

Adoption behavior of cultivated land ecological protection among family farms from the AMO theory perspective: A fuzzy-set QCA approach

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Abstract

Encouraging family farms to adopt cultivated land ecological protection behaviors is conducive to safeguarding China's food security, resource security, and ecological security. Existing studies have primarily focused on analyzing the impact of individual factors on cultivated land protection behaviors, with limited attention paid to the synergistic effects of multiple factors. Drawing upon the AMO (Ability-Motivation-Opportunity) framework, this study employs the fuzzy-set qualitative comparative analysis (fsQCA) method to explore the complex causal mechanisms that drive family farms to generate cultivated land ecological protection adoption behaviors. The findings are as follows: (1) No single antecedent condition constitutes a necessary condition for family farms to generate cultivated land ecological protection adoption behaviors. The adoption behavior of cultivated land ecological protection among family farms is the result of the interplay of multiple factors, including ability, motivation, and opportunity. (2) Two types of pathways drive family farms to generate high cultivated land ecological protection adoption behaviors, namely the "ability-opportunity driven" pathway and the "ability-motivation driven" pathway. (3) Peer effects play a crucial role in driving family farms to generate high cultivated land ecological protection adoption behaviors. In addition, there is a substitutive relationship between organizational support and self-efficacy. The findings of this study contribute to deepening the understanding of the complex causal mechanisms through which multiple factors interact to influence family farms' adoption behaviors of cultivated land ecological protection, and provide useful insights for stimulating such behaviors among family farms.

Introduction

Cultivated land is a core element for ensuring food security (Qie et al., 2023), as protecting cultivated land is key to safeguarding food security. However, for a long time, China has emphasized the protection of cultivated land quantity while neglecting quality and ecological protection (Chen and Liu, 2020). This is prominently manifested in the excessive use of production inputs such as chemical fertilizers and pesticides, leading to soil acidification (Jin et al., 2025), soil compaction (Rahman and Anik, 2020), and exacerbating water eutrophication (Sun et al., 2026), which in turn reduces soil enzyme activity and microbial abundance (Wang et al., 2025), thereby constraining sustainable agricultural development and food security (Yang and Lin, 2020; Cheng et al., 2026). In response, the Opinions of the Central Committee of the Communist Party of China and the State Council on Strengthening Cultivated Land Protection and Improving the Balance of Occupation and Compensation (2017) explicitly proposed that "cultivated land should be protected as preciously as giant pandas," with a focus on strengthening the "trinity" protection of cultivated land quantity, quality, and ecology. Moreover, the No. 1 Central Documents of 2019, 2020, and 2021 all clearly stated the need to "steadily promote the control, remediation, and utilization of agricultural land soil pollution, and strengthen the management of agricultural non-point source pollution." These policies underscore the high importance and expectations that the Party and the government place on cultivated land ecological protection.

Family farms are expected to shoulder high expectations in cultivated land ecological protection. As one of the new-type agricultural business entities, family farms, compared with traditional smallholders, possess a stronger sense of social responsibility and modern perspectives (Zhu et al., 2014), and exhibit greater ecological consciousness (Wang and Du, 2020; Xie et al., 2025), making them the "desirable" subjects for developing ecological agriculture and achieving sustainable agricultural development (Cai and Du, 2016). However, cultivated land ecological protection practices are characterized by intertemporal benefits, high costs,

and operational complexity, which pose challenges to their widespread adoption among family farms, resulting in generally low adoption rates (Yu et al., 2020; Ke and Huang, 2024). Notably, as the most direct, grassroots, and primary participants. Therefore, an in-depth exploration of the driving pathways of family farms' adoption behaviors of cultivated land ecological protection is of significant practical importance for addressing the current low enthusiasm for ecological protection among family farms, and also provides meaningful implications for governments at all levels in formulating cultivated land ecological protection policies.

Literature review

Research on Farmers' Adoption Behavior of Cultivated Land Ecological Protection

Given that cultivated land ecological protection behaviors constitute an important behavioral pathway for achieving the "dual carbon" strategic goals, the factors influencing agricultural operators' adoption of such behaviors have been extensively explored. These factors are primarily categorized into internal and external determinants. Internal factors focus on the influence of farmers' individual internal characteristics on cultivated land ecological protection behaviors. First, individual demographic characteristics serve as the foundation for behavioral decision-making. Studies have shown that demographic variables such as gender, age, and educational level of operators significantly affect their ecological protection behaviors, with farmers of different characteristics exhibiting heterogeneity in technology adoption (Zhou et al., 2017; Wang et al., 2015). Second, psychological cognitive factors are the internal core driving the transformation of farmers' behaviors. Scholars have identified significant intrinsic correlations between farmers' ecological cognition and ecological emotions and their protection behaviors (Fei et al., 2022; Wu et al., 2020). Risk preference, in turn, determines farmers' decision-making tendencies when facing new technologies or novel input models, with risk-averse individuals generally remaining cautious toward green technologies that require upfront investment (Qiu et al., 2020). Moreover, self-efficacy—that is, farmers' confidence and judgment regarding their own ability to successfully implement protection behaviors—has also been confirmed as a critical psychological variable affecting behavioral persistence (Guo et al., 2022). Finally, farmers' own capacities also play an important role in behavioral transformation. Existing literature reveals that information acquisition capability and technical application capability can help farmers overcome information asymmetry and lower the threshold of technology adoption, thereby facilitating the implementation of ecological protection measures (Wang et al., 2022; Lyu et al., 2015). External factors are primarily examined from two aspects: operational characteristics and the policy environment. In terms of operational characteristics, differences in operational scale lead farmers to face varying cost-benefit considerations when adopting conservation technologies, resulting in significant divergence in behavioral choices between large-scale operators and smallholders (Wang et al., 2022; Zhao et al., 2020; Wen et al., 2019). At the level of the policy environment, the academic community generally agrees that government intervention serves as a crucial lever for guiding the green transformation of farmers' behaviors. Policy instruments such as ecological compensation, technical training, and agricultural subsidies can effectively compensate for the positive externalities of cultivated land ecological protection and enhance farmers' willingness to participate (Li and Yin, 2022; Guo et al., 2022). Concurrently, some studies have approached the issue from the perspective of farmers' social capital, suggesting that their social networks can effectively promote the diffusion of cultivated land ecological protection behaviors through information transmission and technical demonstration (Ma et al., 2022).

Gaps in the existing literature

Existing studies on cultivated land ecological protection adoption behaviors have extensively examined factors from individual cognition to institutional environments, yet two gaps remain. First, most research focuses on smallholders, with insufficient attention to family farms—now a major force in agricultural production. Unlike smallholders, family farms operate at larger scales with intensive, commercialized practices and stronger economic capacity, making them key adopters of green technologies. Thus, systematic research on their ecological protection behaviors is urgently needed to inform targeted policy design.

Second, existing studies mainly examine the "net effect" of individual factors on cultivated land ecological protection adoption behaviors, neglecting the synergistic effects among multiple factors. Although some have introduced moderating effect models, these can only handle two- or three-way interactions and fall short for more complex cases (Du et al., 2017). In reality, such behaviors are shaped by the interplay of internal and external factors, which traditional regression cannot fully capture. Configurational analysis, by contrast, treats conditions as interdependent and jointly influential (Du & Kim, 2021). Thus, a configurational approach is needed to uncover the complex pathways through which multiple factors collectively shape adoption behaviors.

