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Farmers' awareness of environmental protection and rural residential environment improvement: a case study of Sichuan province, China

Chen Qing[1] · Shili Guo[2] · Xin Deng[3] · Dingde Xu[1,4]

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Abstract
While most studies focus on the impact characteristics of farmers and family economic traits have on participation in rural environmental improvement, few studies focus on the relationship between farmers' environmental awareness and rural residential environment improvement. Based on the survey data of 200 farmers in Sichuan Province, this paper divides farmers' environmental awareness into three dimensions: environmental problem cognition, environmental pollution tolerance, and environmental protection attitude and constructs a binary logistic regression model to explore the relationship between farmers' environmental awareness and the improvement of rural residential environment. The results show that the rural residential environment in Sichuan Province still faces some challenges, and farmers' environmental awareness significantly influences their improvement behaviors. Higher levels of environmental problem cognition can promote farmers' participation in environmental improvement, but sensitive environmental pollution tolerance does not promote environmental improvement behavior. Positive environmental attitudes have both positive and negative effects on improving behavior. In addition, individual characteristics of farmers, household economic aspects, and nonpoint source pollution status of their residence also affect their participation in rural environmental improvement to varying degrees. This study can help us better understand the explanatory role of farmers' subjective consciousness in their environmental behavior decision-making and thus provide support for the formulation and implementation of policies of human settlements improvement.

Keywords Improvement of rural residential environment · Toilet revolution · Domestic sewage discharge · Waste treatment · Environmental awareness · China

✉ Dingde Xu
dingdexu@sicau.edu.cn

Extended author information available on the last page of the article

1 Introduction

With the development of the world economy, people have created colossal material wealth and caused many environmental problems (Scheffran & Battaglini, 2011; Schwarzenbach et al., 2010). The Global Environmental Outlook, released by the fourth United Nations environment conference, says one-quarter of all premature deaths and diseases worldwide are caused by artificial pollution and environmental damage (UN Environment, 2019). The environment in which we live has suffered tremendous damage. How to effectively manage environmental problems is a significant issue faced by all countries in the world. As the world's largest carbon emitter, China's environmental pollution has become increasingly severe during the past two decades of rapid economic growth (Lu et al., 2017; Shapiro, 2016). For example, the Songhua River water pollution incident in 2005 (Li et al., 2008), the large-scale smog outbreak in 2013 (Cheng et al., 2017), and the Quangang carbon leakage incident in Fujian Province in 2018 (Wang et al., 2020). These pollution incidents seriously endangered social stability and people's health and impacted China's ecological civilization (a strategic decision made by the 18th National Congress of the Communist Party of China to realize sustainable development). Government must carry out environmental improvement work to solve various environmental problems. At the same time, due to the lack of investment in environmental protection in rural areas for a long time, it is more difficult to carry out residential environment improvement in rural areas than in urban areas (Long et al., 2016). Against this background, the 19th National Congress of the Communist Party of China (CPC) puts forward the rural revitalization strategy, which called for efforts to solve great problems and improve rural living environments. As a traditional agricultural production area, Sichuan Province's rural environmental problems are very prominent. According to a report (Zhao, 2014), the harmless treatment rate of rural household garbage in Sichuan Province is only 5.05%. (Harmless treatment rate refers to the percentage of the amount of harmless treated solid waste in the total amount of solid waste.) The average treatment rate of rural domestic sewage is only 20%. Therefore, improving Sichuan Province's rural living environment is extremely urgent as the first battle of China's rural revitalization strategy.

In recent years, China has vigorously carried out a policy-driven campaign to improve the rural residential environment. All regions and departments have conscientiously implemented the arrangements of the Party Central Committee and regarded the improvement of the rural residential environment as an essential part of the construction of a new socialist countryside (Yu, 2019). However, the filthy rural residential condition is still a major socioeconomic drawback for some areas (Peng & Zhang, 2019; Wang et al., 2017). It stands to reason that with the improvement of rural infrastructure construction and the equalization of urban and rural essential public services, the quality of the current rural human settlement environment should have been significantly improved. Why does this phenomenon occur? The academic circle has conducted a lot of explorations on this issue. Researchers generally believe that improving the rural residential environment is a long-term process, which requires sufficient time and the effective participation of the majority of rural residents (Dang et al., 2017; Kochskämper et al., 2016; Lo, 2015; Luo & Miao, 2019). Therefore, the lack of attention to the participation of villagers in the environmental governance process is the main reason for the current governance dilemma. Rural environmental problems are an objective result of farmers' environmental behavior. Fundamentally speaking, the environmental behavior of farmers has a direct and fundamental impact on their living environment (Wang et al., 2018). There are positive and negative environmental behaviors,

and positive environmental behaviors have good ecological benefits. Therefore, whether the conduct of farmers can be reasonably guided, influenced, and changed to meet environmental protection requirements is a critical factor for the success of rural residential environment improvement.

