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How is it effective for farmers to adopt environmentally friendly cultivated land protection technology: a configurational perspective

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The adoption of environmentally friendly farmland conservation techniques by farmers is an important way to effectively curb agricultural surface pollution and promote the conservation of farmland quality. Based on 425 farmers' in-depth interview data, a fuzzy-set qualitative comparative analysis method was used to construct a psychological cognition (farmers' awareness and willingness to participate)—external context (organizational linkages and government regulation)—behavioral effect model to reveal the conditional configuration and multivariate paths of psychological cognition and external contextual factors influencing farmers' behavioral effects on the adoption of environmentally friendly farmland conservation technologies. The results show that individual behavioral decision factors do not influence the behavioral effects of farmers. The results show that individual behavioral decision factors are not necessary to drive the effective adoption of environmentally friendly farmland conservation technologies and that multiple decision factors interact to form three sets of configurations that enhance the behavioral effectiveness of farmers, summarized as the willingness-to-participate dominant model, the internal and external constraints dominant model, and the external context dominant model.

KEYWORDS

environmentally friendly farmland conservation techniques, configuration analysis, behavioral effects, empirical analysis, China

1 Introduction

For more than 40 years of rural reform, China's agricultural production has made tremendous achievements through the extensive use of chemical inputs, such as fertilizers, but the ecological environment has turned on a "red light" (Gisriel et al., 2020). The excessive application and inefficient use of chemical fertilizers in agricultural production have caused serious surface pollution and agricultural product quality and safety problems (Damalas and Eleftherohorinos, 2011), which have restricted sustainable agricultural development (Lu et al., 2015). In 2011, the Ministry of Agriculture and Rural Affairs (formerly the Ministry of Agriculture) issued the Technical Specification for Soil Testing and Fertilizer Application (2011 Revised Version), and in 2021, the Central Government's "Document No. 1" once again stressed the need to continue to promote the reduction of chemical fertilizers and increase their efficiency to solve the problem of excessive application of chemical fertilizers (Lu et al., 2019). According to the third national agricultural census, there are 207 million farming households in China, with over 200 million non-scale farming households. The basic national conditions and farming conditions of a large country with farmers determine that farmers are the mainstay of agricultural production (Wang et al., 2021). Although soil testing and fertilizer application techniques have been promoted for more than 10 years, the adoption of biochemical techniques is the preference of farmers to improve land output (Liu et al., 2019). Therefore, there is a need to address the issue of adopting environmentally friendly farmland conservation technology behavior. Taking soil testing and fertilizer application technology as an example, soil testing and fertilizer application technology are characterized by positive externalities, large investments, and long payback periods (Weeks Jr. and Hettiarachchi, 2019). The decision-making process of adoption behavior is influenced by limited rationality, environmental regulations, and market uncertainty (Cortner et al., 2019), and there is a 'disconnect' or 'divergence' between willingness to participate and adoption behavior, with little initiative and ineffective behavior (Perri et al., 2020).

Research on the factors influencing farmers' adoption of soil testing and fertilizer application technology has focused on two aspects: first, it is influenced by micro factors, such as farmers' production and management characteristics, individual cognition, and willingness (Guo et al., 2022); second, it is influenced by macro governance factors, such as government regulation and organizational linkages, involving regulatory instruments, such as agricultural environmental control, agricultural technology promotion and dissemination, government subsidies, and services provided by agricultural cooperative organizations through the provision of market demand information and standardized technology guidance (Bonnet et al., 2020). The results of previous research are of great significance and reference value to this paper, but there is still room for further improvement. First, in terms of research methods, existing studies have either used traditional regression methods to analyze the net effect of individual factors or structural equations and mediating effect models to analyze the mechanism of moderation of two or three factors (Dong et al., 2022a; Dong et al., 2022b; Dong et al., 2022c). For example, traditional regression analysis must satisfy the assumptions of mutual independence between variables, one-way linear relationship, and causal symmetry, and it is difficult to explain the interaction effect of more than three interaction variables, while qualitative comparative analysis can effectively address the complex causal relationships of multiple independent variables that depend on each other. Second, in terms of research content, the adoption behavior of farmers may be a decision process in which multiple independent variables (more than three) interact with each other. It is unclear whether different factors combine to form different configurations and how these configurations systematically influence the effects of farmers' adoption behavior. The process of configuration theorizing extends and enriches the study of the correlations between individual factors and farm household behavior and their moderating effects.

This study develops an integrated model of psychological cognition–external context–behavioral effect, assuming that the behavioral effect of farmers is influenced by objective conditions, such as government regulation and organizational linkage, as well as psychological factors, such as subjective perception and willingness to participate, and is the result of the combined effect of subjective and objective factors. Based on the view of configuration, a multi-case comparative analysis method, i.e., fuzzy-set qualitative comparative analysis, is adopted to explore the "joint effect" of the interaction between psychological cognition and external context on the behavioral effects of farmers' adoption of soil testing and fertilizer application technology.

The structure of the article is as follows: Section 2 summarizes the theoretical foundations and research framework; Section 3 introduces the methodology; Section 4 presents the results of the study. Section 5 summarizes contributions and provides some practical implications due to empirical findings. Section 6 states the conclusions. Section 7 states the research limitations and future research directions.

2 Theoretical foundations and research framework

From previous research, scholars have proposed different theories to explain individual behavior and the mechanisms behind it (Muthukrishna and Henrich, 2019). The previous theoretical models mainly considered individual subjective factors, such as the Lewin model of behavior (Li Z. et al., 2022), theory of reasoned action (TRA) (Ajzen and Kruglanski, 2019), theory of planned behavior (TPB) (Dong et al., 2022c), and motivation–opportunity–ability model (MOA) (Bopp et al., 2019; Ahmad et al., 2021), and mostly analyze the determinants of willingness based on the perspective of consistency between willingness and behavior, ignoring the inconsistency between willingness and behavior. Cognitive and situational factors can be conditions for the conversion of willingness into behavior (Brand and Cheval, 2019).

Subsequent theories, such as the attitude–context–behavior (ABC) theory (Zhang J. et al., 2020), the consciousness–context–behavior system model (Hou et al., 2021), and the cognitive–context–behavior model (CCB) (Aardema and Wong, 2020), suggest that behavior is the result of the interaction between external contextual factors and subjective psychological factors. Previous literature records have mainly analyzed context-specific moderating effects based on the antecedents of behavior, such as attitudes, consciousness, and cognition, without considering the possible direct influence of external contexts on behavior (Li and Fang, 2022; Lou et al., 2022; Yuan et al., 2022). The causal relationships between the various influences are complex, and the configuration formed by multiple factors has a combined effect on behavior.

This paper constructs the psychological cognition–external context–behavioral effect model, which suggests that farmers' behavioral decisions are the result of a combination of endogenous causes, such as individual cognition and participatory willingness, and exogenous causes, such as government regulation and organizational coupling, and explains the effect of individual factors and the multiple concurrent causal relationships of each factor (Lim et al., 2020). The behavioral effect refers to the effectiveness of farmers' adoption of environmentally friendly farmland conservation technologies (Mozzato et al., 2018), which is highly consistent with their adoption behavior, and the initiative and motivation of farmers to adopt technologies directly affect the level of behavioral effect (Piñeiro et al., 2020).