The AMO (Ability-Motivation-Opportunity) theory constructs an integrative analytical framework encompassing the three dimensions of ability, motivation, and opportunity, providing a solid theoretical foundation for systematically elucidating the mechanisms underlying individual behavior. Importantly, this theory emphasizes that individual behavior is not determined by a single factor, but rather results from the synergistic interaction of ability, motivation, and opportunity. Consequently, it is particularly suitable for analyzing the configurational effects of multiple factors (Xuan et al., 2025). This provides a logical framework for addressing the issue of independence among the antecedent conditions of family farms' cultivated land ecological protection adoption behaviors. Accordingly, this study constructs an AMO theoretical model of family farms' cultivated land ecological protection adoption behaviors. Furthermore, the qualitative comparative analysis (QCA) method, grounded in set theory and embracing a holistic logic, is capable of identifying and analyzing complex phenomena arising from multiple conjunctural causations (Ragin, 2006), thereby providing methodological support for the AMO theoretical model proposed in this study.

Contributions of this study

In view of this, drawing upon the AMO theory, this study employs the fuzzy-set qualitative comparative analysis (fsQCA) method to investigate, from a configurational perspective, the effects of multiple antecedent conditions on family farms' cultivated land ecological protection adoption behaviors under the interplay of ability, motivation, and opportunity. The findings of this study are expected to reveal how ability, motivation, and opportunity jointly guide family farms' adoption behaviors of cultivated land ecological protection, deepen the understanding of the driving pathways underlying such behaviors, broaden the analytical perspectives of relevant research, and provide practical implications for governments to formulate targeted policies to promote family farms' adoption of cultivated land ecological protection behaviors.

Theoretical basis and research framework

AMO theory

The AMO theoretical framework posits that the emergence of specific individual behaviors is the result of the synergistic interaction of three elements: ability, motivation, and opportunity (Shang et al., 2021). This theory holds that individuals not only need to possess the ability to perform a behavior and the motivation to act, but also require external environmental conditions that provide opportunities for the behavior to materialize. These three dimensions together constitute the necessary conditions for behavioral occurrence. Specifically, ability refers to the repertoire of cognitive functions and psychological resources that an individual needs to engage in an activity, with its core function being to ensure that the subject efficiently accomplishes the target activity. Motivation refers to the psychological and emotional predispositions that drive an individual's behavioral decisions, manifested concretely as the sustained drive for an individual to participate in an activity. Opportunity refers to the exogenous conditions that facilitate or constrain the subject's behavioral performance, including uncontrollable events and external factors such as social relationships. By integrating individual ability, motivation, and external situational factors, AMO theory enables both a systematic analysis of individual behavioral performance from the perspective of individual–context interaction, and a clear delineation of the interplay among various conditions. Based on interviews with family farm operators and a systematic review of the literature on AMO theory and family farm cultivated land ecological protection behaviors, this study synthesizes the factors influencing family farms' adoption behaviors of cultivated land ecological protection into three dimensions: ability, motivation, and opportunity. Specifically, self-efficacy and information acquisition capability are selected as ability factors; intrinsic motivation and ecological responsibility cognition are selected as motivation factors; and organizational support and peer effects are selected as opportunity factors.

Ability factors: Self-efficacy and information acquisition capability

Self-efficacy refers to the beliefs, expectations, and judgments that an individual holds about performing a specific activity prior to its implementation. In this study, it specifically refers to family farm operators' subjective perceptions of their own operational feasibility and technological adaptation effectiveness when implementing cultivated land ecological protection behaviors (Guo et al., 2022). According to social cognitive theory, when facing ecological protection decisions characterized by high technical complexity and delayed returns, high self-efficacy can significantly enhance farm operators' psychological resilience in coping with technical difficulties and process uncertainties, thereby increasing their willingness to adopt such behaviors. On this basis, this study incorporates self-efficacy into the analytical framework as a key ability variable affecting adoption behaviors.

Information acquisition capability refers to an individual's ability to obtain raw information from external sources and transform it into personal knowledge reserves and judgmental foundations through comprehension, screening, and internalization, which exerts a significant influence on personal behavioral decisions. In cultivated land ecological protection decisions, information asymmetry often constitutes a behavioral barrier. Family farm operators with stronger information acquisition capability are able to effectively access technical benefit data, subsidy policy updates, and market demand signals, thereby reducing cognitive ambiguity, enhancing perceived behavioral control, and providing a solid cognitive foundation for adoption decisions.

Motivation factors: Intrinsic motivation and ecological responsibility cognition

Drawing upon pro-environmental motivation theory, this study defines intrinsic motivation as the endogenous propensity driven by the psychological satisfaction and pleasure that an individual derives from the act of engaging in cultivated land ecological protection behaviors (Li, 2020). Behaviors stemming from intrinsic motivation tend to exhibit greater autonomy and persistence. For family farm operators, when they perceive that ecological protection behaviors are consistent with their personal values and interests, intrinsic motivation translates into a stable internal drive that encourages them to proactively adopt and persistently adhere to cultivated land protection practices.

Ecological responsibility cognition is defined in this study as an individual's awareness of agro-environmental issues and their self-attribution of responsibility (Nie, 2016). According to the responsible environmental behavior model, responsibility consciousness serves as a critical transformative node linking cognition and action. For family farm operators, cognition that remains at the level of "understanding the severity of the problem" is insufficient to precipitate substantive behavioral change. Only when such cognition elevates to a self-conscious awareness of "I must take responsibility for this" does ecological responsibility truly become the psychological engine driving their proactive adoption of cultivated land protection behaviors. Accordingly, this study regards ecological responsibility cognition as an important motivational factor influencing adoption behaviors.

Opportunity factors: Organizational support and peer effects

Organizational support is defined as an individual's comprehensive evaluation of an organization's emotional responsiveness and resource provision. According to social exchange theory, when family farm operators perceive emotional respect and care from village organizations, they develop a psychological tendency to reciprocate, one manifestation of which is a more proactive adoption of cultivated land ecological protection behaviors that align with organizational expectations. However, emotional drivers alone are unlikely to sustain such behaviors without substantive resource backing. The high-input nature of ecological protection behaviors determines that financial and technical pressures are critical bottlenecks constraining farm operators' decisions. Instrumental support from village organizations—such as subsidies, material inputs, or technical guidance—can directly reduce the marginal costs of behavioral implementation and alleviate the dilemma of "willing but unable," thereby transforming organizational support from mere "psychological perception" into an effective force for "behavioral facilitation" (Zhang et al., 2023).

Peer effects refer to the phenomenon that an individual's decisions are influenced by the behaviors of other members within their social group (Song et al., 2021), with the underlying roots lying in decision-makers' information limitations and bounded rationality. In the context of this study, peer effects operate primarily through two pathways. The first is the information learning pathway: when neighboring farms pioneer the adoption of ecological protection technologies and achieve visible positive outcomes, their successful experiences constitute credible reference examples and a low-cost source of tacit knowledge, which helps reduce other farm operators' information search costs and cognitive uncertainty. Simultaneously, the scaled adoption of such practices within the group can dilute individual concerns about technological risks and

mitigate the "first-mover dilemma." The second is the social norm pathway: when a behavior is endowed with positive moral or social significance by the group, the practices of early adopters gradually solidify into shared behavioral norms within the group, generating strong social demonstration pressure that prompts latecomers to proactively follow suit, driven by norm-conforming motivation.

