the first-hand information obtained by the team, it organically combines the binary Logit model and the explanatory equation model, and analyzes the relevant factors affecting the willingness of farmers to participate in the management of black-smelling water, as well as the hierarchical relationship between the various factors. The results show that: blood relationship network, geographic relationship network, business relationship network, perception of environmental risk facts, perception of environmental risk causes, and perception of environmental risk losses all have a positive influence on farmers' willingness to participate in the management of black-smelling water, while the perception of environmental risk losses is the most fundamental and deepest influencing factor, and the blood relationship network, geographic relationship network, and business relationship network are the most direct and superficial impression factors. At the same time, based on the results obtained from the ISM model, we qualitatively identify the mediating role played by social networks in the process of the influence of environmental risk perception on farmers' willingness to participate, and on this basis we carry out a quantitative test of the mediating role and verify that the hypothesis is valid.

5.2. Enlightenment

First of all, to carry out thorough black stinky water management, we have to let farmers become the main participants and change from "I want to do it" to "I want to do it"[38]. Changing the passive participation of farmers in the management of black-smelling water. Widely broaden the scope of farmers' interpersonal network, the village government can often jointly organize seminars or symposiums with neighboring villages related to the governance of human settlements, exchanging experience in governance, and guiding farmers to offer advice and suggestions at the same time can enable farmers to broaden their social network; or through the development of the "hygiene and

civilization of the household" and other selection activities, the outstanding farmers will be recognized and rewarded to establish a typical, play a leading role in demonstration, and then enhance their willingness to participate. Secondly, the government and rural grassroots organizations can popularize the serious harm of the environmental pollution problem represented by black smelly water to farmers through various forms of publicity and education activities, such as public service advertisements, community activities, and residents' organizations. By explaining in detail the multi-level damages to human health caused by black-smelling water, they can enhance rural residents' awareness of environmental protection and stimulate their enthusiasm to participate in the management of black-smelling water, thus improving the rural habitat. Meanwhile, in the rural social network, influential farmers or farmers with high prestige can communicate with more network members and integrate the resources and information of other members than ordinary farmers, so they usually have richer information resources about the management of black-odor water than other group members. By their extensive influence, they can promote the effective circulation and sharing of information and resources, thereby enhancing mutual trust and cooperation among farmers and significantly reducing the transaction costs for cooperation and joint guardianship of collective interests. Specifically, village committees can set up habitat governance groups or committees, inviting influential farmers to take up important positions and providing them with channels and ways to participate in governance. Alternatively, they can mobilize influential farmers through various channels, such as rural broadcasting systems, information bulletins, and social media WeChat groups, to actively disseminate information on the importance and necessity of rural human settlements improvement to motivate and increase the willingness of other farmers to participate.

References

[1] HUANG Senhui, TANG Dan, ZHENG Yifang. Research on Public Participation in Rural Environmental Pollution Management [J]. China Admin. 2017 (03): 55 - 60.

[2] Yang Jingmei. Interpersonal Trust, Institutional Trust and Farmers' Willingness to Participate in Habitat Governance [D]. Guilin University of Technology, 2023.

[3] Liu Shuai, Tian Shuai, Yu Xiaoyang. Empirical Analysis of Farmers' Willingness to Participate in Agricultural Infrastructure Construction in Main Grain Producing Areas--Based on a Survey of 519 Farming Households in Jilin Province [J]. Agricultural Economy and Management. 2016 (04): 12 - 18.

[4] Su Yi-Qing, Mos Ting. Institutional Logic and Realization Path of Rural Habitat Governance--Taking the Pilot of Rural Living Waste Classification as an Example [J]. China Rural Observation. 2024 (04): 124 - 143.

[5] Ma Qianhui, Zheng Shaofeng, Lu Qian. A study of social networks, Internet use and farmers' green production technology adoption behavior - based on survey data from 708 vegetable farmers [J]. Arid Zone Resources and Environment. 2022, 36 (03): 16 - 21.

[6] Zhu Wenbin. Study on the factors influencing the willingness of farmers to participate in cooperatives in Chifeng City's agricultural and pastoral intertwined areas [D]. Dalian Ocean University, 2024.

[7] Wu Xuelian, Zhang Junbiao, Feng Junhui. Influential factors of farmers' green agricultural technology cognition and its hierarchical structure decomposition - based on the probit-ISM model [J]. Journal of Huazhong Agricultural University (Social Science Edition). 2017 (05): 36 - 45.

[8] Li Tan, Chen Min, Wang Xin. Effects of livelihood capital and perceived environmental risk on farmers' willingness to pay for food waste management [J]. Journal of Agricultural and Forestry Economics and Management. 2020, 19 (05): 643 - 653.

[9] Fan WJ, Cui JN. A study on the influence of herders' risk perception on pro-environmental behavior based on the perspective of environmental regulation--a case study of Sanjiangyuan region [J]. Arid Zone Resources and Environment. 2023, 37 (03): 48 - 54.

[10] Gao Yajing. Research on the dilemma and countermeasures of multiple subjects' participation in rural household toilet renovation [D]. Northwest Agriculture and Forestry University, 2024.

[11] J. Lv, H. Liu, Y. Xue, et al. Risk Aversion, Social Networks and Farmers' Fertilizer Over-application Behavior - Research Data from Corn Farming Farmers in Three Northeastern Provinces [J]. Agricultural Technology Economy. 2021 (07): 4 - 17.

[12] Wu, Qianhui. Social network, institutional trust and farmers' willingness to participate in environmental governance [D]. Zhejiang University of Finance and Economics, 2019.

[13] Wang Zichen. Research on the impact of social network and village belonging on farmers' willingness to participate in habitat improvement [D]. Jiangxi Agricultural University, 2023.