There has been significant research into the factors that influence the participation of farmers in the construction of living environments. Previous research provided a scientific basis for relevant policymaking, but there are still limitations. First, relatively few studies focus on rural environmental improvement compared with those focusing on urban environmental improvement (Kjellstrom et al., 2007; Li et al., 2018; Xi et al., 2015). While the urban environment is improving, environmental pollution in rural areas is becoming more and more prominent (Dzikiewicz, 2000; Hendryx et al., 2010; Ongley et al., 2010; Reddy & Behera, 2006). Second, most of the existing studies focus on a singular aspect of improvement for the rural environment, such as the treatment of household garbage (Han et al., 2018; Liu & Wang, 2012; Tian et al., 2018; Zeng et al., 2016), sanitary toilet renovation (Chen et al., 2013; Cheng et al., 2018; Miao et al., 2012), or domestic sewage treatment (Barnes et al., 2009; Fu et al., 2018). This singular focus lacks attention to multiple measures for the holistic improvement of rural living environments. Third, the exploration of the factors influencing farmers' participation has been limited (Dessart et al., 2019; Prager & Posthumus, 2010). Although many studies have analyzed the factors that affect farmers' involvement in environmental improvement, most of them focus on the impact of individual characteristics and family economic status; few focus on farmers' subjective consciousness. It is generally believed that the socioeconomic characteristics of the household head and family will influence farmers' participation in environmental improvement (Min et al., 2019). However, individual psychological factors such as subjective consciousness and attitude can also predict and explain human behavior (Beedell & Rehman, 2000; Duan & Jiang, 2008). By including farmers' environmental awareness in the explanatory variables and studying the influence of psychosocial variables on farmers' environmental protection decisions, the accuracy of models to predict farmers' environment improvement decisions can be further strengthened. In addition, environmental awareness is generally believed to positively impact people's environmentally friendly behavior (Amir et al., 2021; Vogel, 1996; Wu & Mweemba, 2010). However, the applicability of this conclusion in the Chinese rural environment remains to be verified. Due to the deep-rooted living habits of traditional Chinese farmers, the increase in environmental awareness may not be consistent with the change in their environmental behavior. At the same time, as a subjective emotion, farmers' environmental awareness is often subject to their experimental conditions and resources when they are transformed into actual actions and often presents a phenomenon of high willingness and low behavior (Michel-Guillou & Moser, 2006). Therefore, it is necessary to measure the level of farmers' environmental awareness and analyze the impact of farmers' environmental awareness on environmentally friendly behavior. Fourth, most existing literature focuses on qualitative analysis, lacking empirical study based on fieldwork data (Hu et al., 2006; Han et al., 2016; Ling & Deng, 2011; Wang et al., 2008).

The study has been conducted in Sichuan, a large traditional agricultural province of China. It uses the sample survey data of 200 village households and subdivides farmers' environmental awareness into environmental problem cognition, environmental pollution tolerance, and environmental protection attitude. Based on controlling farmers' characteristics, family characteristics, and living environment characteristics, this study constructed a binary logistic regression model to pay attention to the impact of environmental awareness on farmers' participation in rural residential environment improvement. In addition, the study further explores the factors that influence farmers' behavioral decisions in

environmental improvement, intending to provide support for improving rural human settlement environment policies.

2 Study area and data source

2.1 Study area

Sichuan Province is located in the hinterland of southwest China, in the upper reaches of the Yangtze River, with a land area of 486,000 km^2. Its terrain is complex, with a distribution of mountains, hills, plains, and plateaus. The region is in the subtropical zone, and due to the alternation of topography and varying monsoon circulation, the climate is complex and diverse (Guo et al., 2019; Xu et al., 2017). These weather conditions have led to various land uses, animal and plant resources, and natural geographical landscapes. Sichuan Province enjoys special agricultural production conditions and is an essential agricultural economic region (Huang et al., 2020; Xie et al., 2019); however, the overuse of chemical fertilizers and pesticides in recent years has led to severe issues with agricultural nonpoint source pollution. In 2008, to promote controlling rural pollution in agriculture, the General Office of Sichuan Provincial Party Committee and the Provincial Government Office jointly issued a three-year action plan for improving the rural living environment. Extended into 2020, it strives to achieve more than 90% of sorted household waste disposal, 85% sanitary toilets, and around 50% access to rural sewage treatment and recycling.