Psychological cognitive is the psychological basis for individual behavioral decisions, including farmer cognition and willingness to participate (Costa et al., 2019). These factors enable farmers to form internal preferences for environmentally friendly farmland conservation technologies and influence technology adoption behavior and are the triggering factors for individual behavior (Dong et al., 2022a). Farmer cognition is an intrinsic driver of intention and behavior, and cognition is generally divided into psychological cognition and technical cognition (Elahi et al., 2021). In terms of psychological cognition, some studies have used the theory of planned behavior or the theory of perceived value as a framework for analysis, arguing that farmers' awareness of their responsibility to engage in green production and their perceived value are the most direct reasons for their behavioral attitudes and largely determine whether they adopt environmentally friendly farmland conservation technologies (Xue et al., 2021). Technology cognition is the degree of farmers' understanding of environmentally friendly farmland conservation technologies, including their knowledge of profitability, effectiveness, ease of operation, intrinsic perception of the technology, and the perceived effectiveness of the technology services (Rothgerber and Rosenfeld, 2021). The more comprehensive a farmer's knowledge of the functions and values of a technology, the more likely he or she is to adopt the technology (Šūmane et al., 2018). Participation willingness is the strength of an individual's motivation to participate in a particular behavior (Irfan et al., 2021). Generally speaking, willingness has a direct positive influence on behavioral responses, and the stronger the farmers' willingness to adopt environmentally friendly farming technologies, the more motivated they are to learn new technologies and the more likely they are to adopt new technologies in their production practices.

External context is the external environment faced by farmers, which is mainly composed of various factors such as policies and institutions, cooperative organizations, and social networks, including punitive government regulation, incentive government regulation, and organizational coupling (Yoon et al., 2020). People's subjective attitudes are embedded in each situation and change with each situation, and the situation itself reinforces farmers' adoption of environmentally friendly farming techniques by providing opportunities or constraints to counteract individual decision-making behavior (Joseph and Gaba, 2020). Institutional and policy constraints are important preconditions for changes in farmers' intentions and behavior, and they also govern the behavior of the subject. Individual policies have a driving effect on farmers' green production (Wang et al., 2022). For example, government-imposed agricultural quality control and administrative penalties can regulate and constrain farmers' production behavior, while government-led training and promotion of various application and efficiency reduction techniques and projects to replace chemical fertilizers with organic fertilizers for fruit, vegetables, and tea can motivate farmers to adopt environmentally friendly farmland conservation techniques (Peng et al., 2022). The use of various policies together can better bring into play the effect of government-led green production by farmers (Xie et al., 2021).

The "top–down" technology promotion mode of government departments is a compulsory institutional change, which tends to ignore the actual needs of farmers. It is difficult to play an effective role for a large number of farmers with low overall quality. Organizational linkage and other induced institutional changes play a prominent role in actual production (Łuczka and Kalinowski, 2020). Professional cooperatives or leading enterprises provide technical guidance and training to farmers, standardize production, and purchase agricultural products at a premium, ensuring that farmers receive a certain degree of material incentive to adopt environmentally friendly farming techniques (Ji et al., 2018). Meanwhile, the excessive application of chemical fertilizers affects the quality of agricultural products, and through organizational coupling, farmers are restrained from over-applying (Rahman and Zhang, 2018). The constraints of agricultural production and management organizations have an even greater impact on farmers' production behavior than the incentives.

Farmers' cognition, willingness to participate, government regulation, and organizational coupling are not completely separate but inherently interact with each other (Zhang S. et al., 2020). Improved individual cognition helps farmers understand the policy objectives of government regulation and stimulates potential willingness to participate in the adoption of environmentally friendly farmland conservation technologies, thus achieving a good adoption behavioral effect (Li M. et al., 2022). High levels of government regulation will change farmers' perceptions of development opportunities and external conditions, prompting them to join cooperative organizations, actively seek information and technical support on fertilizer reduction and efficiency, strengthen their knowledge of technology and their ability to participate, and increase the level of farmers' behavioral effect (Song et al., 2019). The enhanced human capital and organizational constraints gained from joining an organization can improve farmers' psychological cognition and influence their participation in environmentally friendly farmland conservation technologies (Ho and Kuvaas, 2020). Considering the "configuration effect" of the internal and external factors, it is necessary to further explore the linkage between the factors using the configuration analysis method and construct a group effect model of psychological cognition and external context on farmers' behavioral effect, as shown in Figure 1.

3 Methodology

3.1 Data collection

From April to September 2022, the research group went to the demonstration counties (districts) of high-standard farmland construction projects in Shaanxi Province—Fengxiang County of Baoji City, Shangnan County of Shangluo City, and Linwei District of Weinan City of Shaanxi Province—to conduct field research on behavioral effect and influencing factors of behavioral effect on the adoption of environment-friendly farmland protection technologies for farmers. The Technical Guidelines for Green Agricultural

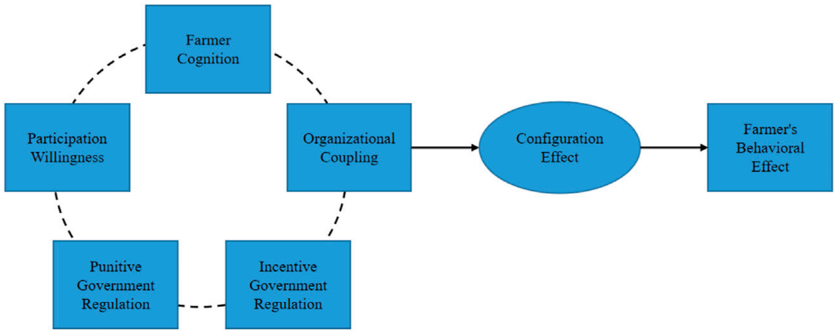

FIGURE 1
Research model.

Development (2018–2030) states that environmentally friendly arable land conservation technologies are those that do not harm the arable land ecosystem within the limits of ecological carrying capacity and environmental capacity, and they are conducive to the ecological protection of the arable land and can also meet the needs of social production. The promotion and application of environmentally friendly farmland conservation technologies are one of the most important ways to improve the utilization rate of chemical fertilizers, reduce surface pollution, and promote the protection of farmland quality. Therefore, only farmers who have adopted soil testing and fertilizer application techniques were selected for this study. To help collect data on the evaluation of the effects of the adoption of the techniques, the following criteria were used: first, they had participated in training on environmentally friendly farming techniques within 3 years. Second, they could be followed up on indefinitely. A stratified random sampling method was used to select three townships in each county, 3–4 administrative villages in each township randomly, and 20–25 questionnaires in each village, taking into account the level of industrial development, external environmental characteristics, and other factors. A total of 460 questionnaires were returned, 35 of which did not meet the screening criteria, for a total of 425 valid questionnaires and a 92.39% effective rate. A combination of semi-structured interviews and questionnaires were used to conduct 20–30 min one-on-one interviews on the factors influencing the adoption of environmentally friendly farmland conservation technologies, followed by a structured questionnaire completed by the farmers themselves with assistance from the investigators to obtain in-depth interview information and primary data and to compile 425 research cases.

