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Rural household waste sorting in China: A systematic review based on the psychology–behavior–institution framework

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Abstract: Rural household waste management is essential for rural revitalization and ecological civilization, significantly impacting habitat improvement, resource recycling, and farmers' ecological benefits. This study systematically reviews research on farmers' participation in waste classification to clarify existing findings, identify gaps, and guide future research and practice. The research employs a standardized literature review method, analyzing studies through the "psychology-behavior-institution" framework. This tripartite approach examines micro-level individual psychology, meso-level social capital networks, macro-level policy environments, and their interactive dimensions. Digital literacy serves as a critical catalyst in bridging the intention-behavior gap, enhancing sorting through improved environmental awareness and information access. Informational policy tools operate via affective event theory pathways, though their effectiveness is moderated by individual characteristics and regulations, with rigid tools posing limitations. Psychological variables demonstrate configurational and grouping effects, where combinations better explain behavioral differences than isolated factors. The government bears primary cost responsibility, while effective governance requires institutional integrity, multi-agent synergy, and income-adjusted cost-sharing mechanisms. This review highlights that effective rural waste governance requires integrated strategies prioritizing digital empowerment to bridge participation gaps and flexible approaches to accommodate regional heterogeneity. Policymakers should develop income-adjusted cost-sharing mechanisms with government leadership, leverage social capital networks while mitigating biases through formal institutions, and implement differentiated interventions. Crucially, transitioning from rigid campaigns to sustainable co-governance models—combining community-driven rules with smart monitoring—can transform administrative mandates into autonomous actions, fostering ecological revitalization.

Keywords: *Farmer participation, Governance model, Rural household waste management, Waste classification.*

1. Introduction

1.1. Background and Significance of the Study

The in-depth promotion of rural revitalization and ecological civilization construction has made rural household waste management a critical focus. Farmers' participation in waste classification directly impacts habitat improvement, resource recycling, and ecological benefits. However, the problem is escalating: rapid rural development and changing consumption patterns have caused explosive growth in waste volume (Yin, Zhao, Hussain, & Ullah, 2024). Ministry of Ecology and Environment statistics show China's annual rural waste removal exceeds 150 million tons, growing at 8% annually. Over 60% is potentially recyclable (like food waste and plastics), yet the resource utilization rate remains below 20%. Waste composition is also becoming more complex, with significant increases in

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electronic waste and packaging, overwhelming traditional disposal methods like landfills and open burning.

Governance effectiveness faces multiple challenges. Firstly, a significant "high willingness - low behavior" gap exists: while farmers' classification knowledge rates often exceed 70%, actual participation falls below 40%. Secondly, systematic implementation biases occur, including vague classification standards, facility shortages, and mixed transportation, creating an ineffective cycle of "front-end classification, back-end mixing." Thirdly, homogenized governance models, like simply transplanting urban "removing barrels/stations + smart monitoring" approaches, ignore rural realities like scattered settlements and aging populations, leading to idle facilities and wasted resources. Fourthly, long-term mechanisms are lacking, with over 65% of pilot villages relying on temporary campaigns without sustained financial or technical support. These issues exacerbate environmental risks like "garbage surrounding villages," soil pollution, and groundwater contamination, threatening health and ecological safety (Yin, Wang, & Zhang, 2025).

In this context, exploring farmers' sorting behavior logic, driving mechanisms, and effective governance paths holds dual value. Theoretically, integrating Planned Behavior Theory, Social Capital Theory, and Institutional Analysis frameworks constructs a "psychological-behavioral-institutional" model. This reveals interaction mechanisms of variables like environmental attitudes and policy perceptions within the rural context, addressing insufficient explanations of "policy flexibility-farmer response" dynamics and offering new perspectives for localized environmental behavioral science. Practically, findings can optimize governance: providing evidence to solve the "government hot, farmers cold" dilemma by identifying key interventions (e.g., boosting digital literacy, activating social capital) for precise policy design; offering technical routes to achieve the "improved classification system" goal in the Rural Habitat Five-Year Plan; promoting differentiated governance models suited to rural economies and structures; and ultimately supporting ecologically livable, beautiful countryside goals to strengthen rural revitalization's ecological foundation.

1.2. Research Status and Purpose of Literature Review

Around the core issue of "why and how farmers participate in garbage classification", academics have carried out fruitful explorations from multiple dimensions and levels, forming a relatively rich accumulation of knowledge. At the micro level, the study analyzes the direct influence and mediating mechanism of individual psychological attributes of farmers on their willingness and behavior of garbage sorting, which involves elements such as digital literacy, environmental attitudes, trust perception, pollution cognition, and village emotion. At the meso level, we focus on the dual impacts of social capital networks in information transmission, behavioral demonstration, supervision and constraints, and the corresponding governance countermeasures, focusing on the mechanisms of social networks, social trust, social norms and other dimensions. At the macro level, research focuses on the shaping and constraining of behavior by the institutional environment and governance models, including institutional elements such as cost-sharing mechanisms, governmental roles, and environmental regulation tools, as well as governance models such as collaborative governance by multiple actors. At the interaction level, some studies have begun to focus on the interactions between psychological variables, social networks and the institutional environment, such as the moderating effect of institutional trust on attitude-behavior relationships and the strengthening or weakening effect of social networks on the dissemination of policy information. These studies have initially constructed a composite analytical framework of "psychology-behavior-institution".