2.2 Data source

The data used in this study are from Sichuan Province in 2018, gathered via the China Rural Development Survey (CRDS) conducted by the Institute of Geographical Resources of the Chinese Academy of Sciences (Shui et al., 2021). The research adopted stratified sampling first and then random sampling with equal probability to determine the survey samples to ensure that the survey samples are typical and representative (Cao et al., 2018; Rozelle, 1996). Firstly, 183 districts in Sichuan Province were divided into five groups according to per capita industrial output value. We randomly selected one section from each group to obtain five sample districts. The five sample districts are Jiangyou, Yantan, Shehong, Guangan, and Yuanba, and their economic level decreases successively. Secondly, the towns in each sample district were randomly divided into two groups through the same method. Then, we randomly selected one town from each group to obtain two towns, and finally, we got ten sample towns. Thirdly, two administrative villages were randomly selected from each sample according to the socio-economic development level and location. Finally, ten households were randomly selected using the village roster and a random number table. This process resulted in a sample of 200 families, which completed the questionnaire. The distribution diagram of sample villages is shown in Fig. 1.

3 Theoretical analysis and research hypotheses

According to the theory of planned behavior, individual behavior is not only influenced by behavioral intention; it is also restricted by actual control conditions such as ability, opportunity, and resources (Ajzen, 1991). On the premise that conditions are fully met,

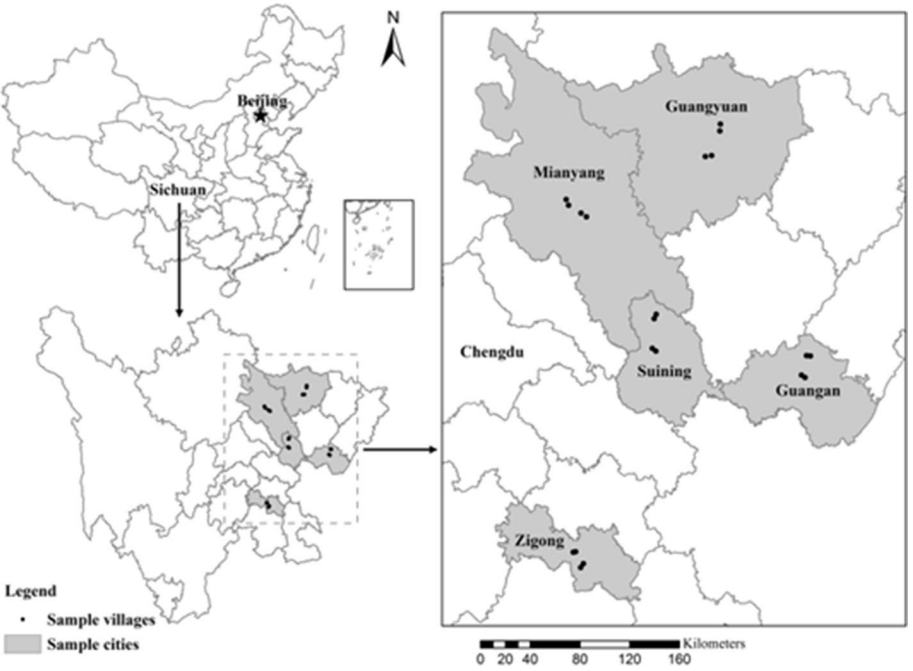

Fig. 1 Distribution of sample villages

behavioral intention directly determines behavior, while behavioral attitude, subjective norm, and perception of behavioral control determine behavioral meaning. This indicates that an individual's consciousness, attitude, and other psychological factors can also predict and explain human behavior. By incorporating environmental awareness into explanatory variables and studying the impact of social-psychological variables on farmers' environmental protection decisions, the model can further strengthen the interpretation and predictability of farmers' environmental behavior decisions. Farmers' participation in environmental improvement is influenced by their willingness to change, which is influenced by factors such as individual subjective consciousness, family economy, labor pressure, and the degree of benefit they will gain from the improvements to the environment (Gifford & Nilsson, 2014). In recent years, the theory of planned behavior has been constantly revised and improved, further verified and promoted through many theoretical and empirical studies (De Leeuw et al., 2015; Kautonen et al., 2015). These studies demonstrate that consciousness is a primary behavior variable, but consciousness and conduct do not show natural consistency (Huang et al., 2016).