Research framework

The AMO theory provides a three-dimensional analytical framework of "ability–motivation–opportunity" for explaining family farms' cultivated land ecological protection adoption behaviors. However, constrained by individual heterogeneity, farm operators exhibit significant disparities in their endowments of the three elements, resulting in diversified behavioral trigger pathways within the same theoretical framework. Meanwhile, existing studies predominantly rely on linear regression models and follow a symmetric analysis logic, which fails to effectively capture the interactive interdependencies and synergistic effects among antecedent variables, thereby limiting the in-depth revelation of the complex mechanisms underlying behavioral formation. Therefore, this study integrates the AMO theory with fsQCA to construct a theoretical analytical model of family farms' cultivated land ecological protection adoption behaviors, and to explore the interaction mechanisms among six antecedent conditions—namely, self-efficacy, information acquisition capability, intrinsic motivation, ecological responsibility perception, government support, and peer effects—and to summarize the multiple configurational pathways that drive such adoption behaviors. The theoretical model is presented in Fig. 1.

Research design

Research method

This study uses fuzzy-set qualitative comparative analysis (fsQCA) to examine how six conditions—self-efficacy, information acquisition, intrinsic motivation, ecological responsibility, organizational support, and peer effects—jointly drive family farms' ecological protection adoption behaviors. The method is chosen for three reasons. First, these behaviors result from the interplay of multiple factors, not single causes, and fsQCA effectively captures such conjunctural effects. Second, fsQCA identifies multiple equivalent pathways (equifinality) to the same outcome, revealing heterogeneous driving patterns and deepening understanding of behavioral mechanisms. Third, fsQCA is well-suited for continuous antecedent and outcome variables, which aligns with the nature of our core variables and research questions.

Data collection

The data come from a household survey of rice-planting family farms in Jiangxi Province, conducted by the research team in December 2023. The selection of this region and farm type rests on two main considerations. First, rice dominates Jiangxi's cropping system, accounting for 85–90% of grain-planting area and 60–70% of total sown area. As a major double-cropping rice region in southern China, the ecological protection behaviors of its rice farms are critical to mitigating agricultural non-point source pollution and advancing local ecological civilization. Second, empirical research on cultivated land ecological protection in rice farming remains limited, unlike the more studied corn, wheat (Li et al., 2017; Cui et al., 2021), and cash crops (Zuo, 2015; Ma and Gong,

2018). Thus, investigating these behaviors offers valuable insights for promoting beautiful countryside development, sustainable land use, agricultural sustainability, and food security.

This study adopted a multi-stage random sampling method. Based on pre-survey results, the formal questionnaire was revised in terms of item design, wording, and bias control. Trained enumerators then conducted one-on-one, paper-based interviews with primary decision-makers of family farms via door-to-door visits. The survey covered operator demographics, farm operations, environmental awareness, and ecological protection behaviors. Of the 450 questionnaires distributed, 380 were valid, yielding an effective response rate of 84%. Sample descriptive statistics are shown in Table 1.

Table 1
Basic characteristics of sample farmers Descriptive statistics of the sample

Category	Indicator	Frequency	Percentage	Category	Indicator	Frequency	Percentage
Gender	Male	343	90.26%	Years of operation of family farm	≤ 5 years	211	55.52%
	Female	37	9.73%		6–10 years	118	31.05%
Age of respondents	< 30 years	10	2.63%		11–15 years	34	8.95%
	30–39 years	53	13.95%	Farm operation area	16–20 years	9	2.36%
	40–49 years	131	34.47%		> 21 years	8	2.10%
	50–59 years	155	40.78%		≤ 50 mu	47	12.37%
	≥ 60 years	31	8.15%		51–100 mu	31	8.15%
Educational level of respondents	Primary school or below	40	10.52%		101–200 mu	56	14.73%
	Junior high school	183	48.15%		201–300 mu	44	11.58%
	Senior high school or above	157	41.32%		≥ 301 mu	202	53.16%

Variable measurement

To ensure validity, all variables were measured using published, empirically validated scales. English-origin instruments underwent rigorous translation and back-translation to reduce cross-cultural bias. In data processing, item scores for each continuous variable were averaged to generate the final observed indicator.

Measurement of family farms' cultivated land ecological protection adoption behaviors. Following the approach of Yang (2018) and with reference to the Action Plan for Cultivated Land Quality Protection and Improvement

promulgated by the former Ministry of Agriculture in 2015, this study selected five technical measures—namely, straw returning, deep tillage and subsoiling, application of commercial organic fertilizer, soil testing and formulated fertilization, and no-till seeding—to characterize family farms' cultivated land ecological protection adoption behaviors. On this basis, drawing upon the method of Willy and Holm-Müller (2013), this study employed the sum of the adoption scores of the above five technical measures as a composite indicator to measure the degree of family farms' cultivated land ecological protection adoption behaviors.

Self-efficacy was measured using the scale developed by Guo et al.(2022), which includes three items such as "Whether to implement cultivated land ecological protection behaviors is entirely up to my own decision." All items were measured on a seven-point Likert scale, with 1 indicating "strongly disagree" and 7 indicating "strongly agree."

Information acquisition capability was measured using the scale proposed by Zhang et al. (2022), which includes eight items such as "How well do you obtain information regarding cultivated land ecological protection?" All items were measured on a five-point Likert scale, with 1 indicating "very few" and 5 indicating "very many."

Intrinsic motivation was assessed using the pro-environmental motivation scale developed by Pelletier et al. (1998), which comprises four items such as "I implement protection behaviors because I derive pleasure from contributing to the environment." All items were measured on a seven-point Likert scale, with 1 indicating "strongly disagree" and 7 indicating "strongly agree."

Ecological responsibility cognition was measured using the scale developed by Li et al (2022), which includes four items such as "I believe that everyone should make contributions to environmental protection." All items were measured on a seven-point Likert scale, with 1 indicating "strongly disagree" and 7 indicating "strongly agree."

Organizational support was measured using the scale proposed by Yang et al. (2018), which comprises six items such as "During the process of cultivated land ecological protection, village organizations provide information services." All items were measured on a seven-point Likert scale, with 1 indicating "strongly disagree" and 7 indicating "strongly agree."

Peer effects were assessed using the scale developed by He et al.(2023), which includes three items such as "Do your relatives adopt cultivated land ecological protection behaviors?" All items were measured as binary variables, with 1 assigned if the respondent answered "yes" and 0 if the respondent answered "no." Following the approach of Zhao et al.(2020), factor analysis was employed to reduce the dimensionality of the above items, and the extracted factor scores were used as a composite indicator of peer effects.

Reliability, validity, and common method bias tests

Reliability was tested using SPSS 26.0 (Table 2). All Cronbach's α coefficients were ≥ 0.80 , indicating good reliability. For validity, content validity was ensured by adopting empirically validated scales from prior studies, with item wording adapted to the research context and Chinese setting. Construct validity was assessed via AMOS 24.0: all factor loadings for self-efficacy, information acquisition, intrinsic motivation, ecological responsibility, and organizational support exceeded 0.60 (above the 0.50 threshold); all AVEs were > 0.50 , and all CRs > 0.80 . These results confirm good composite reliability and construct validity.

