

HOW DOES THE WITHDRAWAL OF RURAL HOMESTEADS IMPACT RURAL RESILIENCE IN CHINA? A MADM MODEL

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Abstract. Rural Resilience represents the ability of maintaining their core functions when facing internal changes and recovering to original conditions through transformation. Withdrawal from rural homesteads (WRH) is considered as one of critical strategy for rural revitalization of China but its systemic impacts on rural resilience remain underexplored. This study develops a multidimensional resilience evaluation framework encompassing economic, social, cultural, environmental, and governance dimensions through a Delphi-structured expert consultation process with 16 specialists. Considering the complexity of rural socio-ecological systems and the interplay among various dimensions of rural resilience, this paper uses the Fuzzy Decision-Making Trial and Evaluation Laboratory methodology to analyze the causal relationships between 22 resilience indicators. Results reveal economic resilience and social resilience as dominant causal dimensions, with economic diversification promotion and collective land marketization emerging as key drivers. Cultural and environmental dimensions exhibit effect characteristics, demonstrating dependence on economic, social, governance interventions. Notably, villagers' income improvement and cooperative mechanisms demonstrate high centrality, while indicators related to culture and environment rank as vulnerable nodes. These findings provide policymakers with a prioritized intervention framework, emphasizing the need for economic restructuring coupled with institutional safeguards to balance developmental and conservation objectives in rural spatial reorganization processes.

Keywords: rural resilience, withdrawal of rural homesteads (WRH), evaluation system, fuzzy decision-making trial and evaluation laboratory (Fuzzy DEMATEL).

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1. Introduction

As a specific socio-ecological system type, the rural territorial system is characterised by a complex combination of natural substrates and human elements (Long et al., 2019). This multidimensional system integrates geographic, infrastructural, cultural, and economic components (Li et al., 2019; Liu et al., 2024). Its dynamics are marked by non-linear evolution, sustained diversification, and emergent resilience (Zhang et al., 2022; Cui et al., 2023; Gucciardi et al., 2021). In the field of rural development research, resilience is widely recognized as a key component of social-ecological systems. Resilience explains how specific rural areas can maintain their core functions, structures, and characteristics when facing internal changes or external shocks and how these rural areas have the inherent

ability to recover to their original state or achieve adaptive transformation (Wilson, 2010; Li et al., 2019). In the current context of rural decline, the role of resilience in the economy, land management, and natural environment of rural areas has been studied (Cui et al., 2023; Li et al., 2018; Huang et al., 2018). These studies serve as valuable references to rural development policy.

Urbanization has promoted global development; it has also led to a large-scale shift of rural populations to urban areas and has profoundly impacted rural regions (Young, 2013). As the world's largest developing country, China has also experienced large-scale rural migration. The rapid urbanization in China has resulted in approximately one out of every four to five rural residents choosing to leave their birthplaces for urban areas during early adulthood (Liu & Li, 2017). Large-scale rural-urban population

mobility has changed the traditional relationship between people and land. In the process of moving rural workers to urban areas, it is common to adopt a strategy of “leaving the countryside without leaving the land”, that is, retaining the right to use rural residential land while investing the proceeds of labour in the construction of new or expanded rural housing (Ye & Christiansen, 2009; Song et al., 2021). It is worth noting that there has been a generational shift in the migration patterns of the new generation of migrants. Compared to traditional survival-oriented migration, migration decisions driven by career development are initiated earlier, and the persistence of this spatial mobility weakens the cultural ties between the younger group and the native society (Zhao et al., 2018). This choice leads to the phenomenon of double space occupation, i.e. rural migrant workers have neither legally withdrawn from their original homesteads nor fully integrated into the urban housing system, creating a paradox where rural housing vacancies coexist with the demand for urban housing (Song et al., 2021). Therefore, the phenomena of have led to the inefficient use of rural residential land (Wang et al., 2018; Liu et al., 2020).

Therefore, China’s withdrawal from rural homesteads (WRH) policy, as an institutional innovation, resolves human-land conflicts through coordinated urban-rural land allocation mechanisms. Centered on rural land asset activation, this policy leverages homestead reclamation and property rights trading to address fragmented ownership constraints, thereby unlocking economic potential and alleviating rural environmental pressures (Chen et al., 2017; Long et al., 2019; Wang et al., 2023). As an institutional design to solve the “double expansion” dilemma of urban and rural construction land and rural revitalization construction land, WRH essentially constitutes an important catalyst for rural spatial reconfiguration (Liu et al., 2021). Studies demonstrate that the homestead withdrawal mechanism, a key strategy for mitigating rural decline, restructures settlement patterns and transforms rural systems through land resource reallocation (Long et al., 2016; Gao et al., 2023; Lyu et al., 2020). This institutional intervention moves beyond land economics, restructuring social networks, renewing cultural memory, and innovating governance to transform rural socio-ecological systems across scales.

Whether persistent disruptions affect rural resilience deserves more study. To maintain resilience, it is necessary to identify the factors influencing resilience and the interrelationships among them. However, few studies have considered the causal relationships and mutual influences among the proposed factors. Kelly et al. (2015) and Wilson et al. (2018) defined rural resilience as the total capacity of rural areas to cope with their inherent economic, social, cultural, natural, and institutional vulnerabilities. Factors such as the cohesion of villagers and the governance capabilities of village officials are judged based on human subjective preferences. A common phenomenon in subjective evaluations is that people tend to give a score

between two extreme values. This is known as the “central tendency” or “doctrine of the mean” in psychology and behavioral economics. However, in many studies, respondents are only allowed to score items with fixed values. Fuzzy logic is thus a better measure for complex issues. The fuzzy decision-making trial and evaluation laboratory (Fuzzy DEMATEL) reveals the relationships among factors within a system by creating interdependence maps and prioritizing criteria based on the type of relationships and their impact on other criteria (Koca et al., 2021). Triangular fuzzy sets add further nuance to subjective evaluations.

Ungar and Theron (2020) defined resilience as a complex process involving the interplay of multiple dimensions, including ecological, psychological, and social aspects. These systems, though operating at different levels, collectively influence resilience and are interdependent. The evaluation framework of the present study on rural resilience involves five dimensions related to WRH: economy, society, culture, environment, and governance. These dimensions interact and influence each other at various levels. The evaluation framework for rural resilience was constructed through a Delphi-structured iterative process. The DEMATEL values were used to analyze the impact and causal relationships among the dimensions and factors. Identifying the factors that influence rural resilience and recognizing the interrelationships among these factors are the core research questions of this paper.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature and proposes the analytical framework of this study. Section 3 provides a detailed description of the research methods and tools employed. Section 4 presents the empirical results. Section 5 presents the discussion. Finally, Section 6 presents the conclusions and policy implications.

2. Impact framework of WRH on rural resilience

2.1. WRH’s multidimensional impact on rural resilience

Resilience refers to an ecosystem’s capacity to retain core structure and function under external pressures (Holling, 1973). As rural decline escalates globally, this concept has been applied to rural studies (Liu & Li, 2017; Hedlund et al., 2017). From an SES perspective, rural systems are nested hierarchies of resource systems (e.g., land, communities), governance structures (e.g., WRH policies), user groups (e.g., farmers, cadres), and socio-cultural norms. WRH enhances land-use efficiency by reallocating idle resources, acting as a governance intervention to optimize the resource system and redistribute resource units (Gao et al., 2023; Liu et al., 2021). Empirical data from Wuxi, Guangzhou, and Chongqing show WRH increased farmers’ welfare by over 15% (Li et al., 2022), driven by dual mechanisms: direct compensation boosting property income, and labor shifts to non-agricultural sectors elevating household earnings (Liang et al., 2022a; Liu et al., 2020).

Post-WRH ecological restoration also improves rural climate resilience (Liang et al., 2022b), reflecting positive feedback between the ecological subsystem and institutional rules. However, centralized resettlement disrupts traditional homestead systems, eroding cultural memory (socio-cultural resource) and weakening villagers' belonging (social capital), thereby reducing development participation (Liu et al., 2021; McManus et al., 2012). Social capital and socio-cultural resources constitute a multidimensional synergistic mechanism in the process of rural disaster recovery. At different stages of the disaster cycle (emergency response, transitional resettlement, and long-term reconstruction), these non-material resource systems show dynamic functional characteristics. This resource transformation mechanism plays a key role in building the resilience of small-scale rural communities, which effectively enhances the resilience and recovery of rural social ecosystems in the face of disaster impacts by strengthening the self-organizing capacity of the community, maintaining the traditional knowledge system, and activating local mutual-help networks (Li et al., 2024; Xiong & Li, 2024). Compensation inequities—evidenced in Nanjing's Jiangning District, where villagers perceived unfair distribution compared to cadres—highlight institutional misalignment between formal governance and informal norms (Wang et al., 2018). These tensions exacerbate governance risks, illustrating weak coupling between the action arena and monitoring mechanisms. Thus, WRH generates interdependent positive and negative impacts, underscoring the SES principle that resilience emerges from interactions across system tiers (Ostrom, 2009).