Thus, increasing farmers' cognition of environmental improvement can facilitate a corresponding subject consciousness (Yu & Yu, 2019). In theory, farmers with higher levels of environmental awareness are more likely to engage in behavior related to environmental protection (Liobikienė & Juknys, 2016). For example, Liu et al. (2013) found that farmers' ecological cognition significantly impacted their environmental behavior decision-making. Using analysis of an integrated model, Wang et al. (2019) concluded that farmers who are sensitive to the threat of water deterioration have a more vital willingness to perform governance. Gao (2018) also found that there is a significant positive correlation between environmental attitude and environmental behavior. However, the improvement

of environmental awareness and changes in ecological behavior is not necessarily synchronized. In fact, most people do not consistently adopt behaviors consistent with their environmental attitudes (Kuhlemeier et al., 1999). Wang and Gu (2012) showed that farmers' level of environmental cognition was inconsistent with their actual behavioral decisions. Environmental awareness influences environmental protection behavior, but its internal mechanism of action requires further in-depth analysis.

Based on the characteristics of farming households, this study summarized the environmental awareness factors affecting farmers' participation in rural environmental improvement into three dimensions: cognition of environmental problems, tolerance of environmental pollution, and attitude toward environmental protection. These dimensions resulted in the following research hypotheses:

H1 The cognition of environmental problems has a significant positive impact on the farmers' participation in rural improvement.

H2 The tolerance of environmental pollution has a significant negative impact on farmers' participation in rural improvement.

H3 Positive attitudes toward environmental protection have a significant positive impact on farmers' participation in rural improvement.

4 Method

4.1 Measurements

4.1.1 Dependent variable

Improving the rural residential environment is a broad concept. This article draws on the three-year action plan issued by the Rural Human Settlements Improvement Office of the State Council. It defines improvements as the classification and treatment of domestic waste, the use of flush toilets, and the treatment of domestic sewage. These actions are used to determine farmers' participation in residential environment improvement (Min et al., 2019; Peng & Zhang, 2019). In the questionnaire results, an answer of "yes" is given a 1, indicating participation in the action described. Conversely, a response of "no" is given a 0, indicating no involvement in the activity described.

4.1.2 Independent variables

The main objective of this study is to explore the relationship between farmers' awareness of environmental protection and their participation in residential environment improvement. Based on Diekmann et al., 2001's theoretical field of environmental awareness, studies by Huang et al., 2016 and Michel-Guillou, 2006, and the actual investigation area, the study intends to measure farmers' environmental awareness across the three dimensions of environmental problem cognition, environmental pollution tolerance, and environmental protection attitude. These three dimensions can be further subdivided into nine items. There are two ways to answer specific questions: "yes" and "no." In the dimension of environmental problem cognition, the values of "correct" and "wrong" were assigned to "1"

and "0," respectively. For environmental pollution tolerance and environmental protection attitude, "yes" and "no" were, respectively, assigned values of "1" and "0." Finally, the scores of all the specific problems in each dimension were added together. Before the follow-up analysis, the research used Cronbach's α to test the reliability of the above three dimensions to ensure the internal consistency of the research design index system. The results show that Cronbach's α of the nine questions is 0.62, and Cronbach's α of the three dimensions is also > 0.6. This indicates that the reliability and stability of the environmental awareness variables used in this study are relatively good, as shown in Table 1.

4.1.3 Controlled variables

To not overestimate or underestimate the impact of farmers' environmental awareness on their participation in rural residential environment improvement, we referred to Fu et al. (2018), Jallow et al. (2017), Liu and Wang (2012), Min et al. (2019). We included factors that may influence farmers' improvement behavior as the primary control variables. These control variables included the individual characteristics of the interviewees, the family economic characteristics, and the characteristics of the farmers' living environments. Among them, individual characteristics are represented by age, gender, and years of education; family characteristics are described by the number of family population and family wealth; the features of the environment in which farmers live are illustrated by nonpoint source pollution, including the breeding of livestock and poultry, the use of mulch and the pollution around the home. The model involves variable definition and data description, as shown in Table 2.

4.2 The empirical model

The dependent variable of this study is the behavior of farmers to improve the rural living environment, which is three dichotomous variables. Because of the distribution characteristics of dependent variables, this study intends to use the binary logistic regression model for subsequent analysis. The model estimation formula is as follows:

$$\ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_{11} X_{11} + \varepsilon_i$$

where $\ln\left(\frac{P}{1-P}\right)$ refers to the environmental improvement behavior of farmers; X_i is 11 independent variables; P represents the probability that farmers carry out environmental improvement behavior under the influence of independent variables; β_0 is the constant term; β_i is the regression coefficient; and ε_i is the residual term.