To mitigate common method bias, this study applied both procedural and statistical controls. Procedurally, following Zhou and Long (2004), we ensured respondent anonymity, included reverse-coded items and scrambled item order, and collected data across multiple times, sites, and methods where possible. Statistically, Harman’s single-factor test showed that the first factor explained 28.233% of variance, well below the 40% threshold, indicating that common method bias was not a serious issue.

Table 2
Reliability and validity test results

Variable	Minimum factor loading	Cronbach’s α	AVE	CR
Self-efficacy	0.647	0.800	0.579	0.800
Information acquisition capability	0.690	0.942	0.665	0.940
Intrinsic motivation	0.917	0.963	0.896	0.972
Ecological responsibility cognition	0.851	0.936	0.806	0.943
Organizational support	0.712	0.958	0.789	0.957

Variable calibration

For QCA, raw variables were calibrated into set-membership scores (0–1) using sample maximum (full membership), median (crossover), and minimum (full non-membership) as anchors. To avoid cases with exact 0.50, such values were adjusted to 0.5001 following Fiss (2011). Calibration details are shown in Table 3.

Table 3
Calibration anchors for each variable

Condition and outcome	Full non-membership	Crossover point	Full membership
Self-efficacy	1	4.609	7
Information acquisition capability	1	3.862	5
Intrinsic motivation	2.5	6.020	7
Ecological responsibility cognition	1	6.196	7
Government support	1	5.845	7
Peer effects	-1.3	0.001	0.28
Cultivated land ecological protection adoption behaviors	0	3.918	5

Results and analysis

Necessity analysis of individual conditions

Before conducting the configurational analysis, it is necessary to analyze whether a single antecedent condition is a necessary condition for inducing family farms to adopt cultivated land ecological protection behaviors. As shown in Table 4, the consistency scores of all conditions are below the threshold of 0.9 (Zhang et al., 2019),

indicating that no single antecedent condition constitutes a necessary condition for family farms' cultivated land ecological protection adoption behaviors. In other words, no individual antecedent condition can independently promote the occurrence of cultivated land ecological protection adoption behaviors. Therefore, it is necessary to further adopt configurational analysis to systematically examine the joint mechanisms through which different combinations of conditions influence adoption behaviors.

Table 4
Necessity analysis of individual conditions

Condition variable	Consistency	Coverage
High self-efficacy	0.674	0.829
Non-high self-efficacy	0.507	0.730
High information acquisition capability	0.715	0.825
Non-high information acquisition capability	0.482	0.753
High intrinsic motivation	0.715	0.796
Non-high intrinsic motivation	0.475	0.780
High ecological responsibility cognition	0.734	0.778
Non-high ecological responsibility cognition	0.448	0.795
High organizational support	0.726	0.791
Non-high organizational support	0.477	0.809
High peer effects	0.882	0.749
Non-high peer effects	0.199	0.603

Configurational analysis

Configurational analysis was performed using fsQCA 3.0 to assess the sufficiency of antecedent condition combinations in producing the outcome. The raw consistency threshold was set at 0.8, PRI consistency at 0.85, and case frequency at 3 (based on sample size), ensuring observed cases accounted for over 80% of total cases (Greckhamer et al., 2018). Standardized truth table analysis generated complex, intermediate, and parsimonious solutions. Conditions present in both intermediate and parsimonious solutions were designated as core; those only in intermediate solutions as peripheral (Pappas and Woodside, 2021). Table 5 presents the configurational results for the six antecedent conditions on high adoption behaviors.

Table 5
Configurational analysis results for high adoption behavior

Condition configuration	H1: Ability–opportunity driven		H2: Ability–motivation driven	
	S1	S2	S3	S4
Self-efficacy	●	●		●
Information acquisition capability			●	●
Intrinsic motivation		⊠	⊠	⊠
Ecological responsibility cognition	⊠	⊠	●	●
Organizational support	⊠		⊠	
Peer effects	●	●	⊠	⊠
Consistency	0.923	0.917	0.933	0.899
Raw coverage	0.264	0.275	0.324	0.440
Unique coverage	0.003	0.014	0.042	0.138
Overall solution consistency	0.887			
Overall solution coverage	0.531			
Note: ● and ⊠ indicate core presence and absence, respectively; ⊠ and ⊗ indicate peripheral presence and absence, respectively; blank cells indicate that the condition may be either present or absent.				

As shown in Table 5, from the perspective of individual configurations, the consistency scores of all four configurations generating high adoption behaviors exceed 0.8. Overall, the overall solution consistency of the four configurations is 0.887, which is above the threshold of 0.80. In the following analysis, while considering the holistic nature of equivalent configurations, we also attend to the uniqueness of each configuration (Du et al., 2021), and provide nomenclature and detailed elaboration for each pathway leading to high adoption behaviors in conjunction with managerial practice.

(1) Ability–opportunity driven type

The first type of configuration driving high adoption behaviors of family farms' cultivated land ecological protection is characterized by high self-efficacy at the ability level and high peer effects at the opportunity level as core conditions, and is therefore collectively termed the "ability–opportunity driven" type. Based on differences in the core absent conditions, this pathway can be further divided into two specific sub-pathways—namely, Configurations S1 and S2, as shown in Fig. 2. Configuration S1 is characterized by high self-efficacy, high peer effects, and absence of organizational support as core conditions, with absence of ecological responsibility cognition as a peripheral condition. This configuration suggests that under conditions of high self-efficacy and strong peer effects, a high level of cultivated land ecological protection adoption can still be achieved even when organizational support is relatively low and farm operators' own awareness of ecological responsibility is weak. Configuration S2 is characterized by high self-efficacy, high peer effects, and absence of intrinsic motivation as core conditions, also with absence of ecological responsibility cognition as a peripheral condition. This pathway indicates that under the joint influence of high self-efficacy and strong peer effects,

even in the absence of intrinsic motivation and ecological responsibility awareness, a high level of adoption of cultivated land ecological protection behaviors can be achieved.

According to Bandura's self-efficacy theory (Bandura, 1978), self-efficacy reflects an individual's degree of confidence in their ability to accomplish specific tasks. For family farm operators, high self-efficacy implies a strong belief in their capacity to implement cultivated land ecological protection behaviors. Within this theoretical framework, individual agency serves as the core driving force of behavioral change. When self-efficacy is combined with peer effects, it can generate a joint action capacity that transcends external resource constraints. In the "ability–opportunity driven" pathway, even in the absence of external organizational support, farm operators with high self-efficacy will proactively seek information, learn, and experiment with new technologies, rather than passively awaiting external assistance. Meanwhile, the frequent interpersonal exchanges and field observation activities within rural communities constitute an informal network for information dissemination and technical learning. This strong peer effect, to a certain extent, compensates for the absence of formal organizational support, enabling the rapid diffusion of practical experience. The synergistic interaction between self-efficacy and peer effects significantly mitigates the barriers posed by insufficient organizational support. In Configuration S1, the core driving force for promoting the adoption of cultivated land ecological protection behaviors is not ecological responsibility awareness, but rather the intrinsic impetus derived from high self-efficacy. Therefore, even if farm operators have a weak perception of ecological responsibility, as long as they possess strong self-efficacy and are situated in a positive peer atmosphere, behavioral adoption can still be facilitated. In Configuration S2, the absence of intrinsic motivation can likewise be compensated by high self-efficacy and high peer effects: when individuals are confident in their behavioral implementation capabilities and observe widespread participation among their surrounding peers, even without an intrinsic identification with environmental values, they can ultimately adopt ecological protection behaviors under the dual influence of technical execution confidence and group behavioral demonstration. In summary, when self-efficacy and peer effects combine to form a sufficiently powerful synergy, the constraints posed by insufficient organizational support and lack of intrinsic motivation can be effectively mitigated, thereby ensuring a high level of adoption of cultivated land ecological protection behaviors.