TABLE 1 Sample characteristics.

Variables	Definitions	Frequency	Proportion (%)
Gender	Female	108	25.4
	Male	317	74.6
Age	20–30 years old	20	4.7
	31–40 years old	15	3.5
	41–50 years old	55	12.9
	51–60 years old	203	47.7
	61 years old and above	132	31.2
Education	Not been to school	126	29.6
	Primary school	115	27.1
	Middle school	101	23.8
	High school	60	14.1
	College	23	5.4
Cadre	Cadre	12	2.8
	Non-cadre	413	97.2

3.2 Research method

Qualitative comparative analysis (QCA) is a Boolean algebra-based set-theoretic configuration analysis method that explores multiple concurrent relationships between multiple conditions by examining the sufficient and necessary subset of relationships between antecedent conditions and outcomes (Ragin, 2008), enabling the identification of different causal pathways to improve the farmer's behavioral effect, i.e., all roads lead to Rome. It is suitable for analyzing small samples and combines the advantages of qualitative analysis (case-oriented) and quantitative analysis (variable-oriented) (Chen and Tian, 2022). On the one hand, it overcomes the non-extensibility of qualitative analysis of a few cases, and on the other hand, it compensates for the inadequacy of quantitative methods for the analysis of qualitative changes and phenomena in large samples, providing new perspectives and ideas for solving complex problems of concurrent causality, equivalence, and asymmetry in social science research.

Fuzzy-set qualitative comparative analysis (fsQCA) was selected based on the following considerations: first, the samples were taken from 425 cases of in-depth interviews with farmers in the demonstration counties of high-standard farmland construction projects, which met the requirements of the method for sample quantity and sample characteristics; second, farmers' behavioral decision to adopt environmentally friendly farmland conservation technologies is a complex interaction process with multiple factors, and the use of conditional variable configuration relationships can identify the combination of variables and diversified paths to improve farmer's behavioral effect. Third, QCA (qualitative comparative analysis) is divided into csQCA (crisp-set qualitative comparative analysis), mvQCA (multi-value qualitative analysis), and fsQCA according to the type of data (Mendel and Korjani, 2012). . csQCA is suitable for dealing with binary data, mvQCA is suitable for dealing with multi-value data, and fsQCA is suitable for analyzing the effects of multiple types of variables on the results. The conditional and outcome variables in this paper are mostly continuous variables, which meet the requirements of the fsQCA method for variables.

3.3 Sample characteristics

As shown in Table 1, 425 valid questionnaires were collected. The characteristics of the samples were as follows: 317 (74.6%) males and 335 (78.8%) middle-aged adults over 50 years of age. Of these, 342 (80.5 percent) had less than high school education, accounting for over three-quarters of the sample size. Only 12 of them were village cadres (the administrator or decision maker of the village). The results of mean and variance of latent variables are shown in Table 2: farmer cognition (M = 5.001, SD = 1.022), participation willingness (M = 5.213, SD = 1.044), organizational coupling (M = 4.722, SD = 1.036), punitive government regulation (M = 4.764, SD = 1.066), incentive government regulation (M = 4.923, SD = 1.178), and behavioral effect (M = 5.197, SD = 1.088).

3.4 Data analysis

The behavioral effect was used as the outcome variable, while farmer cognition, participation willingness, organizational coupling, punitive government regulation, and incentive government regulation were used as antecedent variables, following the proposed psychological cognition–external context–behavioral effect mind integration analysis framework. Among them, farmer cognition and willingness to participate are proxy variables for psychological cognition, and organizational coupling, punitive government regulation, and incentive government regulation are proxies for external contexts. All of the survey's questions use a Likert-7 scale, with responses ranging from "strongly disagree" to "strongly agree" and "strongly ineffective" to "strongly effective" being assigned subjectively. Higher values indicate higher levels of the related variable, with each variable being given a value that is equal to the total of the question items of the applicable dimension.

1) Farmer cognition: The level of awareness of an environmentally friendly farming technology determines whether or not a farmer adopts it (Kassie et al., 2013). On the one hand, farmers' perception of the technology itself, such as their knowledge of environmentally friendly farming techniques, and on the other hand, their perception of the functions or effects of the technology, including the importance of improving agricultural production skills and management.
2) Participation willingness: The research results of Zhang et al. report that participation willingness refers to the propensity of farmers to adopt environmentally friendly farming technologies and the degree of effort they are willing to put in (Zhang et al., 2022). Two questions were used to measure this: "Are you willing to adopt environmentally friendly farming technologies?" and "Would you actively seek environmentally friendly farmland conservation technologies even without government promotion?."
3) Organizational coupling: According to a comprehensive study, organizational coupling can be defined as a series of formal or informal institutional arrangements in the form of contracts between agricultural cooperative organizations and farmers, such as unified production management, technology promotion and dissemination, and product marketing services, to change farmers' awareness of environmentally friendly farmland conservation technologies and to form intrinsic or extrinsic incentives and constraints for technology adoption (Shin et al., 2020). This paper is based on a series of formal or informal institutional arrangements to change farmers' awareness of environmentally friendly farming technologies and to create internal or external incentives and constraints for technology adoption. The items set out in this article are "quality and quality requirements of the agricultural products that cooperatives (enterprises) buy or help to sell," "fertilizer requirements of cooperatives (enterprises) in the production process," and "training of cooperatives (enterprises) in environmentally friendly farming techniques."
4) Government regulation: In this paper, two dimensions, punitive government regulation and incentive government regulation, are selected to measure government regulation. Drawing on Zhang et al.'s approach, farmers are asked about their perceptions of "the strength of government regulation and enforcement in the agricultural production process" and "the likelihood of being punished due to quality and safety issues" to assign a value to punitive government regulation (Zhang et al., 2022). For assigning values to incentive government regulation, farmers were asked about "the impact of government subsidies on the adoption of environmentally friendly farming techniques," "their satisfaction with government training on environmentally friendly farming techniques," "the extent to which government departments publicize environmentally friendly farming techniques," and "the extent to which farming departments publicize environmentally friendly farming techniques."
5) Behavioral effect: Drawing on the research design of Yao et al., the behavioral effect includes three dimensions: economic effect, technical effect, and management effect of adopting environmentally friendly farming technologies (Yao et al., 2019). The economic effect is measured by "reduce fertilizer labor costs," "increase in profit per acre," and "reduce the use of resources such as water and electricity," the technical effect is measured by "operability of environmentally friendly farmland conservation technologies" and "compatibility of training technologies with local agricultural production," and the management effect is measured by "the use of environmentally friendly farmland conservation technologies." The effect of management was measured by "improve the quality of agricultural products" and "improve the planning and controllability of capital expenditure and return." The variables were measured as shown in Appendix A.