[14] Chen Qiuxia, Huang Senwei, Yang Yuanyao. An empirical study of farmers' willingness to participate in environmental governance under social network - based on survey data from 55 villages in Fujian Province [J]. Fujian Forum (Humanities and Social Sciences Edition). 2023 (02): 91 - 103.

[15] Pei Zhijun, He Chen. Social Network Structure, Subjective Class Status and Rural Residents' Participation in Environmental Governance-Taking Garbage Classification Behavior as an Example [J]. Journal of Anhui Agricultural University (Social Science Edition). 2019, 28 (01): 27 - 34.

[16] Tang L, Luo SF, Zhang JB. Social Supervision, Group Identity and Farm Households' Centralized Domestic Waste Disposal Behavior - The Mediating and Moderating Role Based on the Concept of Face [J]. China Rural Observation. 2019 (02): 18 - 33.

[17] Yang Z H. Aging, Social Networks and Farmers' Green Production Technology Adoption Behavior-Validation of Farmers' Data from Six Provinces in the Yangtze River Basin [J]. China Rural Observation. 2018 (04): 44 - 58.

[18] Jia Yajuan, Zhao Minjuan. The effect of environmental pollution perception on rural residents' willingness to source-segregate domestic waste--Another discussion on the mediating effect of responsibility awareness [J]. Journal of Jiangsu University (Social Science Edition). 2022, 24 (04): 54 - 65.

[19] Zhu Honggen, Shan Hui, Shen Yu, et al. A study on the influence of digital literacy on farmers' willingness and behavior of domestic waste classification [J]. Journal of Jiangsu University (Social Science Edition). 2022, 24 (04): 35 - 53.

[20] Guo G, Lu Q, Li YB. Impacts of external shocks and social networks on farmers' adoption of water-saving irrigation technologies - Based on survey data from Zhangye, Gansu [J]. Arid Zone Resources and Environment. 2017, 31 (12): 33 - 38.

[21] SHANG Yan, XIONG Tao, LI Chongguang. Risk Perception, Risk Attitude and Farmers' Willingness to Adopt Risk Management Tools--Taking Agricultural Insurance and "Insurance + Futures" as an Example [J]. China Rural Observation. 2020 (05): 52 - 72.

[22] Wang Qian, Guan Rui, Yu Jin. Analysis of the impact of risk attitude and risk perception on farmers' farmland transfer behavior - Based on panel data of 1429 farmers in Henan, Anhui, Hebei and Jiangsu [J]. Journal of Huazhong Agricultural University (Social Science Edition). 2019 (06): 149 - 158.

[23] Yang F. Research on the impact of social network on production decision-making of farmers [D]. Southwest University, 2019.

[24] Song Lina. The nature of acquaintance society [J]. Journal of China Agricultural University (Social Science Edition). 2009, 26 (02): 118 - 124.

[25] Yan Hong. Acquaintance society, face and village publicity reproduction [J]. Journal of South China Agricultural University (Social Science Edition). 2023, 22 (04): 118 - 129.

[26] Song Yanhui. Study on "Favor and Face" in the Karma Relationship of Rural Youth[J]. Journal of China Youth Politics Institute. 2012, 31 (02): 29 - 33.

[27] Miao Shanshan. Study on the cooperative participation behavior of farmers in small-scale water conservancy facilities under the perspective of multidimensional heterogeneity of social capital [J]. China Population-Resources and Environment. 2014, 24 (12): 46 - 54.

[28] Shi Yuxing, Li Chaoqiong, Zhao Minjuan. The effects of non-market value perception and social capital on farmers' willingness to cooperate in cropland protection [J]. China Population-Resources and Environment. 2019, 29 (04): 94 - 103.

[29] Grothmann T, Patt A. Adaptive capacity and human cognition: the process of individual adaptation to climate change [J]. Global Environmental Change. 2005, 15 (3): 199 - 213.

[30] Perception of environmental risk in the West: Research approaches, segmentation and academic reflections [J].

[31] Zhou Jian. A study on the effects of risk perception and social trust on farmers' participation in centralized domestic waste treatment [D]. Yangzhou University, 2023.

[32] Wang Yuan. Research on the influence mechanism of environmental risk perception on green production behavior of agricultural producers [D]. Jiangnan University, 2023.

[33] ZHAO Peipei, YAN Beibei, LIU Tianjun. Inverted U-shaped relationship between socioeconomic status differences and the diffusion of agricultural green control technologies: the mediating effect of social learning [J]. Arid Zone Resources and Environment. 2021, 35 (08): 18 - 25.

[34] S. M. Sun, Y. Zhang, J. R. Zhang. Empirical analysis of factors influencing the willingness to implement good quality and safety practices in pig farms (households) based on Logit-ISM model [J]. China Rural Economy. 2012 (10): 24 - 36.

[35] Chen R, Zheng YH, Liu WJ. Mediation effect analysis: Principles, procedures, Bootstrap method and its applications [J]. Journal of Marketing Science. 2013, 9 (04): 120 - 135.

[36] Jing Zhang, Lili Wu. Internet use, non-farm employment and farmers' willingness to sort waste [J]. Ecological Economy. 2021, 37 (09): 201 - 207.

[37] Yao Shujie, Wang Jiefei. Internal mechanism and empirical analysis of the deviation of precision poverty alleviation effect under asymmetric information conditions [J]. China Population-Resources and Environment. 2019, 29 (05): 165 - 176.

[38] Sun S. Problems and path analysis of rural habitat governance in the context of rural revitalization: the case of County C in Shaanxi Province [J]. Shanxi Agricultural Economics. 2024 (11): 127 - 129.