(2) Ability–motivation driven type

The second type of configuration driving high adoption behaviors of family farms' cultivated land ecological protection is characterized by high information acquisition capability at the ability level and high ecological responsibility cognition at the motivation level as core conditions, and is therefore collectively termed the "ability–motivation driven" type. Based on differences in the composition of core conditions, this type can be further divided into two equivalent pathways (S3 and S4), as illustrated in Fig. 3. Configuration S3 is characterized by high information acquisition capability, high ecological responsibility cognition, and absence of organizational support as core conditions, supplemented by high intrinsic motivation and high peer effects as peripheral conditions. This configuration suggests that under conditions of sufficient information capability and ecological cognition, combined with strong intrinsic motivation and peer effects, a high level of cultivated land ecological protection adoption can be achieved even in the absence of organizational support. Configuration S4 is characterized by high self-efficacy, high information acquisition capability, and high ecological responsibility cognition as core conditions, also supplemented by high intrinsic motivation and high peer effects as peripheral conditions. This configuration indicates that when self-efficacy, information acquisition capability, and

ecological responsibility cognition are simultaneously at high levels, complemented by sufficient intrinsic motivation and a positive peer effect atmosphere, a high level of cultivated land ecological protection behaviors among family farms can likewise be achieved.

According to the theory of planned behavior (Ajzen, 2011), individual behavioral intention is jointly determined by three core variables: attitude toward the behavior, subjective norms, and perceived behavioral control. In the "ability–motivation driven" pathway, these three psychological variables correspond precisely to the key conditions in the configurations: perceived behavioral control is primarily supported by information acquisition capability and self-efficacy; attitude toward the behavior is rooted in ecological responsibility cognition and intrinsic motivation; and subjective norms originate from the social demonstration generated by peer effects. In Configuration S3, by virtue of strong information acquisition capability, family farm operators are able to fully grasp the relevant technologies for cultivated land protection, which not only enhances their sense of control over the behavior but also significantly strengthens their perceived behavioral control of "I can do it," thereby effectively compensating for the resource constraints resulting from the lack of organizational technical support. Simultaneously, their intrinsic ecological responsibility cognition and pro-environmental motivation jointly shape a firm and positive attitude toward the behavior, substituting for the value identification that organizational emotional support would otherwise provide. In addition, the peer effect creates a community atmosphere of "most people are taking action," which re-establishes individuals' subjective norms and replaces the mobilization function of official demonstration and promotion by village-level organizations with spontaneous collective action pressure. Thus, even in the absence of organizational support, the three components—attitude toward the behavior, subjective norms, and perceived behavioral control—can still form a synergy that drives high adoption behaviors. Configuration S4 presents a pathway characterized by "dual-core ability–motivation driving, reinforced and consolidated by peer effects." In this pathway, self-efficacy and information acquisition capability jointly endow farm operators with the technical confidence to implement ecological protection behaviors, constructing a solid foundation of perceived behavioral control. Meanwhile, ecological responsibility cognition and intrinsic motivation constitute a "cognition–emotion" dual engine, shaping a positive behavioral attitude that is self-sustaining without the need for external incentives. When individuals possess both ability and motivation, the addition of peer effects further creates a social atmosphere in which "the capable take action, and everyone follows suit." At this point, subjective norms do not originate from external pressure, but rather serve as confirmation and reinforcement of individuals' own choices, enabling farm operators to consciously adopt cultivated land ecological protection behaviors under the dual support of technical rationality and ecological philosophy.

A further comparison of the conditional structures of the two types of configurational pathways reveals (see Table 6) that although the "ability–opportunity" driven type and the "ability–motivation" driven type have distinctly different transmission mechanisms, both can effectively drive family farms' cultivated land ecological protection behaviors, exhibiting a clear logic of "equifinality." The "ability–opportunity" driven type is centered on self-efficacy and peer effects, and can facilitate behavioral implementation even in the absence of intrinsic motivation and ecological responsibility awareness, characterized by "strong environmental dependence and weak value internalization." In contrast, the "ability–motivation" driven type is anchored by information acquisition capability and ecological responsibility cognition as its two pillars, and can achieve behavioral self-regulation through information autonomy and value identification even when organizational support is lacking, characterized by "strong ability autonomy and weak external dependence." The comparison of the two pathways

reveals that the adoption behaviors of family farms' cultivated land ecological protection exhibit a diverse implementation spectrum ranging from "community-guided" to "ability-endogenous" types, with different pathways being functionally equivalent. Notably, the two types of pathways show marked differences in case coverage: the raw coverage of Configurations S3 and S4 (ability–motivation driven type) is significantly higher than that of Configurations S1 and S2 (ability–opportunity driven type), indicating that, at the current stage, the driving pathway centered on endogenous capability and ecological values has broader applicability among most family farms. This result does not negate the practical value of the "ability–opportunity" pathway, but rather suggests that farms at different configurations and development stages can identify the most suitable behavioral entry point through the dynamic coordination of multiple factors. Therefore, to effectively promote the practice of cultivated land ecological protection, policy design must move beyond the inertial thinking of single-variable intervention and systematically construct a synergistic promotion system integrating "capability support, motivation stimulation, responsibility internalization, and community linkage" as a four-in-one framework. Overall, whether farmers are "pulled along" by their communities or "propped up" by their own capabilities, guiding family farms' adoption behaviors of cultivated land ecological protection has never been the independent effect of any single factor, but rather the comprehensive result of ability, motivation, and opportunity each playing their respective roles and exerting synergistic forces through multiple configurations.

Table 6

Pathways and characteristics of ability–motivation–opportunity fit driving high adoption behaviors of family farms' cultivated land ecological protection

Pathway of high adoption behaviors of family farms' cultivated land ecological protection	Configurational depiction	Configurational characteristics
"Ability–opportunity" driven type: cultivated land ecological protection behaviors of family farms induced by self-efficacy under peer effects		●High self-efficacy ●Strong peer effects
"Ability–motivation" driven type: cultivated land ecological protection behaviors of family farms induced by information acquisition capability under sufficient motivation		●Strong information acquisition capability ●Sufficient intrinsic motivation ●Strong ecological responsibility cognition ●Strong peer effects
Note: Solid circles in the configurational depiction represent the presence of the relevant conditions (core conditions or peripheral conditions); dashed circles represent the absence of the relevant conditions (core absence or peripheral absence); shaded circles indicate that the relevant conditions are immaterial.		

Robustness test

Following previous studies, this study conducted robustness tests of the configurations from two aspects. First, when the consistency threshold was raised from 0.8 to 0.85, the resulting configurations were consistent with the original configurations. Second, when the PRI consistency threshold was lowered from 0.85 to 0.8, the results showed that the configurations generated under the two PRI consistency levels exhibited clear subset relations, and neither the overall consistency nor the coverage changed substantially. Taken together, the above results indicate that the findings of this study have good robustness.