As Wilson (2010) notes, strong functional quality correlates with positive resilience, while weak quality aligns with negative resilience. In a globalized context, rural positive resilience must address both sudden disasters (e.g., earthquakes, floods) and gradual challenges (e.g., food insecurity, policy shifts, land degradation) (Pike et al., 2010; Roberts et al., 2017; Yu et al., 2023). Integration with the SES

framework, positive resilience emerges from synergistic economic, social, cultural, environmental, and governance progress (Figure 1). These dimensions are interdependent, adapting to external pressures through collective learning (Willett, 2020). For instance, economic gains (e.g., income growth) may drive environmental improvements, and vice versa. Rural development is dynamic and multidimensional: interactions across social processes generate non-linear feedback loops, resulting in systemic complexity (Sharifi, 2016; Heijman et al., 2019).

2.2. Development of a WRH assessment system for rural resilience

In 2018, the vacancy rate of idle rural housing in China reached 20% (Kong et al., 2018). WRH optimizes the utilization of this land, promotes the entry of external capital, and improves the single-industry structure in rural areas (Long et al., 2019), and farmers also receive economic compensation (Liu et al., 2021); however, WRH changes the rural industrial structure, leading some farmers to lose their original livelihoods or requiring them to learn new employment skills (Liu et al., 2020). Additionally, since rural areas are relatively small-scale, homogeneous, and based on familiar relationships, they are often deeply rooted in the social memory and ideology of their communities compared to cities (Wirth, 1938). WRH disrupts neighborhood relationships based on geographical proximity, which may lead to a decrease in villagers' cohesion and the interruption of cultural heritage (Beel et al., 2017). Thus, as a top-down force, WRH comprehensively reshapes the spatial layout, industrial economy, and social structure of villages. These changes affect rural resilience. Which dimension has the greatest impact on rural resilience? How do relevant dimensions/indicators interact with each other? These questions are worth further investigation.

There has been a proliferation of frameworks and indicators for rural resilience; however, compared to mature assessment tools for resilience in urban communities, such as the Baseline Resilience Indicators for Communities (BRIC) (Cutter et al., 2016), the Communities Advancing Resilience Toolkit (CART scale) (Pfefferbaum et al., 2013), and the Conjoint Community Resiliency Assessment Measure (CCRAM toolkit) (Leykin et al., 2013), there is still no widely accepted and commonly used quantitative method for assessing rural community resilience. Kelly et al. (2015) constructed a rural resilience assessment framework based on economic, social, cultural, institutional, and natural domains. Evidence from rural communities in southern Italy assessed under this framework showed that sustainable forest management practices and improvements in the natural domain can help to enhance rural community resilience in the context of land degradation. Wilson (2010) noted that although rural areas have different development trajectories and levels, multifunctionality is often a goal. He found that when the economy, environment, and social capital are highly developed, the stronger the multifunctional quality, the greater the rural resilience.

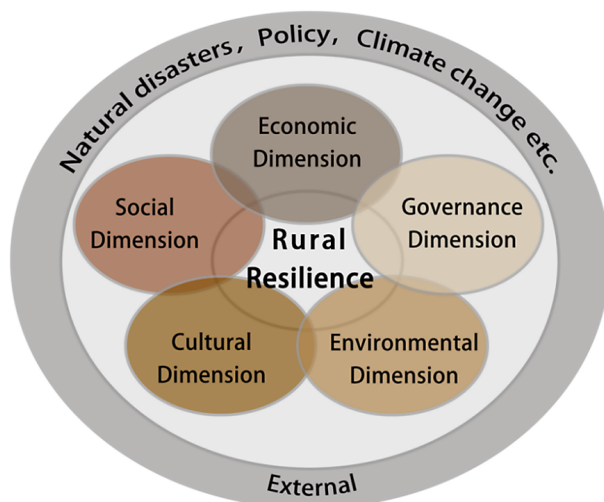


Figure 1. Key dimensions influencing rural resilience

Sharifi (2016) reviewed 36 resilience assessment tools in a research synthesis and identified the following five dimensions commonly used for measuring resilience: environment, society, economy, built environment and infrastructure, and institutions. Moreover, although Xu and Kajikawa (2018) and Baggio et al. (2015) are from different research fields, they independently identified the dimensions of economy, society, environment, and culture. Among the above assessment tools, indicators such as “ensuring post-disaster recovery”, “economic diversification”, “promoting post-disaster employment”, “developing disaster mitigation plans”, “participatory engagement”, and “ensuring fair treatment” are often considered important.

The current study integrates the main dimensions of rural resilience to construct a rural resilience assessment framework that includes the economic, social, cultural, environmental, and governance dimensions for the context of homestead withdrawal in China. This resulted in a total of 23 specific indicators (see Table 1).

2.2.1. Economic dimension

Economically resilient villages can mobilize resources to mitigate shocks and prevent economic losses (Cui et al., 2023). Despite rural China's shift toward non-agricultural production, many groups lack capacity for agricultural labor or land management (Liu & Li, 2017; Long et al., 2019). Homesteads remain critical for housing and livelihoods (Wang et al., 2018), serving as physical capital that supports individual, family, and rural economic development amid urban migration (Long et al., 2016; Wang et al., 2022). However, WRH policy implementation may reduce income for vulnerable groups. Diversified agricultural activities enhance rural economic resilience by reducing dependence on land-based income and creating alternative livelihoods for households post-withdrawal. These activities also depend on infrastructure-driven capital accumulation (Emery & Flora, 2020).

The WRH policy aims to protect farmland and balance urban-rural land use (Song et al., 2021), fundamentally

Table 1. Dimensions of impact of homestead withdrawal on rural resilience

Dimension	Indicators	Descriptions	Sources
Economic dimension (D_1)	(C ₁) Improvement of villagers' income	Improving villagers' income enhances economic resilience	Kaye-Blake et al. (2019), Wilson (2012), Liu and Li (2017), Sherrieb et al. (2010)
	(C ₂) Promotion of villagers' employment	Promoting villagers' employment enhances economic resilience	Cutter et al. (2008), Chen et al. (2017)
	(C ₃) Construction and improvement of infrastructure	Infrastructure aids in economic growth	Emery and Flora (2020), Liu et al. (2022), Magis (2010)
	(C ₄) Promotion of diversity in economic development	Promoting diversity in economic development enhances adaptability	Scott (2013), Adger (2000), Folke (2006), Li (2023), Cutter et al. (2003)
	(C ₅) Entering collective construction land into the market	Collective construction land in the market enhances economic resilience	Cutter et al. (2016), Emery and Flora (2020)
Social dimension (D_2)	(C ₆) Increases in social insurance coverage	Providing social insurance for people in newly established communities ensures their rights and interests	Rahman and Zhang (2018), Huang et al. (2018), Yuan et al. (2018)
	(C ₇) Provision of employment training opportunities	Providing employment training and publicity for residents of new communities strengthens individual resilience and enhances social capital	Wan et al. (2018), Cui et al. (2023), Huang (2022), Cutter et al. (2008)
	(C ₈) Guarantee of housing for withdrawing farmers	Ensuring housing for farmers who have withdrawn land and moved to cities helps them to resolve housing issues in a timely manner	Cai et al. (2020), Roostaie and Nawari (2022), Liang et al. (2022a)
	(C ₉) Improvement of medical services	Improving medical services enhances the convenience and level of medical security for villagers, which improves their quality of life	Zhang et al. (2023), Cox and Hamlen (2015), Wells (2010)
	(C ₁₀) Increases in various disaster prevention facilities	Increasing disaster prevention facilities can help people to cope with disturbances from natural disasters and climate change, thereby enhancing adaptability	Heijman et al. (2019), Chuang et al. (2018), Li et al. (2019), Fenxia (2022)
	(C ₁₁) Improvement of educational resources	Education contributes to the development of a society	Liu (2018), Adisaputri et al. (2023), Zhao et al. (2022)

End of Table 1

Dimension	Indicators	Descriptions	Sources
Cultural dimension (D_3)	(C_{12}) Enhancement of villagers' sense of belonging	Integrating local cultural designs into new housing helps to reflect cultural confidence and highlight the cultural value of the village	Xie et al. (2021), Cutter et al. (2008), Zhao et al. (2022)
	(C_{13}) Integration of local cultural design in architecture	Preserving folk activities helps to protect specific collective memories	Guo and Liu (2021), Gao and Wu (2017)
	(C_{14}) Preservation of folk art activities	Integrating scattered symbols representing local culture helps to protect specific collective memories and historical resilience	Magis (2010), Aldrich and Meyer (2015)
	(C_{15}) Increases in protected cultural heritage areas	Protecting cultural heritage enhances villagers' sense of belonging	Fan et al. (2021), Beel et al. (2017)
Environmental dimension (D_4)	(C_{16}) Adoption of sustainable farming practices	Sustainable farming practices help to protect the environment	Liu et al. (2022), Yu et al. (2023), Yang et al. (2022)
	(C_{17}) Environmental improvement	Promotes the environmental improvement of villages	Tao et al. (2021), Long et al. (2019), Yang and Zhang (2023)
	(C_{18}) Increases in green coverage	Increases green coverage	Kelly et al. (2015), Zhao et al. (2022), Huang et al. (2018)
	(C_{19}) Monitoring and protection of ecosystems	Monitors and protects ecosystems	Cannon and Müller-Mahn (2010), Norris et al. (2008), Peng et al. (2013)
Governance dimension (D_5)	(C_{20}) Strengthening multi-stakeholder participation	Strengthens multi-stakeholder participation	McManus et al. (2012), Kapucu and Sadiq (2016), Yi et al. (2020)
	(C_{21}) Establishment of cooperative and mutual aid mechanisms	Establishes cooperation and mutual aid mechanisms	Xie et al. (2023), Garmestani and Benson (2013)
	(C_{22}) Development of emergency plans and measures	Develops corresponding emergency plans and measures	Pfefferbaum et al. (2013), Leykin et al. (2013)
	(C_{23}) Assurance of fair compensation mechanisms	Ensuring that farmers receive reasonable compensation protects farmers' interests from land expropriation	Xie et al. (2023), Xia et al. (2024), Chen et al. (2017), Song et al. (2021)

restructures rural land resources (Long et al., 2016). Under China's Land Administration Law, village collectives can convert idle homesteads and abandoned construction land into marketable assets with farmers' voluntary consent (Li et al., 2015). This market entry mechanism boosts villagers' property income, attracts investment, creates rural employment, and strengthens rural-urban linkages through economic development.