SPSS 24.0 was used to test the reliability of the five antecedent variables and one outcome variable, and the results are shown in

TABLE 2 Descriptive statistics.

Variables	No. of items	Mean	SD	Cronbach's alpha
Farmer cognition	3	5.001	1.022	0.768
Participation willingness	2	5.213	1.044	0.742
Organizational coupling	3	4.722	1.036	0.773
Punitive government regulation	2	4.764	1.066	0.723
Incentive government regulation	4	4.923	1.178	0.775
Behavioral effect	7	5.197	1.088	0.888

TABLE 3 Descriptive statistics and calibration values.

Variables	Fuzzy-set calibration criteria		
	Fully-out (25%)	Cross-over (50%)	Fully-in (75%)
Farmer cognition	16	18	20
Participation willingness	9	11	13
Organizational coupling	9	12	16
Punitive government regulation	8	10	12
Incentive government regulation	22	24	26
Behavioral effect	38	42	46

Farmer cognition, participatory willingness, organizational coupling, punitive government regulation, incentive government regulation, and behavioral effect, the six variables, were set at the upper quartile (75%), median (50%), and lower quartile (25%) of the descriptive statistics of the case sample for the completely unaffiliated, intersections, and completely affiliated three calibration points, respectively.

Table 2. The Cronbach's alpha of all variables was greater than the recommended value of 0.7, which passed the reliability test (Ali et al., 2018). The results of the questionnaire met the requirements of the stability and consistency test. The KMO value for the questionnaire as a whole was 0.766, indicating that the measures can effectively reflect the underlying qualities of their common factor composition, and the approximate chi-square value of Bartlett's spherical test was 704.913, with a significance level of 0.000, indicating that the scale is suitable for factor analysis.

Fuzzy-set qualitative comparative analysis (fsQCA) analyses set relationships rather than variables and require calibration of the original variable dimensions to set affiliation, i.e., whether the study case belongs to a set or not. The use of fuzzy sets to convert variables into set affiliation generally requires three thresholds: full affiliation, intersection, and full disaffiliation. To avoid subjectivity, the calibration anchors are shown in Table 3, taking the values of each variable at 75%, 50%, and 25% as the calibration parameters (Fiss, 2011).

TABLE 4 Necessity analysis of individual conditions.

Variables	Consistency	Coverage
Farmer cognition	0.651	0.612
~Farmer cognition	0.452	0.582
Participation willingness	0.679	0.613
~Participation willingness	0.442	0.592
Organizational coupling	0.551	0.563
~Organizational coupling	0.559	0.655
Punitive government regulation	0.411	0.553
~Punitive government regulation	0.675	0.615
Incentive government regulation	0.516	0.555
~Incentive government regulation	0.535	0.589

4 Result analysis

4.1 Necessity analysis of individual conditions

FsQCA based on the set theory uses the indicator consistency to identify the sufficient or necessary subset of relationships between the different condition variables, the configuration formed by the condition variables and the outcome variables, where the necessary condition is the condition that always exists when the outcome occurs, and the outcome always occurs when the sufficient condition is present. The coverage indicator reflects the explanatory power of the condition in the process of outcome occurrence; the higher the value, the stronger the explanatory power.

TABLE 5 Analysis of sufficient conditions.

Conditions	Configuration 1	Configuration 2	Configuration 3
Farmer cognition	⊗	●	⊗
Participation willingness	●	⊗	⊗
Organizational coupling	⊗	⊗	●
Punitive government regulation	⊗	●	●
Incentive government regulation	⊗	⊗	⊗
Consistency	0.916	0.888	0.811
Raw coverage	0.270	0.164	0.176
Unique coverage	0.230	0.129	0.130
Solution consistency	0.868		
Solution coverage	0.537		

● = core conditions; ⊗ = absent of core conditions; ● = peripheral conditions; ⊗ = absent of peripheral conditions.

The necessity test is an important step in QCA, where a single antecedent condition has a consistency value greater than 0.9, indicating that the condition is necessary for the outcome variable (Afonso et al., 2018). Table 4 shows the results of the test of whether each antecedent condition is necessary to increase the farmer's behavioral effect. The consistency of the five conditional variables used for this study is all less than 0.9, as shown. It demonstrates that farmer cognition, participation willingness, organizational coupling, punitive government regulation, and incentive government regulation are not necessary conditions for farmers to effectively adopt environment-friendly cultivated land protection technologies. In other words, the increase in behavioral effect is not caused by a particular antecedent condition, and the effects of each condition variable on behavioral effect are interdependent. The configuration effect needs to be further investigated.

4.2 Sufficiency analysis of the condition configuration

Sufficiency analysis uses a truth table algorithm to identify whether a particular configuration is a sufficient configuration for the result, and when the consistency between a particular configuration and the result is greater than or equal to 0.75, the configuration is considered sufficient for the result. The threshold for raw consistency is set at 0.8, following the widely accepted existing studies (Kumar et al., 2022). In addition to the consistency threshold, the number of cases covered by a particular configuration is also a screening criterion for a particular grouping to enter the Boolean minimization process. The selection of frequency thresholds in QCA analysis takes into account both the size of the sample and its distribution between configurations. The frequency threshold for small- to medium-sized samples (10–100 cases) should not be less than 1 and can be increased for larger samples; in this paper, the frequency threshold for cases is set at 3 (Pappas and Woodside, 2021). The complex, simple, and intermediate solutions of the model were calculated using fsQCA3.0 software. Table 5 shows the results of the conditional configuration analysis to achieve the effective adoption of environmentally friendly farmland conservation technologies by farmers. This paper, which is based on the configuration theory, focuses on the interpretation of QCA results regarding intermediate solutions and identifies the core conditions and peripheral conditions of the configuration by combining the parsimonious and intermediate solutions. If an antecedent condition occurs in both the simple and intermediate solutions, it is a core condition; if the antecedent condition occurs only in the intermediate solution, it is a peripheral condition. Solid circles (•) indicate the presence of conditions, forked circles (⊗) indicate the absence of conditions, large circles indicate core conditions, and small circles indicate peripheral conditions (Fiss, 2011). There are three antecedent configurations with explanatory power to improve the farmer's behavioral effect, whose solution consistency is 0.868, which is higher than the theoretical threshold of 0.8, and the consistency of individual antecedent configurations is 0.916, 0.888, and 0.811, respectively, which are also higher than 0.8. This suggests that all three antecedent configurations are sufficient conditions for improving the behavioral effect. The solution coverage was 0.537, indicating that these three groups could explain real-life cases to a certain extent. In general, all three configurations can improve the behavioral effect of farmers' adoption of the technology, which is equivalent; i.e., "different paths lead to the same result."