4.3 Data analysis

A descriptive analysis of all the variables examined in this study was first conducted. Secondly, we used unadjusted binary logistic regression to indicate the relationship between farmers' awareness of environmental protection and participation in rural residential environment improvement (Model 1, Model 4, and Model 7). Thirdly, to test the robustness of the variables concerned, we added control variables into the regression model (Model 2, Model 5, and Model 8). Finally, to better explain the regression results, we tested the marginal effect of each variable with significant influence on the estimated impacts of the

Table 1 Reliability test of characteristic variables of environmental awareness

Dimension	Item	Cronbach's α
Environmental problem cognition	Do you think organic fertilizer pollutes farmland?	0.7005
	Do you think farmyard manure pollutes farmland?	
	Do you think that returning straw to the field pollutes farmland?	
Environmental pollution tolerance	Has man-made environmental pollution become more and more serious in your area in recent years?	0.6013
	Has water pollution in your area become more and more serious in recent years?	
	Have you ever been dissatisfied with the environmental pollution around you?	
Environmental protection attitude	Are you willing to take the time to protect the environment from pollution?	0.6795
	Are you willing to pay money to protect the environment from pollution?	
	Are you willing to strengthen the study and practice of environmental protection in the future?	

adjusted model (Model 3, Model 6, and Model 9). The data analysis was implemented by Stata 15.1 MP version.

5 Results

5.1 Descriptive analysis

Table 2 shows the results of descriptive statistical analysis of all variables in the model. The situation is not optimistic when looking at the domestic waste treatment methods. Only 23% of farmers classify domestic waste, and direct disposal is still the primary method of domestic waste treatment. The penetration rate of sanitary toilets has reached 65%, which indicates that the toilet revolution has been effective. However, there is still much room for improvement before getting the popularity level of urban sanitary toilets. Although only 40% of farmers discharge domestic sewage everywhere, less than half of the total number of farmers in the sample, the figure is still high.

As far as the core variables are concerned, the environmental protection attitude and environmental problem cognition scores are relatively high at 2.63 and 2.35, respectively. However, the environmental pollution tolerance score was only 1.19. This shows that farmers have a positive attitude toward environmental protection and have a high understanding of ecological problems. Still, they offer a high tolerance for environmental pollution problems in rural areas. In addition, as shown in Fig. 2, the study further tested the differences in farmers' environmental awareness in the selected sample counties. In the five sample counties, the average scores of farmers' environmental awareness in three dimensions showed similar distributions. Among them, the score difference of environmental pollution tolerance is the smallest, and the score difference of environmental protection attitude and environmental problem cognition is relatively significant.

In terms of control variables, the sample farmers were mainly middle-aged or elderly and male, with 56% male participation and an average age of 61.80 years. The average

Table 2 Descriptive analysis of variables

Category	Variable	Definition	Mean	SD
Dependent variable	Garbage	Whether to sort and dispose of household waste (1 = yes, 0 = no)	0.23	0.42
	Toilet	Whether to use a flush toilet or not (1 = yes, 0 = no)	0.65	0.48
	Sewage	Whether to discharge domestic sewage everywhere (1 = yes, 0 = no)	0.40	0.49
Environmental awareness	Environmental problem cognition	One point for correct answers, full score is 3[a]	2.35	0.98
	Environmental pollution tolerance	One point for positive answers, full score is 3[a]	1.19	1.01
	Environmental protection attitude	One point for positive answers, full score is 3[a]	2.63	0.76
Individual characteristics	Age	Farmer's age (year)	61.80	10.85
	Gender	Farmer's gender (1 = male, 0 = female)	0.56	0.50
	Education	Years of schooling (year)	5.53	3.61
Household characteristics	Family size	Actual survey value (person)	4.96	1.76
	Household wealth	Sum of household cash income and present value of fixed assets (ten thousand Yuan)	35.08	33.58
Living environment characteristics	Livestock and poultry	Whether to breed livestock and poultry (1 = yes, 0 = no)	0.67	0.47
	Mulch	Whether to use mulch (1 = yes, 0 = no)	0.36	0.48
	Pollution	Is there any industrial or industrial pollution near your home (1 = yes, 0 = no)	0.15	0.36