In summary, this dimension encompasses five indicators: (C_1) improvement of villagers' income, (C_2) promotion of villagers' employment, (C_3) construction and improvement of infrastructure, (C_4) promotion of diversity in economic development, and (C_5) entering collective construction land into the market.

2.2.2. Social dimension

Social resilience can positively spill over into other resilience dimensions (Li et al., 2015; Wilson et al., 2018; Kelly et al., 2015). Post-WRH policy implementation, key societal vulner-

abilities include inadequate social security, farmer skill gaps in new labor markets, and housing insecurity (Scott, 2013; Zhang et al., 2023). Rural areas also face limited emergency and healthcare access compared to urban zones, delaying disaster response and family health crises (Wells, 2010). Enhanced healthcare reduces disparities and improves health outcomes in restructured rural communities.

In complex environments, a set of disaster preparedness strategies should be a high priority for communities (Norris et al., 2008; Gawith et al., 2016; Pfefferbaum et al., 2013; Zhao et al., 2022; Leykin et al., 2013). For rural areas entering post-homestead withdrawal, effective disaster prevention facilities enhance the response capabilities of communities in the face of natural disasters. For rural areas that adopt the indicator replacement model for land withdrawal, the nature of household registration and the geographical location of the community typically remain unchanged (Liang et al., 2022b). Therefore, it is necessary to improve medical services and increase disaster prevention

measures in these rural areas, even more so for those that adopt the asset replacement, monetary compensation, and dual replacement models for land withdrawal (which may involve leaving the original geographical location to enter urban areas) (Huang et al., 2018). Additionally, improving educational resources in villages can strengthen the resilience of individuals, families, and communities, and a good level of education can also promote resilience at other levels (Liu, 2018; Oncescu, 2014; Adisaputri et al., 2023).

Thus, the social dimension comprises six key indicators: (C_6) increases in social insurance coverage, (C_7) provision of employment training opportunities, (C_8) guarantee of housing for land-withdrawing farmers, (C_9) improvement of medical services, (C_{10}) increases in disaster prevention facilities, and (C_{11}) improvement of educational resources.

2.2.3. Cultural dimension

Cultural resilience embodies a village's social norms, traditions, and ideologies (Wilson, 2012). Rural development reflects human agency, fostering social learning and memory that shape collective memories (Beel et al., 2017)—these act as socio-cultural capital, reducing transaction costs and information asymmetry (Aldrich & Meyer, 2015; Wu & Yuan, 2023). Socio-cultural capital promotes mutual aid behaviors in the event of a natural disaster in a village and significantly improves the implementation of community and household preparedness plans during the disaster preparedness phase (Xiong & Li, 2024). Unlike urban areas, rural communities rely on tight-knit social networks and entrenched collective memory (Wirth, 1938; Kelly et al., 2015). However, urbanization and industrialization erode such capital (Beel et al., 2017; Wu & Yuan, 2023). Homestead withdrawal-induced relocation risks fragmenting community culture, mirroring broader threats to rural traditions from urbanization and migration (Beel et al., 2017; Gao & Wu, 2017).

The WRH process centralizes scattered housing into planned residential zones, reducing neighbor proximity. By granting villagers' eligibility for free homesteads (based on household registration), it reinforces their land attachment and community belonging. Such belonging—rooted in cultural practices, social interactions, and personal beliefs—strengthens individual-family-community bonds and enhances rural resilience (McManus et al., 2012). Additionally, China's traditional rural settlements hold cultural heritage capital (e.g., architectural heritage, folk traditions, collective community spirit) that fosters development when preserved (Gao & Wu, 2017).

Therefore, this dimension includes four indicators: (C_{12}) enhancement of villagers' sense of belonging, (C_{13}) integration of local cultural design in architecture, (C_{14}) preservation of folk-art activities, and (C_{15}) increases in cultural heritage protection areas.

2.2.4. Environmental dimension

Natural environmental resilience hinges on sustainable resource use, ecological balance, and disaster monitoring. As a land consolidation tool, the WRH policy protects arable

land by reclaiming homesteads for agriculture. Sustainable farming practices post-withdrawal enhance soil conservation, reduce pollution, and revitalize agricultural systems. Idle homesteads often become waste sites, degrading rural landscapes and ecosystems (Tao et al., 2021; Zhao & Zhang, 2017; Beeton & Lynch, 2012). Local governments must prioritize greening initiatives and environmental restoration post-withdrawal (Emery & Flora, 2020). As open socio-ecological systems, rural communities require proactive assessment and monitoring of environmental shocks to build adaptive capacity for future uncertainties (Cutter, 2012).

In summary, the indicators for this dimension include the following: (C_{16}) adoption of sustainable farming practices, (C_{17}) village environmental improvement, (C_{18}) increases in green coverage, and (C_{19}) monitoring and protection of ecosystems.

2.2.5. Governance dimension

Rural resilience is closely tied to governance, defined as a community's capacity to mobilize resources and collective action to address well-being shocks (Davidson, 2010; Wilson et al., 2018). In rural China, village committees hold strong authority and public trust (Li et al., 2024). Multi-stakeholder collaboration and community mutual aid—formal or informal—are critical governance assets, enabling collective action to strengthen resilience (Folke, 2006; Norris et al., 2008; Wilson, 2010; Sherrieb et al., 2010; Magis, 2010). Post-homestead withdrawal, new stakeholders (e.g., governments, businesses, NGOs, residents) may reshape communities (Liang et al., 2022b). Their participation fosters knowledge sharing and coordinated problem-solving, enhancing intervention sustainability (Crispeels et al., 2018). Targeted post-withdrawal emergency plans also improve disaster preparedness and safety awareness among residents (Cutter et al., 2016; Leykin et al., 2013; Pfefferbaum et al., 2013). Compensation mechanisms significantly influence farmers' withdrawal decisions, reflecting their land rights consciousness (Zhao & Zhang, 2017). However, inequitable or inadequate compensation risks farmer-government conflicts (Chen et al., 2017; Shan & Feng, 2018).

In summary, the indicators for this dimension include the following: (C_{20}) strengthening of multi-stakeholder participation, (C_{21}) establishment of cooperative and mutual aid mechanisms, (C_{22}) development of emergency plans and measures, and (C_{23}) assurance of fair compensation mechanisms for land withdrawal.

3. Material and methodology

The methodology of this study is divided into the two phases shown in Figure 2: (1) assessment of the suitability of indicators using the Delphi method and (2) a Fuzzy DEMATEL was used to explore the complex relationships between dimensions and indicators to access the important factors affecting rural resilience.

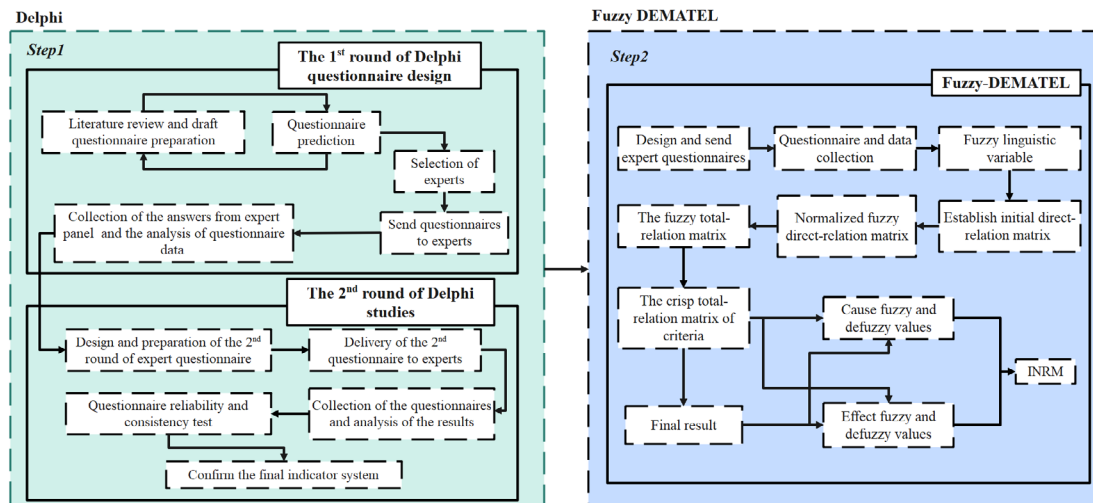


Figure 2. Research framework

The Delphi method aims to achieve consensus through controlled feedback questionnaires which facilitate interaction within a panel of evaluators (Passig, 1997). This method is suitable for the development of evaluation indicators (Chiu et al., 2019; Lee & Hsieh, 2016), for which experts are invited to score based on the research objectives. Researchers then revise the indicators based on the scores and confirm the final evaluation indicators and system. This method has been widely used for the creation of ranked indicator systems for the evaluation of resilience (Labaka et al., 2016; Tseng et al., 2022; Rodriguez et al., 2022; Pei et al., 2019; Wang et al., 2023). Fuzzy DEMATEL is an algorithm for factor analysis. This algorithm, based on graph theory, constructs an analytical structure of causal relationships among complex social factors to identify key elements (Gabus & Fontela, 1972).