However, with the deepening of research and the advancement of practice, the existing theoretical system reveals obvious deficiencies: first, the depth and breadth of theoretical integration are insufficient, lacking the systematic integration and empirical testing of the dynamic interaction mechanism of micro-psychology, meso-social network, and macro-institutional environment, and it is difficult to reveal the complex logic of multi-factors coupling-driven behavior. Second, there are limitations in the research methodology, which is highly dependent on cross-sectional data and linear

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models, making it difficult to capture the dynamic evolution of behaviors, multiple concurrent causation and non-linear relationships in rural social transformation. Third, the policy adaptability is weak, and the research recommendations mostly remain at the level of homogenization and principle, failing to fully consider the economic and social heterogeneity of China's rural areas and the differentiated needs of different groups of farmers, leading to difficulties in implementing the policies. Therefore, it is of great practical significance to systematize, critically reflect and prospectively integrate the existing literature.

The core objectives of this literature review are: first, to systematically sort out the current research progress, clearly outline the core findings and theoretical boundaries, and comprehensively present the theoretical framework, empirical evidence, and key debates. Second, it analyzes the limitations and challenges of the existing studies in terms of theoretical integration, methodological application, and policy applicability, and points out the direction for theoretical breakthroughs in subsequent studies. Third, based on the systematic reflection on the research results and the deep insight into the practical needs, we try to put forward an innovative research framework and governance path proposal that is more integrated, dynamic and operative, so as to provide targeted intellectual support for cracking the dilemma of rural domestic waste governance and improving governance effectiveness.

1.3. Research Methodology and Framework

This study adopts a standardized and systematic literature review method. In the literature search and screening stage, China Knowledge Network (CNKI), Web of Science, ScienceDirect, EBSCO and other important academic databases at home and abroad were systematically searched with the core keywords of "rural domestic waste", "waste classification", "farmer participation", "governance model", "policy tools", "social capital", "digital literacy", etc. The timeframe focuses on the past ten years (2013-2015), which is the period of the study, and the timeframe is the last ten years (2013-2013); The time scope focuses on high-impact journal articles, dissertations and research reports in the past ten years (2013-2024); the screening criteria take into account the theoretical contribution of the research, methodological rigor, empirical basis and relevance to the topic to ensure the representativeness, cutting-edge and comprehensiveness of the included literature. In the stage of literature analysis and integration: Thematic Analysis was used to systematically code, categorize, compare and synthesize the research themes, theoretical perspectives, core variables, research methods, major findings and conclusions of the included literature; special attention was paid to the links, contradictions and evolution of the conclusions of the different studies, as well as the fusion of interdisciplinary perspectives. The research framework of this paper (see Figure 1 for the technical route).

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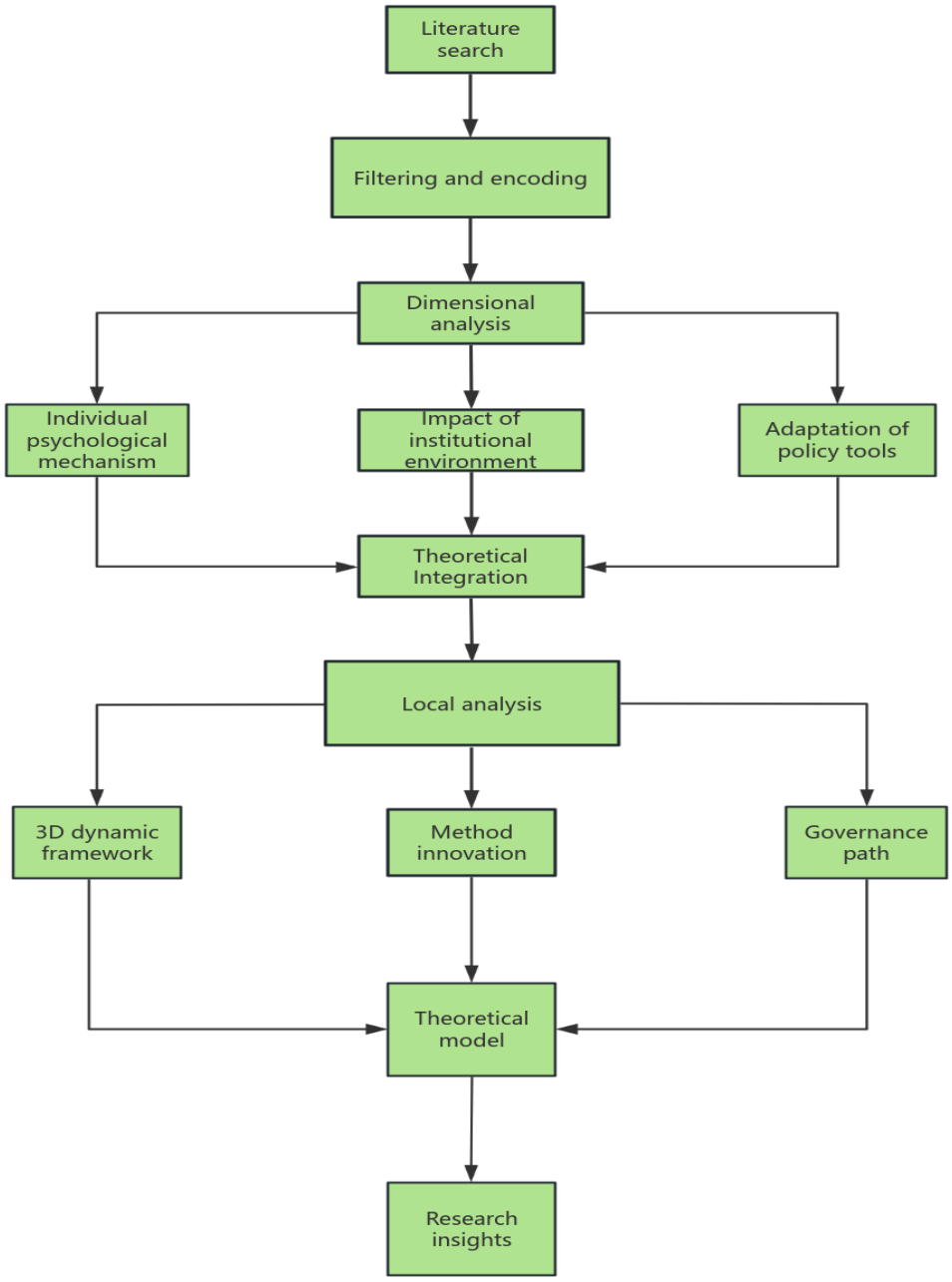