Discussion

First, family farms' cultivated land ecological protection behaviors are the result of the synergistic interaction of multiple factors—including ability, motivation, and opportunity—rather than being determined by any single condition in isolation. Meanwhile, this study identified two types of pathways that promote high adoption levels, namely the "ability–opportunity driven" type and the "ability–motivation driven" type. This finding is consistent with existing studies that emphasize the interactive effects of multiple factors on farmers' environmental protection behaviors. For instance, Chen and Su (2023) pointed out that villagers' participation in rural human settlement environment governance is not only constrained by their subjective abilities such as knowledge and skills, but also profoundly shaped by benefit perceptions (motivation) and formal and informal institutions (opportunity). However, unlike some research paradigms that emphasize a single dominant factor (e.g., policy subsidies or environmental awareness), this study, based on a configurational perspective, reveals the "equifinality" effects generated by different combinations of conditions. This implies that even in the absence of a particular condition (e.g., strong ecological responsibility awareness or insufficient organizational support), behavioral adoption can still be achieved through the reinforcement of other conditions (e.g., high self-efficacy and peer effects), thus providing a more systematic explanation for understanding the multiple pathways of behavioral formation.

Second, intrinsic motivation and ecological responsibility cognition are not necessary prerequisites for high adoption behaviors of family farms' cultivated land ecological protection. In Configurations S1 and S2, high levels of adoption were still observed even when both intrinsic motivation and ecological responsibility cognition were absent. Previous studies have largely regarded intrinsic motivation and environmental responsibility awareness as the most direct psychological drivers of pro-environmental behaviors (Guo et al., 2020; Li et al., 2022), suggesting that in the absence of such motivational factors, farmers would find it difficult to voluntarily adopt cultivated land ecological protection behaviors. However, the "ability–opportunity driven" pathway revealed in this study provides countervailing evidence: under the conditions of both high self-efficacy and strong peer effects, high adoption behaviors can still be achieved even when the two motivational conditions are simultaneously absent. This indicates that intrinsic motivation and ecological responsibility cognition are sufficient conditions rather than necessary conditions for behavioral generation, and should not be regarded as insurmountable constraints in practical interventions.

Third, although motivational elements are not absolutely necessary, they possess significant driving efficacy in promoting cultivated land ecological protection behaviors. The "ability–motivation driven" pathway, constituted by Configurations S3 and S4, demonstrates that on the basis of high intrinsic motivation and ecological responsibility awareness, supplemented by self-efficacy or information acquisition capability, high levels of adoption can be stably achieved. This result reveals a synergistic amplification effect between motivation and ability: when farmers have internalized the value of ecological protection and formed a sense of responsibility,

as long as they possess self-efficacy or sufficient information acquisition capability, they can effectively translate willingness into actual behavior, without relying on organizational support from opportunity factors. Thus, motivational elements have a non-negligible practical significance in the formation of family farms' cultivated land ecological protection behaviors.

Fourth, among all equivalent pathways, peer effects emerge as a foundational condition that runs throughout. In Configurations S1 and S2, peer effects appear as a core condition and combine with ability conditions such as self-efficacy to collectively facilitate ecological protection behaviors. In Configurations S3 and S4, although it recedes to a peripheral supporting condition, it still reinforces the robustness of the motivation–ability combination. The fundamental role of this condition is closely related to the highly embedded acquaintance network structure in rural society: farming behaviors are highly observable, and agricultural decisions among neighbors tend to generate mutual observation and competition, thereby enabling peer effects to effectively reduce the cognitive costs and psychological risks faced by farmers when attempting ecological farming practices (Shi and Zhang, 2022; Yang et al., 2023). Thus, across different antecedent configurations, peer effects may serve either as a "catalyst" that triggers behaviors or as a "stabilizer" that consolidates behaviors, playing a persistent and flexible supporting function across multiple pathways.

Finally, in the "ability–motivation driven" configurational pathways, a substitutive relationship exists between organizational support and self-efficacy. Specifically, when farm operators possess strong self-efficacy, a certain degree of absence of external organizational support can be effectively compensated. Conversely, when external organizational support is sufficient, the requirement for individuals' intrinsic motivation can also be correspondingly reduced. This finding is consistent with the view of compensatory relationships among elements in the "motivation–opportunity–ability" framework (Lou et al., 2024), and also corroborates the conclusion of Shertzer et al. (2025) that self-efficacy can weaken individuals' dependence on external resources. In the context of family farms' cultivated land ecological protection adoption behaviors, this study empirically reveals the existence of such a substitutive logic, indicating that behavioral driving mechanisms possess inherent flexibility. This result also suggests that the current academic debate regarding the necessity of certain factors should perhaps be re-examined from a more systematic configurational perspective; multiple "functionally equivalent" differentiated pathways may exist for behavioral realization.

Implications and limitations

Theoretical contributions

Compared with other relevant studies on cultivated land ecological protection adoption behaviors, the theoretical contributions of this study are mainly threefold.

First, this study integrates the AMO theory with the configurational perspective to construct a theoretical analytical model of family farms' cultivated land ecological protection adoption behaviors, breaking through the limitations of the single-dimensional "net effect" analysis prevalent in existing studies. This achieves a paradigm shift from single-factor driven to multi-factor synergistic configurational approaches, providing a new analytical pathway for research in this field. Most existing studies have examined family farms' cultivated land ecological protection adoption behaviors from a single perspective, such as individual characteristics or social environment (Wang and Zhu, 2025; Ma and Abdulai, 2019; Shi and Zhang, 2022), and few have deeply revealed

the intrinsic mechanisms through which multidimensional antecedent conditions concurrently and synergistically influence behavioral outcomes. The AMO theory emphasizes that individual behavior is the result of the joint action of ability, motivation, and opportunity, with inherent interlinkages among the three. Meanwhile, the qualitative comparative analysis from the configurational perspective provides methodological support for addressing such complex causal issues (Du et al., 2017). The deep coupling of theoretical perspectives and analytical tools not only validates the explanatory power of the AMO framework in the field of agricultural green production transformation, but also, by identifying differentiated configurational pathways, overcomes the limitations of traditional regression analysis in handling complex issues such as multiple conjunctural causation and equifinality, providing new empirical evidence and theoretical insights for revealing how the three-dimensional conditions of ability, motivation, and opportunity synergistically influence behavioral outcomes.

Second, by employing the fsQCA method, this study identifies the key conditions driving family farms' cultivated land ecological protection adoption behaviors, and conducts a dialectical examination of the differentiated effects of single elements across different configurational contexts, thereby promoting a shift in research from a generalized "universal applicability" cognition to a refined "context-specific effectiveness" cognition. Cross-configurational comparisons reveal the critical role of peer effects in driving high adoption behaviors of cultivated land ecological protection among family farms. Although traditional empirical studies have identified peer effects as an important driving force of farmers' green production behaviors (Yu and Cai, 2024; Zeng et al., 2019; Meng et al., 2023; Xu et al., 2022; Peng et al., 2025), two limitations persist. First, the analytical paradigm that characterizes variables by sample means and conducts linear regression can only reveal a positive correlation at the aggregate level, and cannot demonstrate that peer effects positively drive green production behaviors for every type of farmer. Second, it cannot compare peer effects with other antecedent conditions, making it difficult to judge its relative importance. This study effectively overcomes these issues through configurational analysis. Meanwhile, traditional studies have rarely focused on the heterogeneous effects of the same antecedent condition across different contexts. This study finds that the driving effect of ecological responsibility cognition exhibits a pronounced configurational dependence. In Configurations S3 and S4, ecological responsibility cognition needs to be synergistically matched with high information acquisition capability to effectively stimulate cultivated land ecological protection adoption behaviors. In Pathways S1 and S2, however, the combination of high self-efficacy and peer effects already constitutes a sufficient condition set, and ecological responsibility cognition recedes to a non-essential element. This dialectical examination breaks through the traditional assumption of the constant effects of conditions, providing new ideas and valuable extensions for exploring related topics.