3.1. Delphi process

3.1.1. Expert selection

The Delphi method employs a structured approach to validate evaluation systems through expert consensus. Guided by expert panel feedback, we refined the rural resilience evaluation framework via iterative questionnaires—a proven method for indicator development (Lee & Hsieh, 2016). Experts scored preliminary indicators, which were then revised and finalized, aligning with resilience indicator selection practices (Wang et al., 2023).

The selection of the expert panel is a key component of the Delphi method, as the experience accumulated by experts plays a crucial role in the confirmation and validity of the evaluation system. We thus set the following criteria for expert selection: (1) a mid-level or higher

Table 2. Background information of 16 Delphi participants

Department	No	Degree	Areas	Working years	Job title
Academic	1	Ph.D.	Land Resources Planning	12	Professor
	2	Ph.D.	Rural Development	7	Professor
	3	Ph.D.	Land Resources Planning	10	Associate Professor
	4	Ph.D.	Public Administration	8	Associate Professor
	5	Ph.D.	Rural Development	6	Associate Professor
	6	Ph.D.	Public Administration	6	Associate Professor
Government	7	Master's	Rural Development	29	Director
	8	Master's	Urban and Rural Planning	16	Director
	9	Master's	Public Administration	12	Section Chief
	10	Master's	Public Administration	10	Section Chief
	11	Master's	Urban and Rural Planning	6	Deputy Section Chief
Enterprise	12	Ph.D.	Urban and Rural Planning	35	Senior Engineer
	13	Master's	Land Resources Planning	16	Senior Engineer
	14	Bachelor's	Land Resources Planning	14	Designer
	15	Master's	Urban and Rural Planning	14	Department Manager
	16	Master's	Land Resources Planning	14	Department Manager

position in the relevant field and (2) at least five years of experience in rural management. There is no consensus in the existing literature regarding the number of experts; it is usually determined by the available time for conducting the Delphi process, the accessibility of experts in the relevant field, and the research area (Williams & Webb, 1994). Wang et al. (2023) conducted interviews and distributed questionnaires to 13 experts and identified important factors affecting social sustainability after the withdrawal of homesteads. Lin et al. (2021) evaluated the sustainability of urban renewal projects in Taiwan based on 13 experts. Hu et al. (2014) explored the case for improving smartphones based on 14 experts and 10 experienced smartphone users cases. Jiang et al. (2023) based on 7 experts on the sustainability of social housing rentals in Taiwan. A heterogeneous group (expertise from different social or professional groups but on a single topic) are seen as more reasonable groups of experts, typically consists of 10–20 participants, with at least two or three high-level experts (Geist, 2010). Fujian Province was the first region in China to implement WRH policy; we thus selected 16 local land management scholars, rural development, and urban-rural planning experts from this region. Details of these participants are shown in Table 2. Our sample size is in line with Delphi survey standards.

3.1.2. Consensus criteria

This study distributed questionnaires to relevant experts via email. The questionnaire collected background information on the participants and provided them with the opportunity to revise their opinions and add comments. The participants were asked to rate the importance of the five dimensions on a seven-point Likert scale (1 = very low importance to 7 = very high importance). The first round of the survey was conducted from November 15 to November 25, 2023. After collecting the first round of questionnaires, we revised the indicators based on the feedback received. When distributing the questionnaire for the second round, we presented the average scores and feedback results from the first round to the experts and asked them to rate the revised indicators again. The second round of the survey was conducted from November 30 to December 8, 2023.

We statistically evaluated the authority level of the experts from both rounds (see Table 3). The expert authority coefficient (C_r) is determined by two factors: the basis of expert judgment (C_d) and the degree of expert familiarity (C_s), with the expert authority coefficient (C_r) calculated as $C_r = (C_d + C_s) / 2$. The authority level of the expert questionnaires in both rounds exceeded 0.7, meeting requirements. This study adopted three sets of criteria to reach a consensus among expert opinions (see Table 4 for details). Before using the Delphi method, we removed outliers (i.e., the maximum and minimum scores for individual indicators), notified the experts via email meet-

ings, and then obtained their consent. The three sets of calculation standards were the mean (N), standard deviation (SD), and coefficient of variation (CV). After the first round of questionnaires, we calculated the expert rating results. After removing outliers, we calculated the mean (N), standard deviation (SD), and coefficient of variation (CV) and removed indicators with low consistency ($SD > 1$, $CV > 0.25$). This resulted in the exclusion of (C_6) "increases in social insurance coverage". Furthermore, we combined the suggestions from the first round of expert questionnaires and adjusted individual indicators. Thus, the economic indicator (C_3) "construction and improvement of infrastructure" was changed to "improvement of productive infrastructure"; the environmental indicator (C_{19}) "monitoring and protection of ecosystems" was changed to "strengthening environmental monitoring and protection"; the governance indicator (C_{20}) "strengthening multi-stakeholder participation" was changed to "improvement of the village self-governance system"; and the governance indicator (C_{22}) "development of emergency plans and measures" was changed to "formulation of emergency plans for sudden events".

Table 3. Expert authority level

Round	Judgment coefficient (C_d)	Familiarity degree (C_s)	Authority coefficient (C_r)
1	0.844	0.775	0.912
2	0.834	0.747	0.920

Based on the results of the second round of inquiry, we determined the specific descriptions and content of 22 indicators. In the second round of the survey, we further examined the expert scoring. First, we verified the reliability of the questionnaire, with Cronbach's α coefficient of 0.924.

Additionally, in this round of examination, we used the Kendall coordination coefficient to test the consistency of the evaluation, utilizing SPSS software. The result ($W = 0.31$, $p = 0.000$) was statistically significant, indicating that the evaluations of the 16 participants were correlated and consistent. Finally, we sent a new questionnaire to the experts, along with each expert's opinions and the degree of difference from the mean. We collected the experts' opinions and compared them with the opinions from the first step. If the difference between the two stages was less than the threshold of 0.2, the Delphi process was then terminated.

Based on our criteria for expert selection and revision, we constructed an evaluation system for rural resilience following withdrawal from homestead land in Chinese villages. Through a comprehensive and iterative consultation process, consensus was ultimately reached among the selected experts, resulting in an evaluation system composed of 5 dimensions and 22 standards (see Table 5 for details).

Table 4. Results of Delphi method

Dimensions/indicators	Uncorrected value				Deleted extreme values			
	Range	Average	SD	CV	Range	Average	SD	CV
Economic dimension (D_1)	4	6.06	1.181	18.87%	3	6.214	0.860	13.84%
Social dimension (D_2)	3	5.94	0.998	16.27%	3	6.000	0.845	14.09%
Cultural dimension (D_3)	3	5.25	1.000	18.44%	3	5.214	0.860	16.50%
Environmental dimension (D_4)	3	5.44	1.031	18.35%	3	5.429	0.904	16.64%
Governance dimension (D_5)	3	5.56	0.964	16.78%	3	5.571	0.821	14.73%
Improvement of villagers' income (C_1)	2	6.13	0.885	13.99%	2	6.143	0.833	13.56%
Promotion of villagers' employment (C_2)	4	5.31	1.195	21.79%	3	5.357	0.972	18.14%
Construction and improvement of infrastructure (C_3)	2	6.00	0.73	11.79%	2	6.000	0.655	10.91%
Promotion of diversity in economic development (C_4)	4	5.00	1.155	22.36%	3	5.000	0.926	18.52%
Entering collective construction land into the market (C_5)	4	5.31	1.195	21.79%	4	5.357	0.972	18.14%
Increases in social insurance coverage (C_6)	4	5.25	1.571	28.97%	4	5.286	1.436	27.16%
Provision of employment training opportunities (C_7)	4	5.06	1.289	24.66%	4	5.071	1.100	21.68%
Guarantee of housing for land-withdrawing farmers (C_8)	4	6.25	1.183	18.33%	4	6.357	1.042	16.40%
Improvement of medical services (C_9)	4	5.56	1.211	21.99%	3	5.571	0.979	17.58%
Increases in disaster prevention facilities (C_{10})	4	5.50	1.414	24.90%	4	5.571	1.237	22.21%
Improvement of educational resources (C_{11})	4	5.75	1.183	19.92%	3	5.857	0.915	15.62%
Integration of local cultural design in architecture (C_{12})	3	5.56	0.892	15.53%	3	5.571	0.728	13.07%
Preservation of folk art activities (C_{13})	4	5.06	1.063	20.32%	2	5.071	0.799	15.75%
Increases in cultural heritage protection areas (C_{14})	4	5.19	1.223	22.83%	4	5.214	1.013	19.42%
Enhancement of villagers' sense of belonging (C_{15})	4	5.25	1.39	25.64%	4	5.286	1.221	23.09%
Adoption of sustainable farming practices (C_{16})	4	5.81	1.276	21.26%	3	5.929	1.033	17.42%
Promotion of village environmental improvement (C_{17})	2	6.00	0.73	11.79%	2	6.000	0.655	10.91%
Increases in green coverage (C_{18})	4	4.88	1.147	22.79%	3	4.857	0.915	18.83%
Monitoring and protection of ecosystems (C_{19})	4	5.50	1.265	22.27%	3	5.571	1.050	18.84%
Strengthening of multi-stakeholder participation (C_{20})	3	5.63	0.957	16.48%	3	5.643	0.811	14.38%
Establishment of cooperation and mutual aid mechanisms (C_{21})	4	5.31	1.302	23.73%	4	5.357	1.109	20.70%
Development of emergency plans and measures (C_{22})	4	5.06	1.389	26.56%	4	4.857	1.301	24.11%
Assurance of fair compensation mechanisms for land withdrawal (C_{23})	2	6.50	0.632	9.42%	2	6.500	0.627	9.64%