Figure 1.
Literature review technical roadmap.

2. Research on Individual Psychological and Behavioral Driving Mechanisms

2.1. Influence of Digital Literacy on Farmers' Participation Behavior

Digital literacy is increasingly critical for bridging farmers' "intention-behavior gap" in waste classification. Empirical studies consistently demonstrate that digital technologies significantly boost waste-sorting willingness and behavior by enhancing environmental awareness, broadening information access, and lowering participation costs. Digital governance platforms prove particularly effective in

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highly digitized regions by connecting policy requirements with farmer practices. Zhu, Shan, and Shen (2022) established digital literacy's central role in closing this gap through rigorous surveys in Southern Jiangsu, while Zhou, Peng, and Du (2024) confirmed digital skills' positive impact on environmental literacy nationwide through advanced econometric analysis.

Multiple studies quantify digital influence through diverse methodologies: Zhang, Feng, and Yi (2023) used Bivariate Probit models to reveal internet use directly drives sorting willingness/behavior, with waste perception as a key mediator. Leng. Chen (2025) demonstrated digital governance (village affairs disclosure/participation) significantly increases farmer participation in habitat improvement across four Yellow River provinces. Zhang et al. (2023) found digital governance disproportionately benefits non-elite households. Cui verified internet use strengthens ecological awareness and sorting willingness in Hainan. Liu, Yin, and Li (2024) employed evolutionary game theory to show digital technologies reshape urban waste behaviors through enhanced ecological ethics.

Digital solutions show cross-system applicability: Chen documented operational benefits throughout waste management chains - improving resident participation accuracy at source, optimizing collection routes midstream, and enhancing terminal treatment efficiency. Zhou et al. (2024) analyzed Zibo City's "Digital Phoenix" platform, revealing how digital empowerment upgrades rural waste services through conceptual shifts, resource integration, and process re-engineering. These cases demonstrate technology's capacity to align service supply with demand while establishing sustainable governance pathways.

2.2. The Mechanism of Informational Policy Tools Under the Perspective of Affective Event Theory

The effectiveness of informational policy tools lies not only in the transmission of knowledge, but also in how the emotional responses triggered by them ultimately affect behavioral decisions. Research based on affective event theory reveals this non-intuitive psychological transmission path (see Table 1): policy information triggers positive or negative affective experiences, and then regulates individual attitude formation and behavioral intentions. The intervention of digital technology further amplifies this affective effect, for example, visualizing the consequences of garbage pollution can arouse farmers' sense of environmental responsibility more strongly. Xu, Han, and Liao (2025) takes 29 provincial capital cities as the research object, combines the TOE framework and digital governance theory, and through qualitative comparative analysis of fuzzy sets, reveals that urban garbage classification governance in the context of digital governance is subject to the common role of technological, organizational, and environmental factors, and puts forward the optimization path of "technology-environmental double-driven"; Liu, Jingge Yin, and Lingling Li (2024) with the help of evolutionary With the help of evolutionary game analysis and simulation technology, Chen, Hu, Fei, Lai, and Wen (2024) found that the application of digital technology can reduce the cost of supervision, strengthen the residents' ecological morality, and make the people's "green and low-waste" classification behaviors become a universal choice in digital communities; Chen confirmed that the application of digital technology in the whole chain of garbage classification can improve the participation rate of the front-end by empirical cases and algorithmic analysis, optimize the efficiency of mid-end collection and transportation, and improve the efficiency of end-end treatment; Zhou et al. (2024) based on the case of Phoenix Town, Zibo City, deeply analyzes the digital technology through the concept of updating, resource integration and other paths, empowering rural communities to achieve the high-quality supply of garbage classification services. While Liu (2024) and Hou, Gao, and Qiao (2023) and many other scholars around the Le Vision case, from the perspective of fraud pentagram theory, the responsibility of the auditing institution to identify, to explore the corporate financial risk and capital market regulatory issues, and garbage classification and informational policy tools research correlation is weak.

2.3. Grouping Effects of Psychological Variables Under Fuzzy Set Qualitative Comparative Analysis (Fsqca)

Psychological drivers of farmers' waste classification behaviors operate through configurational combinations rather than isolated factors. Empirical research demonstrates that high participation often

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corresponds to specific psycho-cognitive pathways, such as "strong environmental cognition + strong village attachment" or "robust social norms + high institutional trust." Methodologies like fuzzy-set Qualitative Comparative Analysis (fsQCA) effectively reveal these multiple concurrent causalities, explaining policy outcome variations across villages and enabling precise interventions. Liu, Lv, and Han (2021) confirmed local consensus and group integration significantly enhance sorting behaviors in Inner Mongolia, with group integration mediating this relationship. Similarly, Jiyao Liu, Jia, Ji, and Zhao (2021) established in Shaanxi Province that pollution perception coupled with village emotion creates synergistic behavioral drivers, while social networks further amplify classification levels.