[a]See Table 1 for the specific problem items

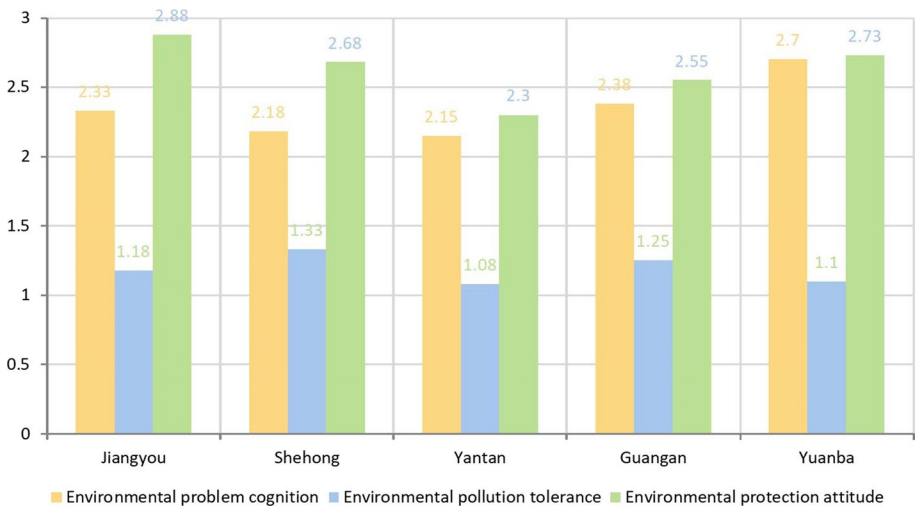

Fig. 2 Statistics on average scores of farmers' environmental awareness in sample counties

length of schooling was only 5.53 years. The sample households had large household populations, with an average of 4.96 people per household. However, the wealth of each family varied greatly. The highest value was 2,157,800 Yuan, and the lowest value was 4600 Yuan, with a mean value of 350,800 Yuan and a standard deviation as high as 335,800 Yuan. The nonpoint source pollution situation of the sample farmers was better, with a livestock and poultry breeding rate of 67%, a plastic film utilization rate of 36%, and an industrial pollution rate of 15%.

5.2 Model analysis

Table 3 reports the estimated results of the influencing factors. It indicates that the impact of farmers' environmental awareness on their participation in ecological improvement decisions is relatively robust. Therefore, the subsequent analysis is based predominantly on Model 2 and 3, Model 5 and 6, and Model 8 and 9. According to Wald statistics, the three models with control variables passed the overall significance test, indicating that at least one independent variable had a significant correlation with the dependent variable in the model. The explanatory ratio of independent variables to dependent variables was between 18 and 22%. At the same time, the multicollinearity among variables should be considered in the cross section data. After the regression, each model's VIF (Variance inflation factor) values were calculated; the maximum VIF is 1.45, which is far less than 10. Therefore, the multicollinearity among variables can be ignored.

The model estimation results show that farmers' environmental awareness will significantly influence their participation in improving rural residential environments. The results also show that their environmental problem cognition, environmental pollution tolerance, and environmental protection attitude all substantially influence their involvement in improving rural living environments. For every point increase in the cognition score of environmental problems, the probability of sorting and disposing of household garbage is increased by 9%. However, the effect of environmental awareness on the use of flushing toilets and the discharge of domestic sewage was not significant. This indicates that while extensive government initiatives and popularized knowledge of environmental protection have enhanced farmers' cognition of environmental problems, farmers' understanding of environmental problems does not contribute effectively to the behavior of ecological improvement. Therefore, cognition plays a minimal role in the factors that affect farmers' participation in the decision-making of rural residential environment improvement. Although farmers with higher environmental pollution tolerance scores demonstrated more excellent perceptions of deteriorating rustic environmental quality, every point increase in its score also reduced the likelihood of using flushing toilets by 8%. It increased the likelihood of discharging domestic sewage by 7%. That is to say, the environmental pollution tolerance of farmers is an obstacle to their participation in environmental improvement. The possible reason is that the tolerance of environmental pollution of farmers only represents their subjective emotions. Still, the transformation of emotion into practical action is often restricted by the actual control conditions such as their ability and resources (Huang et al., 2016). Therefore, farmers with low environmental pollution tolerance may also give up participating in improving the human settlement environment due to their lack of time, money, and labor. In terms of environmental protection attitude, every point increase in the score of farmers' environmental protection attitude leads to a 9% increase in the probability of using flushing toilets and an 8% decrease in the likelihood of discharging domestic sewage everywhere. However, they are also a 10% decrease in the probability of sorting