Table 5. Final evaluation system

Dimension	Indicators	Descriptions
Economic dimension (D_1)	(C ₁) Improvement of villagers' income	After withdrawal from homesteads, farmers may lose income derived from homestead land, making their financial situation more vulnerable. Therefore, it is necessary to improve villagers' income, for example, through compensation income
	(C ₂) Promotion of villagers' employment	Following implementation of WRH, groups who were engaged in traditional agricultural production may face the loss of their livelihoods. Promoting villagers' employment enhances the ability of the rural economic system to adjust its employment structure and opportunities in the face of such shocks
	(C ₃) Construction and improvement of infrastructure	Following implementation of WRH, the construction and improvement of rural productive infrastructure such as transportation, communication, electricity, and water conservancy can enhance the ability to cope with external shocks and market changes
	(C ₄) Promotion of diversity in economic development	Following implementation of WRH, traditional rural industrial structures may change. Villages can develop non-agricultural industries such as manufacturing and services to enhance adaptability
	(C ₅) Entering collective construction land into the market	Following implementation of WRH, village collectives can legally convert compensated homestead land and abandoned public welfare land into collective construction land for market entry. Allowing collective land to enter the market can significantly increase farmers' property income
Social dimension (D_2)	(C ₆) Provision of employment training opportunities	Withdrawal from homesteads may lead to significant population mobility, potentially enabling the development of new industries such as rural tourism and ecological protection. Providing employment training and publicity for new community residents can strengthen individual resilience and social capital
	(C ₇) Guarantee of housing for land-withdrawing farmers	Following implementation of WRH, some farmers may transition to urban residents. Studies have shown that poor housing conditions and high commercial housing prices can complicate this transition. Ensuring housing for land-withdrawing farmers helps them to resolve housing issues in a timely manner
	(C ₈) Improvement of medical services	Following implementation of WRH, improving medical services can enhance the convenience and level of medical security for rural residents, contributing to an improved quality of life, sense of gain, and overall health level
	(C ₉) Increases in disaster prevention facilities	Following implementation of WRH, increasing disaster prevention facilities can help communities to cope with disturbances from natural disasters and climate change, thereby enhancing adaptability
Cultural dimension (D_3)	(C ₁₀) Improvement of educational resources	Following implementation of WRH, improving the community's access to high-quality education helps to improve its resilience
	(C ₁₁) Enhancement of villagers' sense of belonging	Rural culture is often closely related to land, family, and local customs. Withdrawal from homesteads may lead to the loss and decline of these traditional cultural elements. Promoting folk activities helps to protect specific collective memories
	(C ₁₂) Integration of local cultural design in architecture	Following implementation of WRH, integrating local cultural designs into new housing helps to reflect cultural confidence and highlight the cultural value of the village
	(C ₁₃) Preservation of folk activities	Following implementation of WRH, the original spatial structure of the village changes. Integrating scattered symbols of local culture helps to protect specific local memories and historical resilience, such as building revolutionary exhibition halls or agricultural museums
	(C ₁₄) Increases in cultural heritage protection areas	Following implementation of WRH, creating cultural heritage protection areas enhances the residents' attachment to the land and their sense of belonging to the village
Environmental dimension (D_4)	(C ₁₅) Adoption of sustainable farming practices	WRH policy is an effective response to idle homestead land and the protection of arable land area. Adopting sustainable farming practices can protect the environment and reduce soil erosion
	(C ₁₆) Promotion of village environmental improvement	Following implementation of WRH, new land use practices may generate a large amount of wastewater, exhaust gases, and solid waste, polluting the surrounding ecological environment. Therefore, it is necessary to promote the environmental improvement of villages
	(C ₁₇) Increases in green coverage	Following implementation of WRH, increasing green coverage can improve air quality, protect water sources and biodiversity, and improve residents' living conditions
	(C ₁₈) Monitoring and protection of ecosystems	Following implementation of WRH, strengthening environmental monitoring and protection helps communities to adapt in a timely manner to climate change, environmental changes, and even disturbances from natural disasters

End of Table 5

Dimension	Indicators	Descriptions
Governance dimension (D_5)	(C_{19}) Strengthening of multi-stakeholder participation	Following implementation of WRH, it is important to gradually strengthen grassroots movements and the mechanisms of village self-governance
	(C_{20}) Establishment of cooperative and mutual aid mechanisms	Gradually establishing cooperative and mutual aid mechanisms helps to build new social networks after the reconstruction of rural resources
	(C_{21}) Development of emergency plans and measures	Following implementation of WRH, village collectives should develop emergency plans to provide emergency goods and services when needed
	(C_{22}) Assurance of fair compensation mechanisms for withdrawal	Ensuring that withdrawing farmers receive reasonable and fair compensation protects farmers' interests

3.2. Fuzzy DEMATEL

In decision-making problems involving complex systems, experts' quantitative scoring of a factor is often based on their personal experience and professional knowledge rather than precise numerical values. This subjective scoring method introduces ambiguity in how experts perceive and express their impressions of a factor, which can ultimately have a significant impact on the experimental results (Yadegaridehkordi et al., 2020). Fuzzy set theory has a significant advantage in measuring fuzzy concepts related to human subjective judgment (Lin, 2013). Fuzzy DEMATEL uses fuzzy semantics (such as "high", "medium", and "low") to more effectively capture this uncertainty and avoid errors caused by the use of precise numerical values. In recent years, Fuzzy DEMATEL has been widely applied to identify key factors and barriers to sustainable development in areas such as urban housing, Industry 4.0, and rural society, providing more precise and adaptive solutions for complex decision-making problems (Lin et al., 2021; Narwane et al., 2021; Wang et al., 2023). The Fuzzy

DEMATEL model collects expert judgments, identifies interrelationships between criteria, and constructs a system model structure through an influence matrix, forming influence network relations maps (INRMs). The influence matrix explains the causal relationships between standards and helps to identify key factors in decision-making. The application of this matrix theory simplifies complex social-ecological environments and can help to infer directions for improvement.

In this paper, three different linguistic variable intervals are assigned between two adjacent linguistic variables to represent different triangular fuzzy numbers. The experts selected for the Fuzzy DEMATEL questionnaire are shown in Table 6. The questionnaire surveys were distributed from December 16 to 28, 2023. Academic experts were mainly scholars who had published high-quality literature related to WRH policy in domestic and international authoritative journals. Government experts were mainly mid- to high-level leaders from the departments of agriculture and rural development, who had a deep understanding of

Table 6. Background of 15 experts participating in Fuzzy DEMATEL questionnaire

Department	No	Degree	Education	Seniority	Job title
Academic	1	Ph.D.	Land Resources Planning	12	Professor
	2	Ph.D.	Rural Development	7	Professor
	3	Ph.D.	Land Resources Planning	10	Associate Professor
	4	Ph.D.	Land Resources Planning	10	Associate Professor
	5	Ph.D.	Rural Development	6	Associate Professor
Government	6	Master's	Rural Development	29	Director
	7	Master's	Urban and Rural Planning	16	Director
	8	Master's	Public Administration	12	Section Chief
	9	Master's	Public Administration	10	Section Chief
	10	Master's	Urban and Rural Planning	6	Deputy Section Chief
Enterprise	11	Ph.D.	Urban and Rural Planning	35	Senior Engineer
	12	Master's	Land Resources Planning	16	Senior Engineer
	13	Bachelor's	Land Resources Planning	14	Designer
	14	Master's	Urban and Rural Planning	14	Department Manager
	15	Master's	Land Resources Planning	14	Department Manager

homestead land and rural development. Enterprise experts were mainly mid- to high-level managers of land use planning or housing construction planning enterprises, who had a comprehensive understanding of building quality and building area planning.