4.2.1 Willingness-to-participate dominant model

Configuration 1 is summarized as the participation willingness dominant model, indicating that even though farmers' psychological cognition is low and external contexts, such as government regulation and organizational coupling, are less binding, active participation willingness can increase the behavioral effect of farmers' adoption of environmentally friendly farmland conservation technologies. Core conditions include farmer cognition, participation willingness, and incentive government regulation, while peripheral conditions include organizational coupling and punitive government regulation. This configuration can be expressed as follows: when a series of incentives and constraints such as subsidies for organic fertilizers instead of chemical fertilizers and government regulation does not work effectively, agricultural cooperatives and leading enterprises do not provide substantial services, and farmers do not have general knowledge of environmentally friendly farmland conservation technologies; if farmers' participation willingness plays a leading role, willingness and behavior can also maintain a high level of consistent consistency. In-depth interviews revealed that farmers who conformed to this configuration had the common characteristics of having taken the initiative to participate in training on environmentally friendly farming techniques several times in a row, having achieved results in the adoption of environmentally friendly farming techniques, having achieved significant improvements in the quality of their products, and being able to achieve above-average profits, which became a strong driver for farmers' participation willingness to transform into sustainable behavior and produce a good behavioral effect after adopting the techniques.

4.2.2 Internal and external constraint dominant model

Configuration 2 is a combined internal and external constraint model, indicating that enhancing farmer's behavioral effect requires external contexts, such as punitive government regulation, with subjective perceptions as the psychological basis, and participation willingness, organizational coupling, and incentive government regulation play a supporting role, and various internal and external factors interact as antecedent conditions. Core conditions include farmer cognition, organizational coupling, punitive government regulation, and incentive government regulation, and participation willingness is a peripheral condition. This configuration shows that the individual behavior of farmers in the middle stage of technology training depends on their perceptions of the environment, that their initial decisions to adopt environmentally friendly farming technologies need to be guided by compulsory institutional changes, such as punitive government regulation, and that the perceptions formed tend to be more specific, clear, and solid and are more likely to translate into sustainable behavior. During the field survey, it was found that most farmers are aware of the environmental problems caused by excessive fertilizer application and generally have the awareness to reduce the application of chemical fertilizers and increase the application of organic fertilizers, but the degree of implementation is relatively low, showing the phenomenon of "high awareness, low behavior." If the government imposes mandatory regulatory measures to strengthen the regulation and punishment of excessive fertilizer application and the quality and safety of agricultural products, farmers, as rational small-scale farmers, will first consider the additional costs arising from excessive fertilizer application, and when their marginal benefits are less than their marginal costs, they will be driven by loss aversion to adopt and learn environmentally friendly farming techniques. Punitive government regulation can guide and regulate the production behavior of farmers, turning perceptions into endogenous motivation; i.e., the combined pressure of subjective psychological factors and external situations lead farmers to effectively adopt environmentally friendly farming techniques.

4.2.3 External context dominant model

Configuration 3 is a model dominated by external contexts, in which the effective adoption of environmentally friendly farmland conservation technologies by farmers relies on external contexts, such as organizational coupling and punitive government regulation, coupled with the complementary roles of farmer cognition, participatory willingness, and incentive government regulation. In this configuration, participation willingness, organizational coupling, and incentive government regulation are core conditions, and farmer cognition and punitive government regulation are peripheral conditions. This configuration reflects the low level of awareness and willingness to participate of the farmers who participated in the initial technical training. If the government increases its supervision of environmental pollution and agricultural product quality and safety and strengthens the restraining effect on farmers' irregular behavior, and if agricultural cooperative organizations effectively play the role of incentives and guidance to compensate for the shortcomings of farmers' fragmented production behavior, the pressure from the external context can produce a good behavioral effect after the adoption of the reduced application and efficiency technology behavioral effect. The traditional high-input/high-output production method has given farmers a strong path dependency. At the beginning of the change in fertilizer application behavior, the government put forward requirements and restrictions on the agricultural production process, which, to a certain extent, will reduce the possibility of opportunistic behavior on the part of farmers who were forced to reduce the amount of fertilizer application under intense supervision. On the other hand, organizational coupling is an induced institutional change. Cooperative organizations provide members with training in organic fertilizer substitution techniques, unified procurement of fertilizers, and other production factors and implement standardized management of the production process, unified purchase, sale of agricultural products, and other social services so that farmers may achieve high-quality and good prices under large-scale production. The long-term stable economic benefits will stimulate farmers to form strong behavioral motivation, further increasing the behavioral effect of farmers to adopt environmentally friendly farmland conservation technologies.

Comparing configuration 2 and configuration 3, it was found that when high punitive government regulation occurred, there was a substitution relationship between farmer cognition and organizational coupling. The presence of only one condition in the farmer cognition and organizational coupling increases the behavioral effect of technology adoption by farmers.

The robustness test has been carried out mainly by increasing the consistency level. After increasing the consistency level from 0.8 to 0.85, all groups remained unchanged, the solution consistency became 0.907, and the solution coverage became 0.507, with no significant changes, indicating that the study results are reliable, as shown in Table 6.

5 Discussion

Based on the three conditions of configuration for achieving effective adoption of environmentally friendly farmland

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TABLE 6 Robustness tests.

Antecedent conditions	Configuration 1	Configuration 2	Configuration 3
Farmer cognition	⊗	●	⊗
Participation willingness	●	⊗	⊗
Organizational coupling	⊗	⊗	●
Punitive government regulation	⊗	●	●
Incentive government regulation	⊗	⊗	⊗
Consistency	0.916	0.888	0.811
Raw coverage	0.270	0.164	0.176
Unique coverage	0.243	0.137	0.131
Solution consistency	0.907		
Solution coverage	0.507		

● = core conditions; ⊗ = absence of core conditions; ● = peripheral conditions; ⊗ = absence of peripheral conditions.

conservation technologies by farmers, the following insights were gained:

First, to focus on cultivating farmers' willingness to participate in green production, improve the organization of farmers, provide farmers with environmentally friendly farmland conservation technology, services, and information through professional cooperatives and leading enterprises, actively guide farmers to carry out environmentally friendly production, and promote the quality of agricultural products (Liu et al., 2020), through the brand effect of environmentally friendly agricultural products, a premium price is formed for the products, and the agricultural income of farmers is increased, ultimately promoting the formation of farmers' willingness to participate in environmentally friendly production.

Second, to strengthen government supervision and raise the level of active awareness of environmentally friendly production among farmers, the significance of developing environmentally friendly agriculture should be publicized through a variety of means, such as mobile phone Weibo, radio, and the internet, and models of environmentally friendly arable land protection techniques should be promoted and demonstrated to guide farmers to form an awareness of environmentally friendly production (Elahi et al., 2019). Through a series of regulatory instruments, such as agricultural product quality testing and production process supervision, the government can appropriately increase penalties for opportunistic behavior, such as excessive application of chemical fertilizers and substandard quality of agricultural products, to regulate and guide farmers to shift to environmentally friendly production behavior.

Third, a "combination punch" should be played to promote farmers' active integration into environmentally friendly agricultural development. Agricultural cooperative organizations should provide technical, information, service, and financial support to small farmers who lack production factors; government departments should provide differentiated and precise policy guidance according to the heterogeneous characteristics of the target audience and actively guide and regulate farmers' technology adoption behavior through incentive and constraint mechanisms to effectively increase the behavioral effect of farmers' adoption of environmentally friendly farmland protection technologies.