Targeted information interventions and digital access reshape behavioral patterns through cognitive channels. Qin, Zhu, and Zhang (2022) documented through randomized trials in the Taihu Lake Basin that health, environmental, and technological information interventions boost environmental protection behaviors, with environmental concern mediating health information's spillover effects. Digital connectivity similarly influences participation, as Jia and Zhao (2020) revealed internet access significantly increases sorting willingness nationwide, with notable heterogeneity across user groups and access methods. These findings collectively highlight how tailored informational approaches and digital tools activate key psychological mechanisms to bridge intention-behavior gaps.

Behavioral theories identify structural barriers and contextual moderators affecting participation. Zhang and Wang (2020) expanded the Theory of Planned Behavior to identify threshold effects and funnel effects as primary causes of intention-behavior deviations. Contextual factors significantly moderate cognition-behavior relationships, as Lin, Liu, Huang, and Zheng (2017) demonstrated governance contexts in Fujian alter how behavioral attitudes and subjective norms translate into action. Persistent participation gaps exist despite awareness, with Deng, Zhang, and Xu (2013) noting farmers' limited initiative in Dongting Lake areas despite recognizing environmental importance, where socioeconomic factors like income and education differentially shape responses. Tang (2020) further corroborated in Sichuan that environmental cognition substantially influences both willingness and engagement levels.

Table 1.
Literature combing of research on individual psychological and behavioral driving mechanism of rural household waste management.

Topic	Core Content	Method	Authors (Year)
Influence of digital literacy on farmers' participation behavior	Mechanisms of digital literacy/Internet use/digital governance on farmers' willingness and behavior in waste classification	Questionnaire survey, empirical analysis, econometric method, Bivariate Probit model, mediated effects model, least squares method, Oprobit model, evolutionary game analysis, simulation technique, case studies	Zhu et al. (2022); Zhang, Qie, Zhang, and Zhu (2022); Chen and Leng (2025); Zhang et al. (2023); Manqin Liu et al. (2024) and Chen et al. (2024).
Mechanisms of informational policy tools in the perspective of affective event theory	Facilitation mechanism of digital governance/technology application on waste classification focusing on affective-behavioral transmission pathways	Fuzzy set qualitative comparative analysis (fsQCA), evolutionary game analysis, simulation techniques, empirical cases and algorithmic analysis, case studies	Xu et al. (2025) and Chen and Leng (2025).
Grouping effects of psychological variables under fuzzy set qualitative comparative analysis	Grouping effects of psychological cognitive variables (locality consensus/pollution perception/village sentiment, etc.) on waste classification behavior	Probit and IV-Probit methods, randomized controlled trials, DID model, KHB model, Logit model, propensity score matching method, Ordered Probit model, two-column model, hierarchical regression models	Hou et al. (2023); Qin et al. (2022); Liu et al. (2021); Liu et al. (2021); Jia and Zhao (2020); Tang (2020); Lin et al. (2017) and Deng et al. (2013).

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3. Institutional Environment and Governance Model

3.1. Cost Sharing and Government Responsibility for Rural Household Waste Management

The government plays a central role in the cost sharing of rural household waste management, with existing studies (see Table 2) identifying multiple pathways for fulfilling governmental responsibilities across institutional design, technological empowerment, and incentive mechanisms. These studies highlight that digital empowerment can reduce governance costs through resource integration, while a viable cost-sharing mechanism must account for regional economic disparities and farmers' payment capacities, alongside fostering a social foundation to enhance governance sustainability.

Scholars have explored these pathways through case studies and mechanism analyses. Zhou et al. (2024) drawing on the case of Fenghuang Town in Zibo, Shandong, used the "Digital Fenghuang" platform for source management of domestic waste. She analyzed how digital empowerment—via concept updating, resource integration, and process reengineering—optimizes the cost and quality of rural waste classification services by stimulating supply and demand, reducing costs, and reconfiguring rights and responsibilities. Su and Mo (2024) examining four villages in Babu District, Hezhou, Guangxi, applied a nested system analysis framework to highlight how differences in institutional interaction and completeness affect the effectiveness of rural waste classification pilots, providing theoretical support for clarifying governmental responsibilities in institutional design and cost sharing. Zeng (2024) through field surveys, explored the points system in waste governance, identifying paths to improve low-cost rural governance effectiveness by activating social competition and reputation mechanisms, reflecting the government's role in guiding incentive mechanism design. Wang, Pang, and Li (2024) traced the evolutionary stages of the "Ten Million Project," noting that the government's role in rural environmental improvement has shifted from dominance to guiding farmer participation, offering insights into its multifaceted role in waste management.

Quantitative analyses have further informed policy development. Sun, Zhang, Tang, and Wang (2023) utilized data from the China Land Economy Survey (CLES), combined with group regression and Probit models, to confirm that income levels positively influence farmers' willingness to pay for waste management, with environmental regulation exerting a moderating effect—findings that inform differentiated cost-sharing policies. Chen, Huang, Chen, Huang, and He (2023) using 2020CLES data and Logit models, analyzed how guiding, rewarding, and punitive environmental regulations affect farmers' classification willingness, including indirect effects through environmental cognition, providing references for selecting regulatory tools and cost allocation directions. Liu, Guo, and Liu (2023) constructed a tripartite evolutionary game model involving villagers, enterprises, and the government, clarifying their respective responsibilities and evolutionary stability strategies to underscore the government's dominant and coordinating role in cost sharing. Jiang Pei (2023) through a case study of a dock village in northern Zhejiang, emphasized that endogenous village norms and organizational mobilization structures form the social foundation for long-term waste classification mechanisms, highlighting the government's responsibility to nurture such foundations. Shi and Yu (2024) using data from 795 Gansu farmers, analyzed how pro-environmental awareness and environmental regulation shape classification behavior within an "awareness-situation-behavior" framework, guiding policy design and cost inputs to enhance farmers' environmental consciousness.