We designed a specialized expert questionnaire for Fuzzy DEMATEL based on existing research findings (Lin et al., 2022; Koca et al., 2021). The questionnaire collected background information on the experts and asked them to assess the impact of the relationships among the indicators on a five-point Likert scale (no influence $\leftarrow$ 1, 2, 3, 4, 5 $\rightarrow$ extremely high influence) (Jassbi et al., 2011; Lin, 2013). The purpose of the Fuzzy DEMATEL questionnaire was to confirm interrelationships and causality by scoring the degree of interaction between indicators based on the judgments of an expert panel. The direct impact scores of experts' judgments on multiple criteria were taken as the initial direct impact matrix. The main steps of Fuzzy DEMATEL were as follows:

Step 1: Convert linguistic variable scores to fuzzy numbers.

In other words, 5 levels of linguistic variables are transformed into fuzzy numbers: 1 (no impact), 2 (very low impact), 3 (low impact), 4 (high impact) and 5 (very high impact). See Table 7 for details.

Table 7. Vague interpretation of linguistic expressions

Linguistic variable	Influence score	Fuzzy linguistic value		
No influence	1	0	0	0.25
Very low influence	2	0	0.25	0.5
Low influence	3	0.25	0.5	0.75
High influence	4	0.5	0.75	1
Very high influence	5	0.75	1	1

Step 2: The direct impact scores of the expert judgments on multiple criteria are used as the initial direct impact matrix A (see Table S1 in the online supplementary material for more details).

$$A = [a_{ij}]_{n \times n}. \quad (1)$$

Step 3: Combine the evaluations of p experts to obtain the defuzzified direct influence matrix Z .

$$z_{ij} = \frac{1}{p} (z_{ij}^1 + z_{ij}^2 + \dots + z_{ij}^p) \quad (2)$$

Step 4: Normalization directly affects the relationship matrix.

Using the matrix Z , the normalized direct influence relationship matrix (see Table S2 in the online supplementary material for more details) is obtained using Equation (3) as follows (Wu et al., 2022).

$$D = \frac{x_{ij}}{\max \left(\sum_{j=1}^n x_{ij} \right)}. \quad (3)$$

Step 5: Use Equation (4) to synthesize the impact matrix T_D .

The synthesized system matrix (see Table S3 in the online supplementary material for more details) embodies the combined effect of the impacts between the elements in the system. Where I is noted as the unit matrix (Lin, 2013).

$$T_D = (D + D^2 + \dots + D^k) = \sum_{k=1}^{\infty} D^k = D(I - D)^{-1}. \quad (4)$$

Step 6: Identify the causal attributes.

The sum of each row r_i and column c_i of the fuzzy total effect matrix (see Table S4 in the online supplementary material for more details) was calculated using Equations (5) and (6) (Lin et al., 2021; Lin, 2013). As follows:

$$r_i = \sum_{j=1}^n x_{ij}, (i = 1, 2, \dots, n); \quad (5)$$

$$c_i = \sum_{j=1}^n x_{ji}, (i = 1, 2, \dots, n). \quad (6)$$

Step 7: Construct influence network relationship maps (INRMs).

A threshold must be established to create the network structure using the total effect matrix. Once the threshold is determined, the cell values in the total effect matrix that are equal to or higher than this threshold indicate the relationships between the criteria as well as the direction of these relationships. The thresholds chosen in this paper are $r_i, c_i, r_i + c_i > \text{mean}, r - c > 0$ (Lin et al., 2021; Jiang et al., 2023). Various methods can be used to determine the threshold. In this study, the threshold was determined by taking the average of all elements in the total effect matrix (Koca et al., 2021; Wang et al., 2023).

4. Empirical results

4.1. The interdependent relationship among dimensions based on Fuzzy DEMATEL

This paper sought to identify the interrelationships and importance of factors of WRH that influence rural resilience. Table 8 presents the inter-dimensional influence relationships and causal positioning. The r_i indicates the degree of its influence on the other dimensions, the Economic dimension (D_1) has the largest value (9.473) which means that it has the highest degree of influence and the remaining dimensions are ranked in order: Social dimension (D_2) (7.636), Governance dimension (D_5) (6.863), Cultural dimension (D_3) (5.995), Environmental dimension (D_4) (5.699). Among them, the values of the Economic dimension (D_1) and Social dimension (D_2) are the only two dimensions that are higher than the threshold (7.133), which means that these two dimensions influence the other dimensions to a greater extent. In terms of the influence received c_i , which indicates the extent to which a dimension is influenced by other dimensions, the Economic dimension (D_1) is still the largest among all the dimensions

Table 8. Results of Fuzzy DEMATEL for dimensions

Dimension	r (influence given)	c (influence received)	$r_i + c_i$	$r_i - c_i$	Characteristics
Economic dimension (D_1)	9.473	8.623	18.096	0.85	Cause
Social dimension (D_2)	7.636	7.448	15.083	0.188	Cause
Cultural dimension (D_3)	5.995	6.672	12.667	-0.677	Effect
Environmental dimension (D_4)	5.699	6.267	11.966	-0.568	Effect
Governance dimension (D_5)	6.863	6.657	13.52	0.206	Cause
Threshold	7.133	7.133	14.266	0	

with a value of 8.623, indicating that it is still strongly influenced by other dimensions.

$r_i + c_i$ indicates the degree to which a dimension is at the center of the system, with higher results signifying a greater importance of the dimension/indicator. The economic dimension (D_1) has the greatest influence on rural resilience following the implementation of WRH (18.096), followed by the social dimension (D_2) (15.083), governance dimension (D_5) (13.52), cultural dimension (D_3) (12.667), and environmental dimension (D_4) (11.966). The value of $r_i - c_i$ indicates the causal relationship of the dimension in the system. The economic dimension (D_1) (0.85), governance dimension (D_5) (0.206), and social dimension (D_2) (0.188) exhibit positive $r_i - c_i$ values, indicating “cause” attributes. The environmental dimension (D_4) (-0.568) and cultural dimension (D_3) (-0.677) show negative $r_i - c_i$ values, indicating that these symbolize the “effect” orientation. They are locked into passive response units whose dynamic evolution is highly dependent on the policy adjustments of the first three. Based on the centrality results, the cultural dimension (D_3) and the environmental dimension (D_4) have relatively lower importance in the system. The decay of cultural heritage effectiveness and the externalisation of environmental costs have become systemic vulnerabilities of the WRH mechanism, suggesting that the current resilience construct has significant non-inclusive flaws.

4.2. The interdependent relationship among dimensions based on Fuzzy DEMATEL

The influence given r_i , the influence received c_i , the degree of centrality $r_i + c_i$ and the degree of cause $r_i - c_i$ of the indicators are shown in Table 9, and based on this, the INRMs are plotted as shown in Figure 3. According to the vector of the influence given r_i , (C_4) “promotion of diversity in economic development”, (C_1) “improvement of villagers’ income situation”, and (C_5) “entering collectively owned construction land into the market” are the indicators that rank in the top three places, which means that the three indicators have high degrees of influence. Meanwhile, (C_8) “improvement of medical services”, (C_{21}) “development of emergency response plans” and, (C_{12}) “preservation of folk art activities” are the bottom three indicators, which means that they are neglected in WRH system and are influenced by other indicators. According to influence received vector

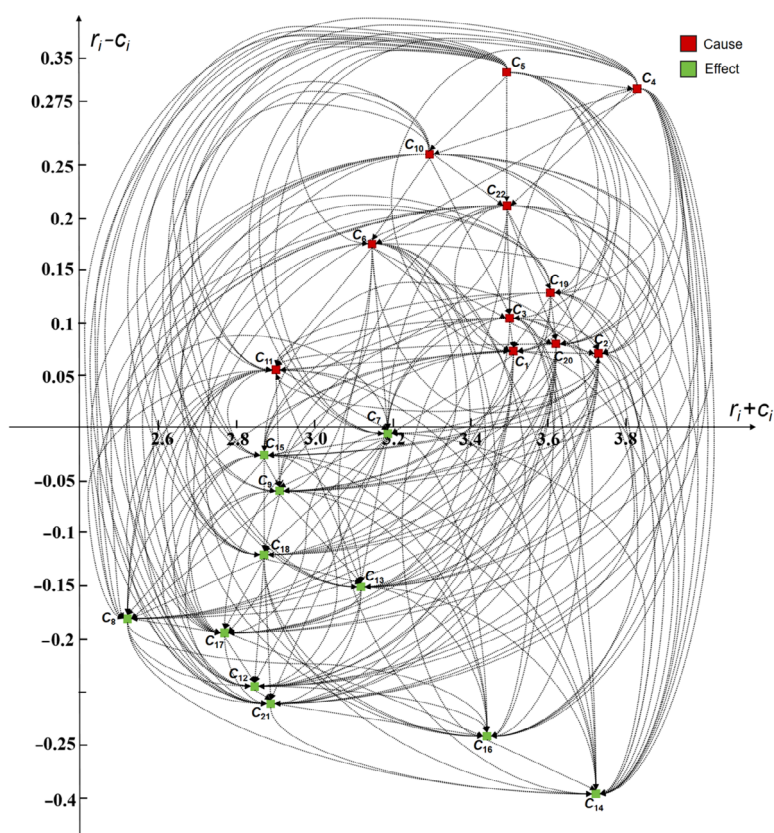
c_i , the top three ranked indicators are (C_{14}) “enhancement of villagers’ sense of belonging”, (C_{16}) “promotion of village environmental improvement” and, (C_1) “improvement of villagers’ income situation”. In contrast, the three lowest ranked indicators are (C_8) “improvement of medical services”, (C_{15}) “adoption of sustainable farming practices” and, (C_{11}) “integration of local cultural design into architecture” are the bottom three indicators.