To summarize the three types of contexts, the psychological cognition and external context factors are different for farmers at different stages of technical training. In the early stages, farmers need the combined pressure of external contexts, such as punitive government regulation and organizational coupling. In the middle stage, farmers gradually form a correct knowledge of fertilizer reduction, but the role of punitive government regulation is still indispensable. In the later stage, farmers' willingness to participate dominates, which can directly encourage farmers to participate. In the later stages, farmers' willingness to participate is the dominant factor, which can lead to the effective adoption of environmentally friendly farming techniques.

6 Conclusion

With different factors combining to form different configurations and how these configurations systematically influence the effects of farmers' adoption behavior, the process of configuration theorizing extends and enriches the study of the correlations between individual factors and farm household behavior and their moderating effects.

First, participation willingness is the key to increasing the behavioral effect of technology adoption when external contextual conditions such as farmers' psychological cognition, organizational coupling, and government regulation play a limited role.

Second, the combination of farmers' subjective psychological cognition and external punitive government regulation is the main way to achieve effective adoption of environmentally friendly farmland conservation technologies by farmers.

Third, when internal conditions, such as farmer cognition and willingness to participate, are not available, external situational factors, such as punitive government regulation and organizational coupling, are important ways to improve farmers' behavioral effects.

Furthermore, when high punitive government regulation occurs, there is a substitution relationship between farmer cognition and organizational coupling, with the presence of only one of the conditions in farmer cognition and organizational coupling increasing the behavioral effect of technology adoption by farmers.

7 Limitations and future research

Although the snowball sampling method was adopted for the sampling survey, the sampling scope was mainly limited to Guanzhong Plain of Shaanxi Province, which affected the representativeness of samples and the accuracy and generalization of research results to a certain extent. In the future, more samples can be selected across the country for empirical testing, and the measurement scale and theoretical model proposed in this paper can be revised, expanded, and improved. In addition, the empirical study in this paper used cross-sectional data, while the questionnaire collected data at roughly the same point in time and did not involve dynamic simulation of the effects of different policies. Therefore, the structural equation method can be used in the future to carry out micro-effect evaluation and explore the influence of different influencing factors and their combinations on the adoption of environmentally friendly farmland technology by farmers so as to provide a decision-making basis for further environmentally friendly agricultural production.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Conceptualization, TC and HD; methodology, HZ and HD; software, JW; validation, HZ; formal analysis, JW; investigation, JW; resources, XW; data curation, XW; writing—original draft preparation, HZ and HD; writing—review and editing, HZ and HD; visualization, XW; supervision, TC; project administration, TC; funding acquisition, TC. All authors contributed to the article and approved the submitted version.

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Conflict of interest

Authors HD, HZ, JW, TC, and XW were employed by the company Shaanxi Provincial Land Engineering Construction Group Co., Ltd.

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References

Aardema, F., and Wong, S. F. (2020). Feared possible selves in cognitive-behavioral theory: An analysis of its historical and empirical context, and introduction of a working model. *J. Obsessive-Compulsive Relat. Disord.* 24, 100479. doi:10.1016/j.jocrd.2019.100479

Afonso, C., Silva, G. M., Gonçalves, H. M., and Duarte, M. (2018). The role of motivations and involvement in wine tourists' intention to return: SEM and fsQCA findings. *J. Bus. Res.* 89, 313–321. doi:10.1016/j.jbusres.2017.11.042

Ahmad, B., Da, L., Asif, M. H., Irfan, M., Ali, S., and Akbar, M. I. U. D. (2021). Understanding the antecedents and consequences of service-sales ambidexterity: A motivation-opportunity-ability (MOA) framework. *Sustainability* 13, 9675. doi:10.3390/su13179675

Ajzen, I., and Kruglanski, A. W. (2019). Reasoned action in the service of goal pursuit. *Psychol. Rev.* 126, 774–786. doi:10.1037/rev0000155

Ali, F., Rasoolimanesh, S. M., Sarstedt, M., Ringle, C. M., and Ryu, K. (2018). An assessment of the use of partial least squares structural equation modeling (PLS-SEM) in hospitality research. *Int. J. Contemp. Hosp. Mngt* 30, 514–538. doi:10.1108/IJCHM-10-2016-0568

Bonnet, C., Bouamra-Mechemache, Z., Réquillart, V., and Treich, N. (2020). Viewpoint: Regulating meat consumption to improve health, the environment and animal welfare. *Food Policy* 97, 101847. doi:10.1016/j.foodpol.2020.101847

Bopp, C., Engler, A., Poortvliet, P. M., and Jara-Rojas, R. (2019). The role of farmers' intrinsic motivation in the effectiveness of policy incentives to promote sustainable agricultural practices. *J. Environ. Manag.* 244, 320–327. doi:10.1016/j.jenvman.2019.04.107

Brand, R., and Cheval, B. (2019). Theories to explain exercise motivation and physical inactivity: Ways of expanding our current theoretical perspective. *Front. Psychol.* 10: 1147. doi:10.3389/fpsyg.2019.01147

Chen, H., and Tian, Z. (2022). Environmental uncertainty, resource orchestration and digital transformation: A fuzzy-set QCA approach. *J. Bus. Res.* 139, 184–193. doi:10.1016/j.jbusres.2021.09.048

Cortner, O., Garrett, R. D., Valentim, J. F., Ferreira, J., Niles, M. T., Reis, J., et al. (2019). Perceptions of integrated crop-livestock systems for sustainable intensification in the Brazilian Amazon. *Land Use Policy* 82, 841–853. doi:10.1016/j.landusepol.2019.01.006

Costa, D. F., Carvalho, F. de M., and Moreira, B. C. de M. (2019). Behavioral economics and behavioral finance: A bibliometric analysis of the scientific fields. *J. Econ. Surv.* 33, 3–24. doi:10.1111/joes.12262

Damalas, C. A., and Eleftherohorinos, I. G. (2011). Pesticide exposure, safety issues, and risk assessment indicators. *Int. J. Environ. Res. Public Health* 8, 1402–1419. doi:10.3390/ijerph8051402

Dong, H., Wang, B., Han, J., Luo, L., Wang, H., Sun, Z., et al. (2022a). Understanding farmers' eco-friendly fertilization technology adoption behavior using an integrated S-O-R model: The case of soil testing and formulated fertilization technology in shaanxi, China. *Front. Environ. Sci.* 10, 2021. doi:10.3389/fenvs.2022.991255

Dong, H., Wang, B., Zhang, P., Chen, X., and Han, J. (2022b). Research on the influence mechanism of agricultural entrepreneurship: Evidence from five provinces in western China. *Front. Psychol.* 13, 864226. doi:10.3389/fpsyg.2022.864226

Dong, H., Wang, H., and Han, J. (2022c). Understanding ecological agricultural technology adoption in China using an integrated technology acceptance model—theory of planned behavior model. *Front. Environ. Sci.* 10, 927668. doi:10.3389/fenvs.2022.927668