3.2. Governance Principles and Synergy of Subjects under the Environmental Co-Governance Model

The environmental co-governance model centers on building synergistic mechanisms among multiple subjects—government, villagers, and market actors—with existing studies revealing context-dependent governance principles and synergy pathways, focusing on rights protection, digital empowerment, and institutional coordination (see Table 2). These studies emphasize that full-cycle participatory governance requires safeguarding residents' right to information and participation, while the synergy of digital technology and institutional systems can significantly improve subject interaction efficiency, breaking the "government-led, villagers passive" governance dilemma.

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Case studies have illuminated practical synergistic mechanisms. Ke (2025) focusing on the comprehensive governance of the Maota River sub-watershed (a national water source), identified governance principles that guarantee residents' information and participation rights throughout project cycles, demonstrating how government-resident synergy emerges through capacity building and trust mechanisms. Chen and Leng (2025) using data from 1,047 farmers across four provinces in the Yellow River Basin, confirmed via econometric models that rural digital governance promotes government-farmer synergy in habitat improvement by enhancing institutional trust and village identity—with digital village affairs disclosure having the most significant impact on subject synergy. Gu and Wang (2024) studying waste classification governance in four villages of Town, Hubei, found that interactions between village-level organizations and market actors form four relational patterns; among these, proactive leadership by village-level organizations drives farmer agency, while effective market actor engagement provides external incentives, together forming a subject synergy mechanism.

Quantitative and comparative analyses have further refined synergy pathways. Xu et al. (2025) noted that subjective norms, perceived behavioral control, and policy trust synergistically influence farmers' waste classification behavior, with classification attitudes exerting the strongest synergistic effect. Su, through comparative case studies of four villages in Guangxi and using a nested system framework, proposed that synergy between institutional completeness and interactivity is key to collective action in rural habitat governance, yielding three institutional synergy pathways such as the "vertical leap type."Xiao and Jing (2024) using data from 2,508 rural households in Hunan and an ordered Logit model, confirmed that pollution perception positively influences household Ren (2025) waste treatment behavior, with village identity synergizing with pollution perception through the mediating and moderating effects of institutional trust to promote standardized environmental behavior. Cai and Wang (2025) based on fieldwork in Hongze District, Jiangsu, highlighted gaps in post-transformation maintenance of rural toilets, proposing a long-term management mechanism of "triple synergy" between toilet reform, agricultural production, waste classification, and rural civility, emphasizing functional synergy among multiple government bodies. Ren, analyzing village WeChat groups in D Village, N City, showed how digital technology breaks temporal and spatial barriers, promoting spatial extension synergy among government (Wang, Lu, & Guo, 2024) villagers, and other subjects in rural public welfare by reshaping participants, consciousness, and actions. Wang, using fsQCA to analyze data from farmers near the Qinling (Luo, Tan, Lyu, & Chen, 2025). Mountains, identified three synergistic grouping pathways formed by the "multiple concurrency" of environmental attitudes, social trust, and perceived behavioral control—with interpersonal trust-pollution perception synergy as a key driver, and institutional trust mitigating negative impacts of classification cognition.

3.3. The Double-Edged Sword Effect of Social Capital network and Governance Countermeasures

Social capital networks exert a double-edged influence on farmers' waste classification behavior: existing studies confirm positive drivers like social trust and network norms, but also reveal implementation biases from traditional acquaintance networks, alongside governance countermeasures to balance these effects (see Table 2). Research indicates that leveraging social capital's positive effects requires synergy with formal institutions, while digital technology can expand social capital inclusivity and alleviate participation inequalities stemming from the "digital divide."

Empirical studies have quantified these dual effects. Zhang et al. (2022) using data from rural residents in the Taihu Lake Basin and applying Ordered Probit and OLS models, confirmed that social capital dimensions—social networks, trust, and norms—positively influence rural residents' waste classification willingness and behavior. However, they noted that over-reliance on traditional acquaintance networks may distort classification standards, suggesting strengthening grassroots organizational networks to balance social capital's double-edged nature. Yang Shuo (2022) using microdata from 821 rural residents in Shaanxi, found that family structure aging negatively impacts waste classification willingness, with social trust moderating this effect—though systemic trust shows weaker moderating power, prompting calls to improve social security systems to mitigate negative

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social capital impacts. Wei and Ma (2022) employing a complex network evolutionary game model, found that without government intervention, spontaneous waste classification diffusion is unlikely; combining reputation penalties with reward policies promotes behavioral diffusion, but single-policy approaches risk free-riding, suggesting aligning incentives with rural "acquaintance society" characteristics to build a reward-penalty synergy mechanism.