Among all the indicators, there are 11 indicators with $r_i + c_i$ centrality above the threshold of 3.242. (C_4) “promotion of diversity in economic development” has the highest influence, with a $r_i + c_i$ value of 3.861, and is considered the most important indicator. Other indicators with an important influence on resilience following the implementation of WRH include the following: (C_{14}) “enhancement of villagers’ sense of belonging” with a $r_i + c_i$ value of 3.767; (C_1) “improvement of villagers’ income situation” with a $r_i + c_i$ value of 3.738; (C_{20}) “establishment of cooperative and mutual aid mechanisms” with a $r_i + c_i$ value of 3.61; and (C_{19}) “improvement of the village self-governance system” with a $r_i + c_i$ value of 3.601. The indicators with the least influence were as follows: (C_8) “improvement of medical services” with a $r_i + c_i$ value of 2.558; (C_{17}) “increases in green coverage” with a $r_i + c_i$ value of 2.813; and (C_{12}) “preservation of folk activities” with a $r_i + c_i$ value of 2.827. The three indicators have the lowest ranked $r_i + c_i$ values, indicating that the three indicators are low-importance factors.

A positive $r_i - c_i$ value signifies that the indicator is cause, while a negative $r_i - c_i$ value indicates that the indicator is characteristic of an effect (Addae et al., 2019). The indicator with the highest $r_i - c_i$ value (0.298), and thus greatest influence on other indicators, was (C_5) “entering collectively owned construction land into the market”. This was followed by (C_4) “promotion of diversity in economic development” (0.284), (C_{10}) “improvement of educational resources” (0.255), (C_{22}) “assurance of fair compensation mechanisms for withdrawal” (0.214), (C_6) “provision of employment training opportunities” (0.172), (C_{19}) “improvement of the village self-governance system” (0.129), (C_3) “improvement of productive infrastructure” (0.108), (C_{20}) “establishment of cooperative and mutual aid mechanisms” (0.086), (C_2) “promotion of villager employment” (0.081), (C_1) “improvement of villagers’ income situation” (0.079), and (C_{11}) “integration of local cultural design into architecture” (0.063). The “effect” indicators were (C_7)

Table 9. Results of Fuzzy DEMATEL for indicators

Indicator	$r(\text{influence given})$	$c(\text{influence received})$	$r_i + c_i$	$r_i - c_i$	Characteristics
C ₁	1.908	1.830	3.738	0.079	Cause
C ₂	1.798	1.716	3.514	0.081	Cause
C ₃	1.808	1.700	3.508	0.108	Cause
C ₄	2.072	1.788	3.861	0.284	Cause
C ₅	1.887	1.589	3.475	0.298	Cause
C ₆	1.661	1.489	3.150	0.172	Cause
C ₇	1.595	1.598	3.193	-0.003	Effect
C ₈	1.191	1.367	2.558	-0.176	Effect
C ₉	1.421	1.481	2.901	-0.06	Effect
C ₁₀	1.768	1.513	3.281	0.255	Cause
C ₁₁	1.504	1.441	2.945	0.063	Cause
C ₁₂	1.307	1.520	2.827	-0.213	Effect
C ₁₃	1.495	1.633	3.128	-0.138	Effect
C ₁₄	1.689	2.078	3.767	-0.389	Effect
C ₁₅	1.416	1.439	2.855	-0.023	Effect
C ₁₆	1.602	1.842	3.444	-0.240	Effect
C ₁₇	1.313	1.500	2.813	-0.187	Effect
C ₁₈	1.368	1.486	2.854	-0.118	Effect
C ₁₉	1.865	1.736	3.601	0.129	Cause
C ₂₀	1.848	1.762	3.610	0.086	Cause
C ₂₁	1.306	1.529	2.834	-0.223	Effect
C ₂₂	1.844	1.630	3.475	0.214	Cause
Threshold	1.621	1.621	3.242	0	

**Figure 3.** INRMs for indicators

“guarantee of housing for land-withdrawing farmers” (–0.003), (C₁₅) “adoption of sustainable farming practices” (–0.023), (C₉) “increases in disaster prevention facilities” (–0.06), (C₁₈) “strengthening of environmental monitoring and protection” (–0.118), (C₁₃) “increases in cultural heritage protection sites” (–0.138), (C₈) “improvement of medical services” (–0.176), (C₁₇) “increases in green coverage” (–0.187), (C₁₂) “preservation of folk activities” (–0.213), (C₂₁) “development of emergency response plans” (–0.223), (C₁₆) “promotion of village environmental improvement” (–0.24), and (C₁₄) “enhancement of sense of belonging among villagers” (–0.389). Thus, improvements in the causal indicators will positively impact these indicators.

INRMs of the relationships between indicators are presented in Figure 3. As shown in Table 9, the factor with the second-highest $r_i - c_i$ is (C₄) “promotion of economic diversification”, with a score of 0.284; its r_i -value is the highest among all system factors, with a score of 3.861. Additionally, this $r_i + c_i$ of this indicator ranks first in the system, while its r_i -value ranks third, indicating that (C₄) has the capability to improve and exert a significant influence on the system. Other important indicators in the system include (C₁₄) “enhancement of villagers’ sense of belonging”, (C₁) “improvement of villagers’ income”, (C₂₀) “establishment of cooperative and mutual assistance mechanisms”, and (C₁₉) “improvements in the villagers’ self-governance system. However, (C₁₄) has the lowest $r_i - c_i$, suggesting that any disturbance or change in all of indicators within the system will affect the sense of belonging in rural communities. Interestingly, (C₈) “improvement of medical services”, (C₁₇) “increases in green space coverage”, (C₁₂) “preservation of folk art activities”, and (C₁₈) “strengthening of environmental monitoring and protection” are among the least important indicators, all with $r_i - c_i$ less than 0. Furthermore, the centrality metrics for all four indicators are below the thresholds, which reflecting their importance in the current policy framework and their role as vulnerable nodes in the system. This hierarchy provides an important basis for optimising resource allocation, emphasising that priority should be given to strengthening the system regulating capacity of driver indicators, while establishing a dynamic protection mechanism for vulnerable nodes.

5. Discussion

Rural communities have always struggled to reach a state of equilibrium, and their development process is determined by the internal capabilities of the community, external conditions, and the ability to adjust internal and external functions and structures (Harris et al., 2000). The level of resilience depends on the extent to which a specific rural area can tolerate changes before reorganizing around a new set of structures and processes. This capability is oriented towards uncertainty, i.e., it is future-oriented. Enhancing this is key to reversing rural decline and improving the level of rural resilience (Heijman et al., 2019; Chuang et al., 2018). Therefore, identifying the dimensions

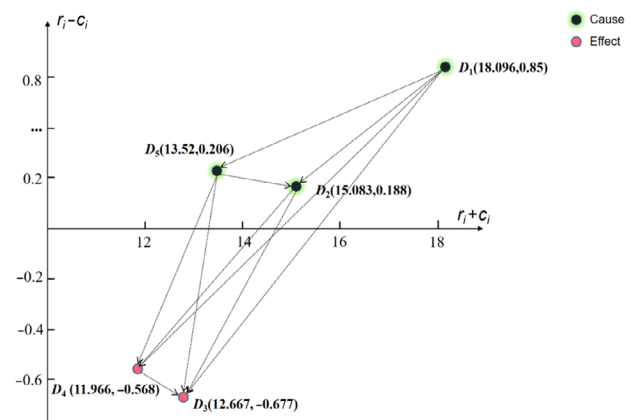


Figure 4. Mapping of inter-dimensional influence network relations

and indicators of this capability is particularly important, especially after a specific rural area is restructured due to land use policies.

This study employs the Delphi method to iteratively screen indicators and applies Fuzzy DEMATEL to measure the impact of the 5 dimensions and their 22 indicators on rural resilience. Figure 4 illustrates the importance and interrelationships among the dimensions. Overall, economic resilience is the most important and significantly influences the other dimensions. The social and governance dimensions follow in importance. In contrast, the cultural and environmental dimensions are considered non-critical factors. The resilience of rural areas in the economic dimension affects the cultural dimension through mediating variables such as the social, governance, and environmental dimensions, and the enhancement of the cultural dimension in turn promotes the strengthening of the economic dimension. This finding means that policymakers cannot overlook dimensions that do not play a dominant role, as each dimension is interdependent.