Table 3 Model estimation results

Variable	Sort and dispose of household garbage			Use flush toilets			Discharge domestic sewage everywhere		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Environmental problem cognition	0.626***	0.627***	0.09***	−0.223	−0.144		−0.060	−0.133	
	(0.21)	(0.22)		(0.18)	(0.18)		(0.16)	(0.20)	
Environmental pollution tolerance	−0.345**	−0.278		−0.295**	−0.358*	−0.06**	0.211	0.357**	0.07**
	(0.17)	(0.19)		(0.15)	(0.18)		(0.15)	(0.17)	
Environmental protection attitude	−0.751***	−0.728***	−0.10***	0.355*	0.518**	0.09**	−0.163	−0.439**	−0.08**
	(0.21)	(0.23)		(0.20)	(0.22)		(0.20)	(0.22)	
Age		−0.008			−0.044**	−0.01**		0.059***	0.01***
		(0.02)			(0.02)			(0.02)	
Gender		−0.020			−0.301			0.301	
		(0.43)			(0.41)			(0.39)	
Education		0.075			0.078			−0.112**	−0.02**
		(0.06)			(0.06)			(0.06)	
Family size		0.030			−0.058			0.156	
		(0.13)			(0.11)			(0.10)	
Household wealth		−0.004			0.031***	0.005***		−0.010	
		(0.01)			(0.01)			(0.01)	
Livestock and poultry		0.686			−0.744*	−0.13*		0.656	
		(0.49)			(0.42)			(0.43)	
Mulch		1.238***	0.17***		−0.693*	−0.12*		0.309	
		(0.36)			(0.39)			(0.38)	
Pollution		0.550			0.167			−0.923*	−0.17*
		(0.61)			(0.51)			(0.53)	
Constant term	−0.492	−1.732		0.569	2.745*		-0.091	−3.600**	
	(0.64)	(1.60)		(0.62)	(1.46)		(0.62)	(1.56)	
Wald statistic	19.37***	32.91***		7.28*	36.08***		2.64	29.44***	

Table 3 (continued)

Variable	Sort and dispose of household garbage			Use flush toilets			Discharge domestic sewage everywhere		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Pseudo R^2	0.10	0.18		0.03	0.22		0.01	0.18	

The coefficients are odds ratios; the figures in brackets are robust standard errors; *, **, ***are significant at the levels of 0.1, 0.05, and 0.01, respectively

household waste. This shows that environmental protection attitude has both positive and negative effects on a households' participation in environmental improvement. The positive influence may be since the government has vigorously promoted the construction of human settlement environment in recent years, which makes the majority of farmers have a positive attitude toward environmental protection, thus increasing their participation probability to a certain extent. The negative influence may be because, compared with the treatment of toilets and domestic sewage, the classification and treatment of household wastes are more complicated, and it is necessary to distinguish between perishable and non-perishable wastes (Tong et al., 2020). Due to the effect of the traditional lifestyle, farmers are not accustomed to this method, which results in the discrepancy between the positive attitude and the actual participation.

The models also demonstrate that the household's characteristics and economic characteristics can influence the use of flushing toilets and the discharge of domestic sewage. The regression slope coefficient between the age of farmers and the use of flushing toilets is negative. In contrast, the correlation coefficient between the generation of farmers and the discharge of domestic sewage is positive, indicating that older farmers are less willing to use flushing toilets and more likely to discharge domestic wastewater. Fewer years of education also indicate a higher likelihood of discharging domestic sewage. Household wealth significantly impacts whether farmers use flushing toilets, but its marginal effect is negligible. For every 10,000 Yuan increase in per capita household wealth, the probability of farmers using flushing toilets only increases by 0.5%. At the same time, gender and family populations do not significantly influence the household's participation in environmental improvement. Finally, the nonpoint source pollution in the living environment will also affect households' participation in rural ecological advances. Specifically, the more serious the nonpoint source pollution, the more the possibility of sorting and disposing of domestic waste and the less likely the possibility of discharging domestic waste everywhere, but it also reduces the possibility of using flushing sanitary toilets.

6 Discussions

The purpose of this study was to explore the effect of farmers' environmental awareness on their participation in improving the rural human settlement environment. Compared with previous studies, this study has two contributions: First, different from the existing studies, which only focus on the environmental awareness of farmers and the single environmental improvement behavior, this study systematically expands the dimension of farmers' environmental awareness and the mode of human settlement environment improvement behavior, which is more in line with the reality of China. Second, the study verified the research hypothesis by using the data from the primary survey of farmers in the typical hilly areas of Sichuan Province, and it empirically explored the relationship between environmental awareness and environmental improvement behavior. The study area is a traditional agricultural area in China, and the living environment is relatively severe. The results of this study can provide a reference for the improvement of the rural human settlement environment in China and other developing countries.