Further studies have proposed targeted countermeasures. Zhou (2021) using a logistic model and data from 12 villages in Hubei, confirmed that social capital factors like neighborhood networks and village moral norms promote centralized waste disposal, but warned that over-reliance on informal norms may fragment governance—advocating strengthened synergy between formal systems and social capital. Chen and Liu (2023) using China Land Economy Survey data, found that internet use enhances social norms and environmental awareness to promote waste classification, but risks exacerbating participation inequalities via the digital divide, suggesting using the internet to expand social capital inclusivity. Liang, Zhang, and Song (2023) studying Jiangsu farmers, noted that social capital factors like other villagers' environmental attitudes boost classification willingness, but the "strong willingness, weak behavior" phenomenon reflects inadequate social network supervision—proposing strengthened group supervision norms. Yong, Shao, Xie, and Song (2023) using data from 2,301 rural households in Jiangsu, confirmed that institutional trust (e.g., village cadre credibility) positively influences classification willingness, but imbalances between interpersonal and institutional trust may weaken governance effects, urging standardized laws to balance these trusts. Li and Zhang (2023) utilizing CLDS microdata, found that internet use enhances social capital to boost waste classification participation, but online social networks may weaken offline supervisory interactions—advocating integrated online-offline social capital. Yuan and Song (2023) and studying waste classification governance in District N, Zhejiang, noted that digital empowerment improves efficiency by integrating social capital networks, but technological dependence may erode traditional social capital, proposing a "technology-society" dual integration mechanism. Wu, Nie, Yi, and Zhang (2023) analyzing the "dual-operation" system of Loudi Supply and Marketing Cooperative in Hunan, showed that combining renewable resource recycling networks with social capital networks improves governance efficiency, but poor interdepartmental collaboration constrains social capital—suggesting a multi-subject social capital integration mechanism.

Table 2.
Literature review of rural household waste management system environment and governance model research.

Theme	Core content	Methods	Authors (year)
Cost sharing and government responsibility of rural household waste management	Cost-sharing mechanism of garbage classification and government's role, including financial input, choice of regulatory tools and cultivation of social base	Case study, nested system analysis framework, group regression, probit model, logit model, evolutionary game theory, structural equation modeling	Zhu et al. (2022); Zhang et al. (2022); Chen and Leng (2025); Zhang et al. (2023); Manqin Liu et al. (2024) and Chen et al. (2024)
Governance Principles and Subject Synergy under the Environmental Co-Governance Model	Synergistic governance mechanism of multiple subjects (government/villagers/market subjects) and the principle of rights protection	Practical path analysis, econometric modeling, variable analysis, structural equation modeling, nested regime analysis framework, ordered logit modeling, fsQCA approach	Xu et al. (2025) and Chen and Leng (2025).
The double-edged sword effect of social capital networks and governance countermeasures	Double-edged effects of social capital (network/trust/norms) on waste classification and balancing strategies	Ordered Probit model, OLS model, two-column model, complex network evolutionary game model, logistic model, empirical analysis	Hou et al. (2023); Qin et al. (2022); Liu et al. (2021); Liu et al. (2021); Jia and Zhao (2020); Tang (2020); Lin et al. (2017) and Deng et al. (2013).

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4. The Choice of Policy Instruments and Their Match with Individual Traits

4.1. Negative Effects of Rigid Policy Instruments and Flexible Implementation

Rigid policy instruments encounter bottlenecks in rural household waste management, with studies highlighting their shortcomings in policy appropriateness, cognitive intervention limitations, and lack of alignment with social foundations (see Table 3). These tools struggle to penetrate the complex social fabric of rural areas, and over-reliance on external coercion hinders efforts to change farmers' intrinsic values and integrate diverse governance resources.

From the perspective of policy implementation, Qu and Zhao (2022) pointed out that rigid tools suffer from issues like insufficient supply, low operability, and poor environmental (He, Huang, Chen, & Huang, 2022) support, making rural waste classification policies hard to enforce. (Wang, Song, & Liu, 2023) using a moderated mediation SEM model, found that stronger policy tools weaken the mediating role of ecological cognition in linking anticipatory emotions to farmers' classification behavior, underscoring their limitations in shaping intrinsic cognition (Li, 2023). Zhu and Qin (2023) analyzing 2,420 rural households with a logistic model, noted that while variables like publicity and rewards/punishments (as part of rigid tools) aid in aligning willingness and behavior, these tools have limited impact on changing actual behaviors and standardized perceptions.

Case studies and comparative analyses further reveal the inflexibility of rigid tools. Juanfeng Chen and Meng (2022) took Weiyuan County, Gansu, as an example, highlighting problems such as classification difficulties, funding shortages, and single-subject governance—reflecting rigid tools' inability to integrate resources and foster multi-subject synergy (Chen, Cheng, & Yang, 2021). Noted that rural waste classification reforms are constrained by preliminary work gaps and the urban-rural dual structure, showing rigid tools' poor adaptability to complex rural environments. Jiang Pei (2023) through a northern Zhejiang village case, emphasized that endogenous village norms and organizational structures form the social foundation for long-term mechanisms, contrasting with rigid tools' lack of adaptability to local social contexts. Su, via multi-case comparisons, proposed that institutional integrity and interactivity drive collective action, indirectly indicating that single rigid tools cannot achieve effective rural habitat governance.

4.2. Information Dissemination and Behavior Driving under the Perspective of Social Networks

Social networks, as key carriers of rural information dissemination, play a unique role in driving farmers' garbage classification behavior. Studies focus on network structure, group norms, and digital integration to reveal the "informal network - cognitive updating - behavioral change" transmission mechanism (see Table 3). The combination of social network trust, neighborhood effects, and digital technology can overcome rigid policies' cognitive intervention limitations, forming a more endogenous behavioral driver.