Our results indicate that WRH policy significantly impacts the economic resilience of rural areas by increasing the availability of construction land and transforming existing rural industrial activities (Jiang et al., 2022; Ma et al., 2020; Chen et al., 2020). If a rural area loses economic resilience following WRH—as manifested in reduced employment opportunities and lower incomes—it becomes more susceptible to economic shocks, thereby increasing its economic vulnerability (Wilson, 2010; Heijman et al., 2019). Our findings support the idea that maintaining diversity and redundancy is a key principle of economic resilience (Zhang et al., 2022). Wilson (2010) also pointed out that over-reliance on a single element may be the beginning of the journey towards vulnerability for rural communities. A study in Lankao County, China, found that industrial and livelihood diversity are fundamental requirements for enhancing village adaptability and that ideally there should be a combination of industrial specialization and diversity (Cui et al., 2023). Entering collectively owned construction land into the market (C₅) is an innovative indicator based on the context of WRH in China. This practice not only

improves the property income of a village but also enhances the living conditions of rural households (Guo & Li, 2023). It also promotes connections between the village and external forces, strengthening the community's ties with external social capital (Cutter et al., 2016; Emery & Flora, 2020). WRH releases the economic value of land by entering it into the market and promotes industrial diversification to enhance the ability of the rural community to cope with market fluctuations. However, over-reliance on a single compensation mechanism may lead to livelihood vulnerability for rural households, which needs to be supplemented by employment training and infrastructure improvement.

Owing to the extensive promotion of China's Rural Revitalization Strategy, the impacts of social and governance dimensions on rural resilience have become increasingly significant and beneficial. The WRH policy primarily targets farmers, who, compared to urban residents, exhibit a higher overall level of vulnerability (Long et al., 2019). Farmers' dependence on land and their risk assessment capabilities require the efficient allocation of resources to ensure housing security and social welfare for rural populations (Xie et al., 2023; Liang et al., 2022b). Social security indicators (C_{7-10}) and multi-stakeholder participation serve as critical linkages between economic and environmental resilience. For instance, after WRH, a well-functioning village self-governance system can effectively mediate conflicts of interest, while emergency response plans enhance the community's disaster resilience. Finally, risks such as financial shocks and climate change can also significantly disrupt rural resilience. Therefore, during and after the implementation of the WRH policy, decision-makers must ensure equitable compensation and foster a sense of co-operation within rural communities.

While existing studies have measured rural resilience across various dimensions/indicators or identified critical indicators, their methodologies not only failed to elucidate the contributions and causal relationships among these dimensions/indicators but also tended to overemphasize dominant dimensions/indicators (Fan et al., 2021; Wang et al., 2023). However, non-dominant dimensions/indicators constitute integral components of the system and are essential criteria for robust resilience (Wilson, 2010). Our findings reveal that the cultural dimension (D_3), though classified as non-critical, deserves greater attention from policymakers. In contemporary China, livelihood priorities have intensified geographical separation in intergenerational family relationships (Wu & Yuan, 2023). Against this backdrop, the WRH policy has exacerbated the geographical isolation of remaining rural populations, thereby eroding long-established place-based memories and social networks. To improve the impact of WRH policy on cultural resilience, policymakers could organize regular region-specific artistic activities and preserve these as community cultural heritage in local museums (Beel et al., 2017). For instance, in Minnan rural villages of Fujian Province, development initiatives often receive financial or resource support from town associations when needed. This under-

scores the importance of maintaining rural cultural identity and social network cohesion (Liang et al., 2022b). Similarly, the environmental dimension (D_4) remains crucial. WRH policy enhances land-use efficiency by repurposing idle land for reclamation, ecological restoration, and vegetation coverage improvement, thereby upgrading rural ecological environments, and creating space for environmental infrastructure and thus treating environmental dimensions as non-dominant risks mismanagement. Poorly regulated land reuse may lead to irrational development, ecological degradation, and heightened resource governance challenges. As such, strategic planning and management are imperative to ensure that homestead withdrawal policies effectively strengthen rural environmental resilience. Both environmental (D_4) and cultural (D_3) dimensions should thus be prioritized in policy refinements due to their latent long-term value and pivotal contributions to sustainable development; this warrants focused attention from decision-makers.

Therefore, from a decision maker's perspective, it is justified to give high priority to optimisation strategies and paths. In particular, the cultural dimension (D_3) and the environmental dimension (D_4) have significantly higher passive dependency indices than the economic and social dimensions, and optimisation of these two dimensions is more important. Policy makers can take into account the actual situation of each region to invest a percentage of land transfer revenues in the construction of cultural facilities to enhance villagers' sense of belonging, and break the unidirectional dependency of the economic and cultural dimensions through policy tools. Relevant staff can preserve symbolic spatial elements (e.g., ancestral shrines) in resettlement zones and establish participatory planning committees to codify local knowledge. This approach promotes a sense of belonging among residents, which makes residents close to each other and enhance homesickness among out-of-town residents miss their hometowns, which makes them willing to contribute to the development of their hometowns. This type of capital is called 'connective' capital, which facilitates the connection between the rural community and the outside world, and strengthens the connection between the community and external social capital (Cutter et al., 2016). For the environmental dimension, policy makers could require development entities to deposit 20% of their investment as an ecological deposit, and forfeit the funds if the indicator compliance rate is less than 90% within five years. In addition, policymakers can adopt the strategy of restoring 0.3 mu of ecological land for every 1 mu of land used for construction, and include the restoration area in the evaluation index of local governments (Zhou et al., 2023). Finally, policy makers can link land-released zones to green industrial clusters (e.g., agro-tourism hubs) while allocating 5–10% of WRH-derived revenues to community-led cultural revitalization programs. By addressing these systemic linkages, WRH can transition from a land-centric tool to a catalyst for holistic rural resilience, balancing efficiency with equity and continuity.

Overall, Given the critical functions of rural homesteads and their significance to farmers, it is essential to evaluate the impact of WRH on rural resilience. WRH has injected new vitality into rural development by ensuring construction land needs, promoting industrial integration, enhancing governance capabilities, and optimizing spatial layouts, thereby fully unlocking the value of idle residential properties. We argue that priority should be given to supporting economic diversification and the marketization of collective land, while strengthening social security and employment training to prevent farmers from falling into poverty due to land loss. However, the implementation of this policy has also revealed shortcomings, such as the weakening of cultural and environmental dimensions of resilience. Research indicates that policymakers, markets, and the private sector often overlook the sustainability of environmental and cultural aspects in the pursuit of economic outcomes (Oyebanji et al., 2017). This contradicts the comprehensive goals of the rural revitalization strategy, which, like resilience, requires coordinated development across multiple dimensions. Policymakers can integrate local cultural elements into new communities and enhance a sense of belonging through folk activities, mitigating cultural disconnection caused by population mobility. Simultaneously, environmental monitoring and green space planning should be strengthened to ensure that land reclamation and ecological restoration proceed in tandem. Therefore, future rural development and transformation should draw lessons from this experience, shifting traditional management paradigms, fostering civic spirit, allocating resources rationally, and emphasizing environmental construction and cultural preservation. By building a new type of urban-rural relationship, the endogenous development capacity of villages and farmers can be enhanced, aligning rural resilience with the rural revitalization strategy and laying a solid foundation for comprehensive revitalization.

6. Conclusions

Various land use policies have been formulated in response to rapid urbanization. For example, WRH policy is designed to reconstruct the countryside. Land use policies are closely linked to rural resilience, making this an important topic of research in the field of rural development. However, research on the impact of WRH policy on rural resilience is lacking. Moreover, traditional decision-making methods do not take into account the degree of influence and causal relationships among resilience factors. To fill these gaps, the current paper sought to identify important dimensions and indicators of rural resilience under the impact of WRH policy.

Based on a review of existing literature, this paper constructed an evaluation system for rural resilience following homestead land withdrawal based on five dimensions: the economy, society, culture, the environment, and governance. We refined this system using the Delphi method,

illustrating our specific calculation methods and sources. Considering the uncertainty and fuzziness of qualitative indicators in the evaluation system, this study introduced a combination of expert questionnaire surveys and fuzzy multi-criteria decision-making methods for assessment. Because rural resilience is interdependent and mutually influential at different levels, we applied Fuzzy DEMATEL to derive INRMs to explore the relationships among the indicators. We found that the economic (D_1), social (D_2), and governance (D_5) dimensions have a higher degree of influence and are indeed causal for the environmental (D_4) and cultural (D_3) dimensions. Among them, the economic dimension (D_1) is the most critical. The results of the INRMs also show that promoting diversity in local economic development, entering collective land into the market, improving educational resources, and providing employment training opportunities for residents are key indicators because they have the greatest impact on other indicators. Therefore, when optimizing homestead land withdrawal policies, decision-makers should prioritize these indicators to promote sustainable development in rural areas.

This study can be further expanded. First, the evaluation system proposed in this study could be modified to the needs of different regions. Second, combining DEMATEL technology with different weight calculation methods could help to elucidate the importance of dimensions from multiple aspects. Finally, because homestead land withdrawal can impact rural culture, future research should consider the impact of WRH policy on the social and cultural resilience of rural areas to better our understanding of rural resilience.

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