Elahi, E., Weijun, C., Zhang, H., and Abid, M. (2019). Use of artificial neural networks to rescue agrochemical-based health hazards: A resource optimisation method for cleaner crop production. *J. Clean. Prod.* 238, 117900. doi:10.1016/j.jclepro.2019.117900

Elahi, E., Zhang, H., Lirong, X., Khalid, Z., and Xu, H. (2021). Understanding cognitive and socio-psychological factors determining farmers' intentions to use improved grassland: Implications of land use policy for sustainable pasture production. *Land Use Policy* 102, 105250. doi:10.1016/j.landusepol.2020.105250

Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. *AMJ* 54, 393–420. doi:10.5465/amj.2011.60263120

Gisriel, C., Shen, G., Kurashov, V., Ho, M.-Y., Zhang, S., Williams, D., et al. (2020). The structure of Photosystem I acclimated to far-red light illuminates an ecologically important acclimation process in photosynthesis. *Sci. Adv.* 6, eaay6415. doi:10.1126/sciadv.aay6415

Guo, A., Wei, X., Zhong, F., Wang, P., and Song, X. (2022). Does cognition of resources and the environment affect farmers' production efficiency? Study of oasis agriculture in China. *Agriculture* 12, 592. doi:10.3390/agriculture12050592

Ho, H., and Kuvaas, B. (2020). Human resource management systems, employee well-being, and firm performance from the mutual gains and critical perspectives: The well-being paradox. *Hum. Resour. Manag.* 59, 235–253. doi:10.1002/hrm.21990

Hou, C., Zhang, M., Wang, M., Fu, H., and Zhang, M. (2021). Factors influencing grazing behavior by using the consciousness-context-behavior theory—a case study from yanchi county, China. *Land* 10, 1157. doi:10.3390/land10111157

Irfan, M., Elavarasan, R. M., Hao, Y., Feng, M., and Sailan, D. (2021). An assessment of consumers' willingness to utilize solar energy in China: End-users' perspective. *J. Clean. Prod.* 292, 126008. doi:10.1016/j.jclepro.2021.126008

Ji, C., Jia, F., and Xu, X. (2018). Agricultural co-operative sustainability: Evidence from four Chinese pig production co-operatives. *J. Clean. Prod.* 197, 1095–1107. doi:10.1016/j.jclepro.2018.06.279

Joseph, J., and Gaba, V. (2020). Organizational structure, information processing, and decision-making: A retrospective and road map for research. *ANNALS* 14, 267–302. doi:10.5465/annals.2017.0103

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F., and Mekuria, M. (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: Evidence from rural Tanzania. *Technol. Forecast. Soc. Change* 80, 525–540. doi:10.1016/j.techfore.2012.08.007

Kumar, S., Sahoo, S., Lim, W. M., Kraus, S., and Bamel, U. (2022). Fuzzy-set qualitative comparative analysis (fsQCA) in business and management research: A contemporary overview. *Technol. Forecast. Soc. Change* 178, 121599. doi:10.1016/j.techfore.2022.121599

Li, C.-Y., and Fang, Y.-H. (2022). Go green, go social: Exploring the antecedents of pro-environmental behaviors in social networking sites beyond norm activation theory. *Int. J. Environ. Res. Public Health* 19, 14265. doi:10.3390/ijerph192114265

Li, M., Liu, Y., Huang, Y., Wu, L., and Chen, K. (2022a). Impacts of risk perception and environmental regulation on farmers' sustainable behaviors of agricultural green production in China. *Agriculture* 12, 831. doi:10.3390/agriculture12060831

Li, Z., Lewin, M., Ruiz, P., Nigra, A. E., Henderson, N. B., Jarrett, J. M., et al. (2022b). Blood cadmium, lead, manganese, mercury, and selenium levels in American Indian populations: The Strong Heart Study. *Environ. Res.* 215, 114101. doi:10.1016/j.envres.2022.114101

Lim, J. S., Choe, M.-J., Zhang, J., and Noh, G.-Y. (2020). The role of wishful identification, emotional engagement, and parasocial relationships in repeated viewing of live-streaming games: A social cognitive theory perspective. *Comput. Hum. Behav.* 108, 106327. doi:10.1016/j.chb.2020.106327

Liu, Y., Ruiz-Menjivar, J., Zhang, L., Zhang, J., and Swisher, M. E. (2019). Technical training and rice farmers' adoption of low-carbon management practices: The case of soil testing and formulated fertilization technologies in Hubei, China. *J. Clean. Prod.* 226, 454–462. doi:10.1016/j.jclepro.2019.04.026

Liu, Y., Sun, D., Wang, H., Wang, X., Yu, G., and Zhao, X. (2020). An evaluation of China's agricultural green production: 1978–2017. *J. Clean. Prod.* 243, 118483. doi:10.1016/j.jclepro.2019.118483

Lou, J., Han, N., Wang, D., and Pei, X. (2022). Effects of mobile identity on smartphone symbolic use: An attachment theory perspective. *Int. J. Environ. Res. Public Health* 19, 14036. doi:10.3390/ijerph192114036

Lu, H., Zhang, P., Hu, H., Xie, H., Yu, Z., and Chen, S. (2019). Effect of the grain-growing purpose and farm size on the ability of stable land property rights to encourage farmers to apply organic fertilizers. *J. Environ. Manag.* 251, 109621. doi:10.1016/j.jenvman.2019.109621

Lu, Y., Song, S., Wang, R., Liu, Z., Meng, J., Sweetman, A. J., et al. (2015). Impacts of soil and water pollution on food safety and health risks in China. *Environ. Int.* 77, 5–15. doi:10.1016/j.envint.2014.12.010

Łuczka, W., and Kalinowski, S. (2020). Barriers to the development of organic farming: A polish case study. *Agriculture* 10, 536. doi:10.3390/agriculture10110536

Mendel, J. M., and Korjani, M. M. (2012). Charles ragin's fuzzy set qualitative comparative analysis (fsQCA) used for linguistic summarizations. *Inf. Sci.* 202, 1–23. doi:10.1016/j.ins.2012.02.039

Mozzato, D., Gatto, P., Defrancesco, E., Bortolini, L., Pirotti, F., Pisani, E., et al. (2018). The role of factors affecting the adoption of environmentally friendly farming practices: Can geographical context and time explain the differences emerging from literature? *Sustainability* 10, 3101. doi:10.3390/su10093101

Muthukrishna, M., and Henrich, J. (2019). A problem in theory. *Nat. Hum. Behav.* 3, 221–229. doi:10.1038/s41562-018-0522-1

Pappas, I. O., and Woodside, A. G. (2021). Fuzzy-set qualitative comparative analysis (fsQCA): Guidelines for research practice in information systems and marketing. *Int. J. Inf. Manag.* 58, 102310. doi:10.1016/j.ijinfomgt.2021.102310

Peng, X., Wang, F., Wang, J., and Qian, C. (2022). Research on food safety control based on evolutionary game method from the perspective of the food supply chain. *Sustainability* 14, 8122. doi:10.3390/su14138122

Perri, C., Giglio, C., and Corvello, V. (2020). Smart users for smart technologies: Investigating the intention to adopt smart energy consumption behaviors. *Technol. Forecast. Soc. Change* 155, 119991. doi:10.1016/j.techfore.2020.119991

Piñeiro, V., Arias, J., Dürr, J., Elverdin, P., Ibáñez, A. M., Kinengyere, A., et al. (2020). A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. *Nat. Sustain* 3, 809–820. doi:10.1038/s41893-020-00617-y

Ragin, C. (2008). *Redesigning social inquiry: Fuzzy sets and beyond*. Chicago: Bibliovault OAI Repository, the University of Chicago Press.