Empirical studies confirm social networks' core role in behavioral drive. Dai, Lin, and Li (2023) using the ISM-MICMAC model, identified social networks as a key deep factor influencing farmers' willingness to participate in environmental governance, shaped by variables like age and out-of-home work. Tian, Zhang, Li, and Guan (2023) leveraging 2021 CLES data with an Ordered Probit model, found that informal norms (e.g., village rules, neighborhood effects) and formal norms (e.g., publicity) positively affect classification behavior, with environmental cognition acting as a partial mediator. Ng, Huang, and Guo (2023) analyzing 5,704 households across 8 provinces via the OProbit model, showed that digital technology adoption boosts farmers' participation in habitat improvement by expanding social networks and information channels, with information channels having a more prominent mediating effect (Zhao & Xie, 2022).

Further research highlights the interplay of social network elements and behavior. Yang Shuo (2022) using 821 Shaanxi rural residents' data with a two-column model, found social trust mitigates the negative impact of family structure aging on classification willingness, emphasizing trust's regulatory role. Tian et al. (2023) drawing on Taihu Lake Basin data, revealed that social capital (social networks, trust) enhances environmental cognition to positively influence classification willingness and behavior.

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Liu, Zhu, and Zhang (2023) via Taihu Basin farmer experiments, noted that a harmonious community atmosphere (as a social network environment) is crucial for information intervention to improve classification effectiveness. Other studies, such as those by Qiu and Lin (2021) consistently confirmed that social capital dimensions like neighborhood networks and social participation significantly drive farmers' waste management participation, with network size and centrality also playing positive roles.

Table 3.
Literature combing of research on the selection of policy tools for rural household waste management and their match with individual traits.

Topic	Core content	Method	Authors (year)
Negative effects of rigid policy tools and flexible implementation	Limitations of Rigid Policy Instruments in Behavior Change and Flexible Implementation Paths	Policy implementation analysis, mediated SEM model with moderation, logistic model, case study method, empirical test	Qiu and Lin (2021); Zhu et al. (2022); Zhang et al. (2022); Chen and Leng (2025); Zhang et al. (2023); Manqin Liu et al. (2024) and Chen et al. (2024).
Information Dissemination and Behavioral Driving under Social Network Perspective	Mechanisms of Social Networks Driving waste classification Behavior through Information Dissemination	ISM-MICMAC model, Ordered Probit model, OProbit model, Structural equation model, Behavioral experiment, Logistic model	Dai et al. (2023); Tian et al. (2023); Wu et al. (2023); Zhao and Xie (2022); Liu et al. (2023) and Qiu and Lin (2021).

5. Limitations of Existing Studies and Future Research Directions

5.1. Major Limitations of Existing Research

The first is the lack of depth and breadth of theoretical integration. A large number of studies tend to explore single-level factors in isolation, either focusing on micro-psychological variables or on meso-social capital or macro-institutional environment, and lack systematic theoretical integration and empirical testing of the complex mechanisms of how these different levels of factors dynamically interact with each other and mutually construct each other in order to jointly shape the behavior of farm households. For example, few studies have explored in depth whether and how institutional trust moderates the strength of behavioral attitudes on willingness to participate, and how farmers' decision-making logic changes when the information provided by social networks conflicts with formal policy information. This fragmented research perspective makes it difficult to comprehensively and profoundly reveal the multi-level, multi-factor coupling-driven internal logic behind farmers' garbage sorting behavior, leading to an obvious "fault" in the theoretical explanatory power.

The second is the limitation of research methodology. Current mainstream research relies heavily on cross-sectional questionnaire data and generally uses linear regression models for analysis. Although this method can identify the "net effect" of a single factor, it is difficult to effectively capture and explain the phenomenon of "multiple concurrent causation" that exists in reality, i.e., different antecedent conditions may lead to the same result through different combinations of paths, or the same factor acts in different contexts in different directions. That is, different antecedent conditions may lead to the same result through different combinations of paths, or the same factor may reverse its direction or intensity of action in different contexts. In addition, the rural society itself is in rapid transformation, and the psychology and behavior of farmers and their embedded institutional environments are all evolving dynamically, while the existing static and cross-sectional research methodology is difficult to portray such dynamics, and the neglect of complex system characteristics such as nonlinear relationships, tipping point effects, and path dependence greatly reduces the robustness and predictive ability of the study's conclusions.

Finally, the homogenization of policy recommendations is weak in terms of homogenization and contextual adaptation. The policy recommendations put forward by many studies tend to remain at the macro-principle level or are simply generalized based on the experiences of specific regions, without sufficient consideration of the huge heterogeneity of the vast rural areas. This "one-size-fits-all" approach ignores the profound differences in economic development, social structure, geography and

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cultural traditions that exist in different rural areas. Especially critical is the serious lack of attention to the differentiated needs of groups with different characteristics in rural areas, and the existing research fails to propose highly targeted and operable differentiated governance paths for the special situations and behavioral logics of these heterogeneous groups, resulting in the actual implementation of many policies encountering "not suited to the local conditions", which affects the maximization of the effectiveness of governance. The result is that many policies are not well suited to the actual implementation of the policies, which affects the maximization of governance effectiveness.

5.2. Future Research Direction and Theoretical Innovation

First, a three-dimensional dynamic integration framework of "psychology-behavior-environment" can be constructed. In order to break through the existing relatively static three-dimensional framework of "psychology-behavior-institution", future research should propose and systematically explain the three-dimensional dynamic integration framework of "psychology-behavior-environment". In order to break through the existing relatively static three-dimensional framework of "psychology-behavior-institution", future research should propose and systematically explain the "psychology-behavior-environment" three-dimensional dynamic integration framework. On the basis of retaining the core psychological and behavioral variables, this framework significantly expands the content of the "environment" dimension to include not only the macro institutional policy environment, but also the meso social network environment and physical technology environment. We focus on how different types and intensities of environmental regulations regulate the influence of psychological variables on participation willingness and behavior, as well as the interaction between environmental regulations and social networks, so as to reveal the more complex and context-dependent causal mechanisms behind farmers' decision-making on waste classification, and to achieve a panoramic and dynamic understanding of behavioral driving forces.