Similar to the research results of Liu et al. (2013) and Liobikienė and Juknys (2016), this study also found that the cognition of environmental problems and the positive attitudes toward environmental protection has a significant positive impact on the farmers' participation in rural residential environment improvement (confirm H1 and H3).

Specifically, suppose farmers have a high awareness and understanding of environmental issues. In that case, they will often realize the risk of environmental pollution caused by negative behaviors, thereby reducing negative environmental behaviors and increasing behaviors with good ecological benefits. Farmers with a positive attitude toward environmental protection are usually very willing to participate in actions to protect and improve the environment, so they are also active groups in the construction of rural human settlements. On the other hands, the empirical results also show that a low level of environmental pollution tolerance does not promote environmental improvement behaviors (reject H2). This may be because the sensitive tolerance of environmental pollution only represents the farmers' aversion to corruption. Still, the actual change of action is also limited by time and resources, so consciousness and action may be inconsistent. This is consistent with the studies of Huang et al. (2016), Michel-Guillou (2006), Wang and Gu (2012) that found farmers' commitment to environmental action depends more on social factors than their environmental awareness, and that higher environmental awareness does not necessarily lead to desired behavioral decisions. The result noted that gender and family population had no significant influence on the household's participation in environmental improvement. For example, Fu et al. (2018) found that women are more willing to participate in sewage treatment than men, and Min et al. (2019) found a significant positive correlation between the number of family members and the use of flushing toilets. For every one-person increase in the family, the probability of farmers using flushing toilets increased by 1.8%. This may be because Sichuan is a typical labor export province, and many young workers are migrant workers. Thus, there is a lack of participation in building drainage facilities and compost toilets for their families, or because the cost and actual use of such utilities are not equal.

In addition to expanding the existing literature, these findings also have significance for developing environmental policies. According to our results, farmers in developing countries are often restricted by their access to resources and exhibit a low conversion rate from emotional intention to practical action when making residential environment improvement decisions. Therefore, policymakers should work to establish effective support mechanisms to facilitate farmers' participation in environmental improvement. At the same time, the government should increase educational initiatives so that farmers can understand the importance and urgency of environmental progress. This would promote the transformation from psychological cognition to behavioral action. In fact, China has experimented with relevant laws and regulations in many places (such as Shanghai, Beijing, and other cities demonstrating garbage classification). Practice shows that these policies have played a significant role in improving residents' awareness of environmental protection. However, if these policies are widely adopted in China, their applicability may need further verification.

This study does contain some gaps which can be explored in future research. For example, this study only uses cross-sectional data to examine the impact of environmental awareness on farmers' participation in rural environmental improvement. However, environmental awareness and farmers' environmental improvement behavior are dynamic processes, and panel data could further explore the causal relationship between them. Furthermore, environmental awareness is a broad concept that has not yet been defined or measured. This study only explored three dimensions of environmental awareness: cognition of environmental problems, tolerance of environmental pollution, and attitude toward environmental protection. Future studies could explore the impact of environmental policy cognition on environmental improvement behavior.

7 Conclusions

This study uses a binary logistic regression model to analyze the relationship between farmers' environmental awareness and their three environmental improvement behaviors. The empirical results show that environmental awareness is an essential factor that affects farmers' behaviors to improve the rural residential environment, and farmers' subjective awareness can effectively predict their environmental improvement behaviors. In addition, environmental awareness has different effects on different improvement behaviors. On the one hand, the improvement of environmental awareness is conducive to ecological improvement behaviors, especially for sorting and disposing of domestic waste. On the other hands, the impact of environmental awareness on improving behavior is not significant or even harmful. Higher environmental awareness does not necessarily lead to positive behavioral decisions. Therefore, these results help us better understand the explanatory role of farmers' subjective consciousness in their environmental behavior decision-making and may help increase the participation rate in the construction of rural human settlements in the future.

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Declarations

Conflict of interest The authors declare no conflict of interest.

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Authors and Affiliations

Chen Qing[1] · Shili Guo[2] · Xin Deng[3] · Dingde Xu[1,4]

Chen Qing
qingchen@stu.sicau.edu.cn

Shili Guo
guoshili@swufe.edu.cn

Xin Deng
dengxin@sicau.edu.cn

[1] College of Management, Sichuan Agricultural University, Chengdu 611130, China

[2] China Western Economic Research Center, Southwestern University of Finance and Economics, Chengdu 610074, China

[3] College of Economics, Sichuan Agricultural University, Chengdu 611130, China

[4] Sichuan Center for Rural Development Research, College of Management, Sichuan Agricultural University, Chengdu 611130, China