Third, this study identifies two types of pathways driving high-level adoption behaviors of family farms' cultivated land ecological protection, namely the "ability–opportunity driven" type and the "ability–motivation driven" type, reflecting the complex causal characteristic of "equifinality" and effectively responding to the core question of how multiple factors interdependently and collectively shape behavioral outcomes. Among them, the "ability–opportunity" synergistic driven pathway highlights the combined role of self-efficacy and peer effects, which is more applicable to family farms that are still in the early stages of development, relatively small in scale, and highly dependent on policy support and external demonstration effects. Such farms often have limited internal resource accumulation, and their adoption decisions are more susceptible to external opportunities such as neighborhood demonstration and the policy environment. The "ability–motivation"

synergistic driven pathway emphasizes the synergy between information acquisition capability and ecological responsibility cognition, and is more applicable to family farms that are relatively mature in development and tend toward operational stability. The adoption behaviors of such farms place greater emphasis on self-capacity building and the awakening of intrinsic responsibility awareness. Notably, the applicability of this pathway is significantly broader than that of the "ability–opportunity" synergistic driven pathway, making it a more prevalent adoption driving model at the current stage. This indicates that with the continuous advancement of agricultural modernization, an increasing number of family farms have moved beyond the start-up phase toward standardized and ecologically oriented operations, and the intrinsic driving forces for adopting ecological protection behaviors have gradually replaced sole reliance on policy support and external demonstration. This is highly consistent with the current national policy direction of promoting the high-quality development of new-type agricultural business entities and emphasizing the endogenous drivers of green agricultural development. This not only reveals the differentiated driving mechanisms of cultivated land ecological protection adoption behaviors among family farms at different development stages, but also provides refined theoretical references for relevant policy formulation.

Practical implications

First, the government should stimulate family farms' adoption behaviors of cultivated land ecological protection based on the configurational effects of multiple factors. The findings of this study indicate that no single factor constitutes a necessary condition for high adoption behaviors of cultivated land ecological protection among family farms. Rather, high adoption behaviors are the product of the synergistic interaction of multiple factors, and different combinations of factors give rise to multiple equivalent pathways, reflecting "equifinality." This suggests that the government should adopt a holistic perspective, taking into account family farms' resource endowments and existing conditions, and coordinate individual ability factors, motivational factors, and opportunity factors in an integrated manner to leverage the synergistic and matching effects among multiple factors, thereby formulating "context-specific" strategies to drive high adoption behaviors of cultivated land ecological protection among family farms.

Second, the government should attach importance to the pivotal role of peer effects. Given that peer effects are a key social factor in cultivated land ecological protection behaviors, guiding family farms to adopt such behaviors requires the creation of a positive social atmosphere for green production promotion. On the one hand, an incentive system centered on social reputation and psychological identification can be established, such as an annual "Ecological Pioneer Farm" selection, providing non-monetary rewards such as media publicity and priority credit access to winners, encouraging them to play a leading role, stimulating the willingness of surrounding farms to emulate, and ultimately achieving the comprehensive promotion of green agricultural production methods. On the other hand, demonstration households should be actively cultivated, a field observation and learning system should be established, and informal communication networks among farmers should be improved to facilitate the natural diffusion of green production technologies and ecological experiences within neighborhoods and communities.

Third, the government should make good use of the substitution and complementarity relationships among elements and implement dynamically adaptive and flexible intervention strategies based on farms' development stages. This study finds a significant substitutive effect between self-efficacy and organizational support, and the role of ecological responsibility cognition is highly configurational-dependent. This implies that under

resource constraints or when certain conditions are difficult to improve in the short term, there is no need to demand the simultaneous completeness of all elements. Instead, the most leverage-effective intervention nodes should be selected based on the specific institutional and technical constraints faced by family farms. Specifically, for family farms with temporarily insufficient intrinsic ecological motivation, organizational support such as technical training and information platforms can be prioritized to facilitate behavioral change through external assistance. For family farms with weak information acquisition capability, they can be guided to integrate into social interaction scenarios such as neighborhood observation and pioneer selection, leveraging peer effects and social learning to drive behavioral adoption. Furthermore, policy design should further refine the differentiation in farms' development stages: family farms in the start-up phase and small in scale are more suited to the "ability–opportunity driven" model, and policies should focus on expanding their external learning opportunities and access to community demonstration networks. In contrast, family farms with mature operations and tending toward stability are more aligned with the "ability–motivation driven" model, and policies should focus on enhancing their information analysis capability and ecological value identification.

Research limitations and future directions

Despite its contributions, this study has several limitations. First, using cross-sectional data, it identifies configurational pathways but cannot capture behavioral dynamics over time. Future research could adopt longitudinal data and dynamic QCA to reveal temporal evolutionary mechanisms. Second, it does not examine mediating mechanisms between AMO conditions and adoption behaviors. Exploring such complex mediation (e.g., Gao and Chen, 2026; Du et al., 2024) would enrich the literature and offer practical insights. Finally, the findings are based on Chinese family farms, so generalizability to other entities or cultural contexts requires caution.

Conclusion

Drawing upon the AMO theory as an analytical framework, this study adopts a configurational perspective and employs the fsQCA method to explore the complex causal mechanisms through which ability, motivation, and opportunity factors drive family farms' cultivated land ecological protection adoption behaviors. The main conclusions are as follows: (1) None of the single antecedent conditions—self-efficacy, information acquisition capability, intrinsic motivation, ecological responsibility perception, government support, or peer effects—constitutes a necessary condition for cultivated land ecological protection adoption behaviors. (2) Four pathways leading to high adoption behaviors of family farms' cultivated land ecological protection are identified, which can be categorized into two types: the "ability–opportunity driven" type and the "ability–motivation driven" type, reflecting the characteristic of "equifinality" in the generation of high adoption behaviors. (3) Peer effects play a pivotal anchoring role in driving high adoption behaviors. Meanwhile, a substitutive and compensatory relationship exists between organizational support and self-efficacy, whereby a deficiency in either condition can be compensated by the reinforcement of the other, thus further revealing the dynamic compensatory mechanisms among multiple factors.

Data availability

The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

The author declare no competing interests

Ethical approval

This study was reviewed and approved by the Jiangxi Agricultural University Science and Technology Ethics Committee (Approval number: JXAULL-2026-08-01, approval date: 3 Aug 2026). All procedures performed in this study were in accordance with institutional research guidelines and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent

Not applicabl.

Author Contribution

Liping Zhou contributed to conceptualization, methodology, investigation, writing – original draft, project administration, and funding acquisition, and was responsible for validation. Siqi Wei was responsible for validation, resources, data curation, writing – review & editing, and supervision. Sihan Hu participated in conceptualization, software, formal analysis, and polished the manuscript. Hong Su contributed to conceptualization, writing—original draft, review & editing.