Secondly, it can innovate the research methodology and enhance the rigor of the study. Using advanced statistical techniques such as structural equation modeling (SEM) and Bootstrap intermediate effects test, we construct an integrated structural equation model, which incorporates key antecedent variables such as perceived value, perceived risk, and past participation experiences, core psychological variables such as behavioral attitudes and subjective norms, perceptual-behavioral control variables, and the final willingness to participate and behavioral variables into the unified model. Using the Bootstrap repetitive sampling technique, we precisely quantify the magnitude and statistical significance of the mediating effects among the variables, clearly depict the chain of transmission of external stimuli and internal states into behavioral intentions through psychological processes, and provide empirical evidence to accurately identify the "leverage points" of intervention.

Finally, we explore the dual-core driven governance path of "flexible governance + digital empowerment". "Flexible governance" emphasizes the inclusiveness, consultative and motivational nature of governance, deepens the cognitive drive mechanism, adopts participatory, experiential and localized publicity and education methods, and develops appropriate information transmission modes for different groups; improves the behavioral incentive mechanism, and designs a multi-level, differentiated incentive system; cultivates the subject's self-awareness, and strengthens farmers' awareness through empowerment. Enhance farmers' sense of responsibility and effectiveness through empowerment. "Digital empowerment" makes full use of modern information technology to realize accurate governance in information dissemination, behavioral incentives, supervision and management, develops age-appropriate intelligent tools, promotes digital points management systems, and explores intelligent monitoring to assist manual inspections. Through the in-depth integration and synergistic innovation of the two, we will promote the construction of a new paradigm of rural household waste management that is more inclusive, precise and sustainable.

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Table 4.
Key points of future research directions and "dual-core driven" governance paths.

Innovation Dimension	Core content	Examples of specific initiatives/research directions
Theoretical framework innovation	Construct a three-dimensional dynamic integration framework of "psychology (P)-behavior (B)-environment (E)".	Expanding environmental dimensions: institutional policy environment + social network environment + physical technology environment
		To study the moderating effect of environmental regulation on the psychological-behavioral chain.
		Explore the interaction between social network environment and technological environment.
		Introducing a time dimension to study dynamic evolution
Innovation in Research Methodology	Integration of multiple methods to enhance rigor and explanatory power.	SEM + Bootstrap mediation test (precise quantification of transmission paths)
		fsQCA (identifies multiple concurrent causal groupings)
		Tracking/Panel Study (capturing behavioral dynamics)
		Agent-Based Modeling (ABM) (simulating complex system evolution)
		Mixed Methods Research (combining quantitative + qualitative)
Innovation in Governance Pathways	Flexible Governance Core	Villagers' councils set up sorting rules
		Garbage sorting demonstration households/craft workshops
		Customized promotional materials by age/gender
		Basic Participation Award + Accurate Sorting Award + Reduction Contribution Award
		"Clean Family" honor system
		Empowering villagers to supervise and participate in revenue distribution
		Composting and other skills training
	Digital Empowerment Core	WeChat/APP/Radio Accurate Push
		Graphic-voice version of easy APP/one-button calling
		RFID/Sweeping code/AI recognition automatic points
		Transparent redemption in points mall
		AI camera assisted supervision
		Reporting and handling of problems on village affairs platform
		Blockchain record points and recycling volume

6. Conclusion

Research on rural households' participation in garbage sorting within rural waste management has developed a composite analytical framework of "psychology-behavior-institution." This framework, which integrates micro-individual psychology, meso-social capital networks, macro-policy and institutional environments, and their interactions, reveals several key insights. These include the critical role of digital literacy in bridging the "intention-behavior gap," the non-intuitive mechanism through which informational policy tools influence participation willingness via affective mediation, the context-dependent nature of psychological variables' grouping effects, and conclusions such as the government's primary responsibility in cost sharing, the "discretionary power-benefit" principle in multi-dimensional governance, and the double-edged sword effect of social capital networks. These findings provide a solid foundation for theoretical innovation and practical guidance (Yin, Wang, Liu, & Wang, 2024).

However, existing research has limitations: it lacks systematic analysis of the dynamic interaction between psychological, behavioral, and environmental dimensions in theoretical integration; relies heavily on static cross-sectional data, making it hard to capture behavioral evolution logic amid rural social transformation; and offers policy recommendations with insufficient adaptability due to neglecting regional and group differences, struggling to address real governance dilemmas like "digital exclusion," "administrative dependence," and "free-riding." Future research should thus construct a three-dimensional dynamic integration framework of "psychology-behavior-environment," focusing on environmental regulation's moderating effect on psychological variables and interactions between the

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technological environment and social networks. By combining structural equation modeling and Bootstrap tests to clarify variable transmission chains, exploring a "flexible governance + digital empowerment" dual-core path—using age-appropriate design, hierarchical incentives, and village rules to address group differences, and leveraging intelligent tools, digital points, and blockchain supervision to enhance participation—and strengthening interdisciplinary integration, it can embed dynamic adjustment mechanisms, cultivate multi-subject learning abilities, and build a feedback loop between governance effectiveness and ecological benefits. This will promote a shift from administrative promotion to conscious action in rural waste governance, offering sustainable solutions for rural ecological revitalization with both theoretical depth and practical value.

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The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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