Rahman, K. M. A., and Zhang, D. (2018). Effects of fertilizer broadcasting on the excessive use of inorganic fertilizers and environmental sustainability. *Sustainability* 10, 759. doi:10.3390/su10030759

Rothgerber, H., and Rosenfeld, D. L. (2021). Meat-related cognitive dissonance: The social psychology of eating animals. *Soc. Personality Psychol. Compass* 15, e12592. doi:10.1111/spc3.12592

Shin, H. C., Yu, D. J., Park, S., Anderies, J. M., Abbott, J. K., Janssen, M. A., et al. (2020). How do resource mobility and group size affect institutional arrangements for rule enforcement? A qualitative comparative analysis of fishing groups in South Korea. *Ecol. Econ.* 174, 106657. doi:10.1016/j.ecolecon.2020.106657

Song, Y., Yang, T., and Zhang, M. (2019). Research on the impact of environmental regulation on enterprise technology innovation—An empirical analysis based on Chinese provincial panel data. *Environ. Sci. Pollut. Res.* 26, 21835–21848. doi:10.1007/s11356-019-05532-0

Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Rios, I. des I., et al. (2018). Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *J. Rural Stud.* 59, 232–241. doi:10.1016/j.jrurstud.2017.01.020

Wang, J., Ding, X., Li, D., and Li, S. (2022). The impact of organizational support, environmental health literacy on farmers' willingness to participate in rural living environment improvement in China: Exploratory analysis based on a PLS-SEM model. *Agriculture* 12, 1798. doi:10.3390/agriculture12111798

Wang, X., Zhang, W., Lakshmanan, P., Qian, C., Ge, X., Hao, Y., et al. (2021). Public–private partnership model for intensive maize production in China: A synergistic strategy for food security and ecosystem economic budget. *Food Energy Secur.* 10, e317. doi:10.1002/fes3.317

Weeks, J. J., Jr., and Hettiarachchi, G. M. (2019). A review of the latest in phosphorus fertilizer technology: Possibilities and pragmatism. *J. Environ. Qual.* 48, 1300–1313. doi:10.2134/jeq2019.02.0067

Xie, J., Yang, G., Wang, G., Song, Y., and Yang, F. (2021). How do different rural-land-consolidation modes shape farmers' ecological production behaviors? *Land Use Policy* 109, 105592. doi:10.1016/j.landusepol.2021.105592

Xue, Y., Guo, J., Li, C., Xu, X., Sun, Z., Xu, Z., et al. (2021). Influencing factors of farmers' cognition on agricultural mulch film pollution in rural China. *Sci. Total Environ.* 787, 147702. doi:10.1016/j.scitotenv.2021.147702

Yao, T., Qiu, Q., and Wei, Y. (2019). Retaining hotel employees as internal customers: Effect of organizational commitment on attitudinal and behavioral loyalty of employees. *Int. J. Hosp. Manag.* 76, 1–8. doi:10.1016/j.ijhm.2018.03.018

Yoon, C., Lim, D., and Park, C. (2020). Factors affecting adoption of smart farms: The case of Korea. *Comput. Hum. Behav.* 108, 106309. doi:10.1016/j.chb.2020.106309

Yuan, Y., Xu, M., and Chen, H. (2022). What factors affect farmers' levels of domestic waste sorting behavior? A case study from shaanxi Province, China. *Int. J. Environ. Res. Public Health* 19, 12141. doi:10.3390/ijerph191912141

Zhang, J., Xie, C., Morrison, A. M., and Zhang, K. (2020a). Fostering resident pro-environmental behavior: The roles of destination image and confucian culture. *Sustainability* 12, 597. doi:10.3390/su12020597

Zhang, S., Hu, W., Zhang, J., Li, M., and Zhu, Q. (2020b). Mismatches in suppliers' and demanders' cognition, willingness and behavior with respect to ecological protection of cultivated land: Evidence from caidian district, wuhan, China. *Int. J. Environ. Res. Public Health* 17, 1156. doi:10.3390/ijerph17041156

Zhang, Y., Lu, X., Zhang, M., Ren, B., Zou, Y., and Lv, T. (2022). Understanding farmers' willingness in arable land protection cooperation by using fsQCA: Roles of perceived benefits and policy incentives. *J. Nat. Conservation* 68, 126234. doi:10.1016/j.jnc.2022.126234

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Appendix A

TABLE A1 Survey instrument.

Variables	No. of items
Farmer cognition (1. strongly disagree to 7. strongly agree)	
FC1	How much do you know about environmentally friendly farmland conservation techniques?
FC2	How much do you know about environmentally friendly farmland conservation techniques?
FC3	Do you think environmentally friendly arable land conservation techniques are important to improve management?
Participation willingness (1. strongly disagree to 7. strongly agree)	
PW1	Would you like to adopt environmentally friendly farmland conservation techniques?
PW2	Would you actively seek environmentally friendly farming technologies even if they were not promoted by the government?
Organizational coupling (1. strongly disagree to 7. strongly agree)	
OC1	Requirements for quality and quality of the agricultural products that the cooperative (enterprise) buys or helps to sell
OC2	Cooperatives' (enterprises') requirements for fertilizer application in the production process
OC3	Training efforts of cooperatives (enterprises) on environmentally friendly farming techniques
Punitive government regulation (1. strongly disagree to 7. strongly agree)	
PGR1	The strength of government regulation and enforcement in the agricultural production process
PGR2	Potential for penalties due to agricultural quality and safety issues
Incentive government regulation (1. strongly disagree to 7. strongly agree)	
IGR1	Do government subsidies strongly influence your adoption of environmentally friendly farmland conservation techniques?
IGR2	Do you have a strong interest in the government-organized promotion of environmentally friendly farmland conservation technologies?
IGR3	Has agricultural extension (agricultural technicians) helped you to adopt environmentally friendly farmland conservation technologies?
IGR4	Do government departments promote environmentally friendly farmland conservation techniques?
Behavioral effect (1. strongly effective to 7. strongly ineffective)	
BE1	Reduce fertilizer labor costs
BE2	Increase in profit per acre
BE3	Reduce the use of resources, such as water and electricity
BE4	Operability of environmentally friendly farmland conservation technologies
BE5	Compatibility of training technologies with local agricultural production
BE6	Improve the quality of agricultural products
BE7	Improve the planning and controllability of capital expenditure and return