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Figures

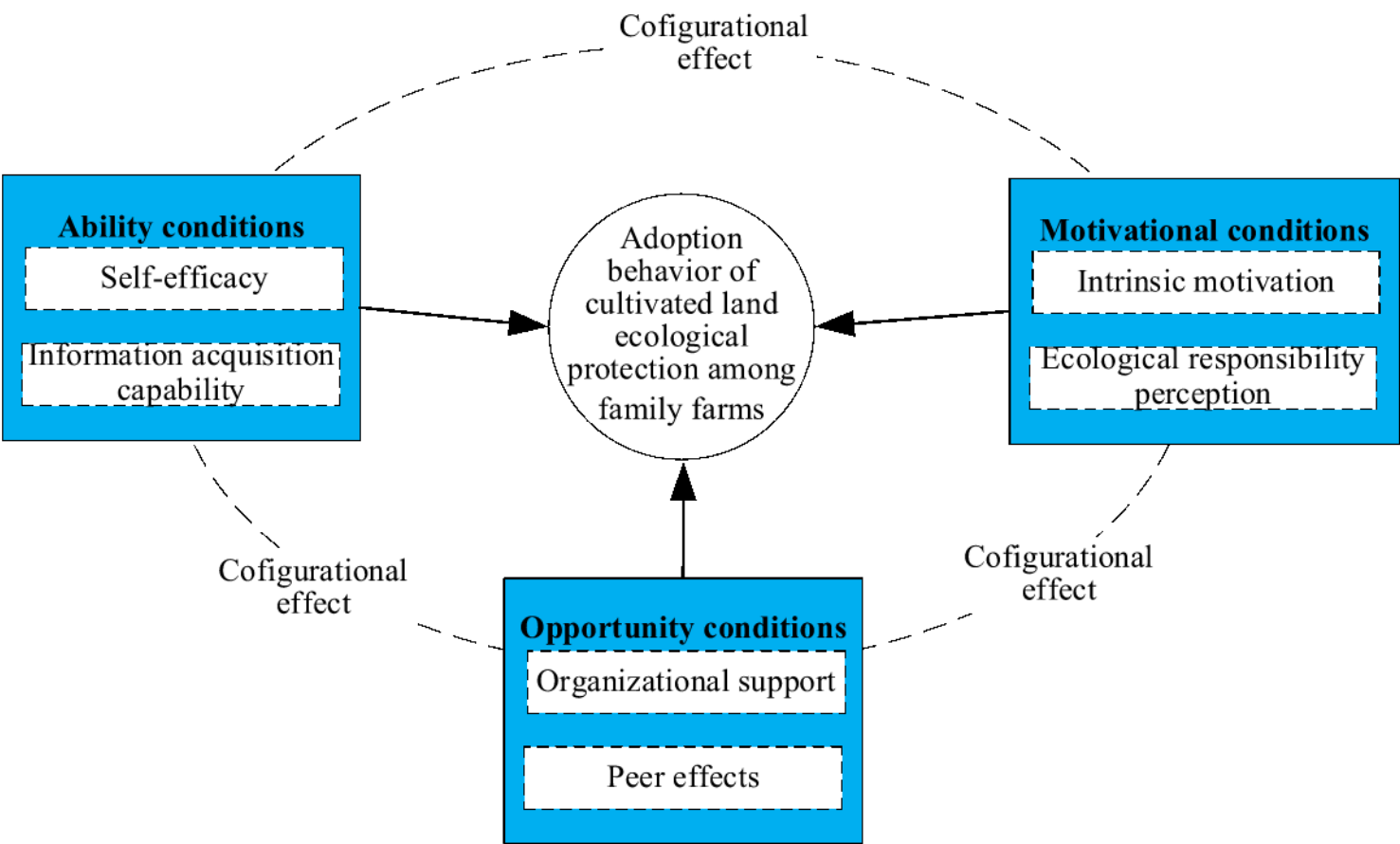


Figure 1

Analytical framework

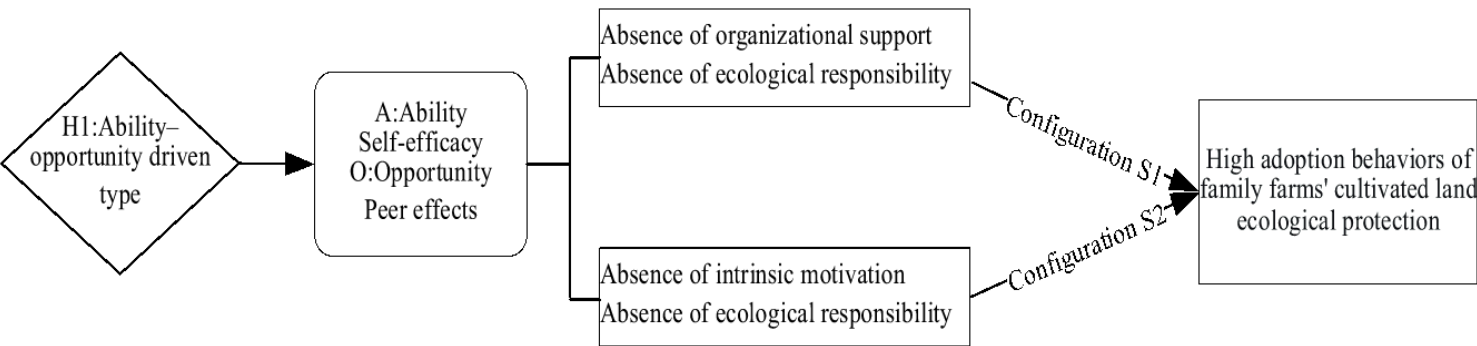


Figure 2

H1: Ability–opportunity driven type

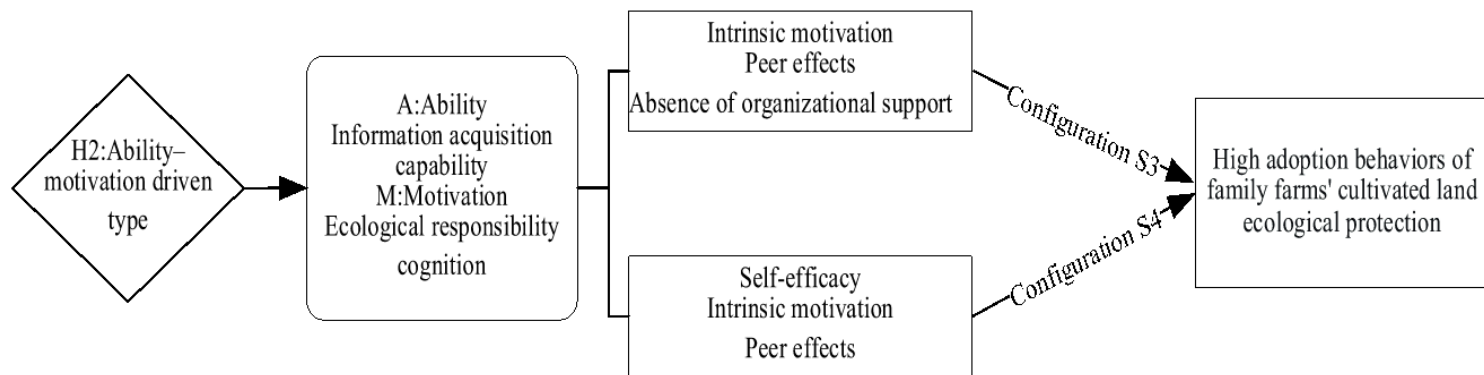


Figure 3

H2: Ability-motivation driven type

Supplementary Files

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