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Research article

Bilateral matching decision-making for rural homesteads withdrawal patterns and types of peasant households' welfare needs: Evidence from China in the context of land spatial planning regulation

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ABSTRACT

In order to solve the issue of idle rural homesteads and enhance the welfare of peasant households, the Chinese government has implemented various rural homestead withdrawal patterns. In the context of land spatial planning regulation, based on the field survey data from 210 peasant households in Xuzhou City and Ganzhou City, this study constructs a bilateral matching model between rural homestead withdrawal patterns and types of welfare needs of peasant households. This study uses a Discrete Particle Swarm Optimization algorithm improved on the 0–1 knapsack strategy to solve the matching model, aiming to find the optimal homestead withdrawal patterns that match the types of peasant households. The results show that: (1) The matching of rural homestead withdrawal patterns and types of peasant households conforms to the principle of comparative advantage. (2) In the case of "one-to-one matching" between peasant households and homestead withdrawal patterns, matching the "economic-material-oriented" peasant households with the withdrawal pattern of "monetary compensation", matching the "social-service-oriented" peasant households with withdrawal pattern of "indicator replacement", and matching the "welfare-assistance-oriented" peasant households with the withdrawal pattern of "asset replacement". (3) The bilateral overall preference of the combined rural homestead withdrawal patterns is higher than that of the single rural homestead withdrawal pattern, and satisfaction has increased by at least 8 %. The authors argue that the government should design and implement diversified withdrawal patterns based on a full understanding of the welfare needs of peasant households.

1. Introduction

Since the establishment of the People's Republic of China, the rural homesteads land use system has been designed a crucial system for welfare and guarantee of land [1]. On one hand, the rural homesteads land use system provides institutional guarantees for the

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limited welfare supply of "one-household-one-residence" for farmers. On the other hand, it offers essential support to meet the production and living needs of rural residents while maintaining social stability. However, as China continues to promote regional coordinated development and rural revitalization strategies, the management of rural homesteads has been relatively delayed, resulting in increasingly prominent issues such as scattered layout, excessive land area, and extensive utilization [2]. Implementing the withdrawal of rural homesteads has become a crucial approach to alleviate the contradiction between urban and rural land supply and demand, and to expand the utilization of new industrial land within society. Promoting the implementation of China's comprehensive land spatial planning and supporting rural revitalization and urban-rural integration are also urgent requirements.

In 2015, China initiated the pilot reform of withdrawal from rural homesteads policy. Since then, various representative patterns of rural homestead withdrawal have been developed through practical implementation [3]. Theoretically, a well-designed withdrawal pattern for rural homesteads is beneficial as it enhances the asset value of homesteads and facilitates the capital accumulation of rural households. This also promotes the improvement of the welfare level of peasant households [4,5]. However, in practice, local governments often promote homogenized relocation and compensation measures guided by planning policies. On one hand, local governments tend to prioritize the acquisition and construction costs of homesteads while overlooking the multifunctional development value that the land holds after homestead withdrawal [6–8]. This approach, to some extent, compromises the future welfare of rural households. On the other hand, existing welfare allocation schemes often misalign with the actual welfare needs of households, resulting in increased government burden and low welfare benefits from the homestead withdrawal policy [9–11].

This makes it a bilateral matching decision for rural households to choose different withdrawal patterns for rural homesteads based on their welfare needs. It requires comprehensive consideration of the supply-demand relationship between the entities implementing and withdrawing from rural homesteads [12]. Differentiated withdrawal patterns for rural homesteads should be designed in accordance with farmers' welfare demands for homestead withdrawal. With the implementation of the national spatial planning strategy, rural socio-economic development is entering a new phase, and the multifunctional development attributes undertaken by homesteads in different regions have been reflected following their withdrawal [3,13,14]. In this context, influenced by policy environment and subjective cognitive differences among farmers regarding the multifunctional value of homesteads, the post-withdrawal multifunctional utilization of homesteads exhibits spatial differentiation characteristics, and different peasant households also have distinct welfare demands for homestead withdrawal. Therefore, accurately identifying the welfare demands of different peasant households for homestead withdrawal and selecting a withdrawal pattern for rural homestead that maximizes the match with peasant households' welfare demands is crucial in designing differentiated homestead withdrawal policies in practice. Three relevant questions are: (1) What are the types of peasant households' welfare demands and the types of rural homestead withdrawal patterns? (2) Under the perspective of land spatial planning regulation, what kind of rural homesteads withdrawal patterns should be matched to peasant households with different welfare demands? (3) What are the matching patterns and decision-making mechanisms? Resolving these questions is of significant theoretical and practical significance for promoting rural homestead system reform and the implementation and integration of overall land spatial planning strategies.

From existing research, scholars have extensively explored relevant issues regarding the withdrawal from rural homestead. However, due to differences in land management systems between China and Western countries, research conducted by Western scholars primarily focuses on the consolidation of rural residential land [15–18]. They have proposed a series of reform measures and implementation plans, such as granting land development rights to farmers, expanding agricultural land use rights, and establishing a system for securing land rights ([19,20]; Boue et al., 2018). These provide valuable experiences and references for studying the issue of homestead withdrawal in rural areas of China. Compared to developed Western countries, China faces a distinct and complex issue of homestead withdrawal due to its larger rural population, stronger sense of belonging, and attachment to land. Scholars have primarily focused their research on various aspects, including the reform of the rural homestead system in China, the factors influencing homestead withdrawal, the selection of withdrawal pathways, protection of rights during the withdrawal process, and farmers' intentions regarding homestead withdrawal ([21,22]; Wu et al., 2020; [7,23,24]). As research progresses, scholars have shown significant interest in studying the development of homestead withdrawal patterns in different scenarios and the corresponding changes in farmers' welfare levels following homestead withdrawal in rural China [25,26]. According to various studies, several factors have the potential to impact the welfare of farmers following their withdrawal from rural homesteads. These factors encompass household income, population size, social security, homestead area, compensation standards, and access to social public services [25,27–30]. Furthermore, although scholars have not yet systematically summarized the different patterns of homestead withdrawal, they have conducted preliminary research exploring the applicability, feasibility, risk levels, and classification methods of these various patterns ([31]; Wang and tan, 2020 [32]). While some scholars have initiated preliminary research on the relationship between homestead withdrawal patterns and peasant households' welfare demands, this research is still in the theoretical stage. It primarily focuses on analyzing the distribution of benefits, changes in welfare, and compensation in existing cases of rural homestead withdrawal.

Overall, some scholars have explored the research topic of this study. However, there is still room for further research in the following areas: (1) In the context of land spatial planning regulation policies, the existing literature lacks a systematic analysis of the types of peasant households' welfare demands and fails to effectively summarize the key patterns of homestead withdrawal in China's current policy environment. (2) There have been few scholars who have conducted systematic research on the supply-demand relationship between peasant household types and rural homestead withdrawal patterns, making it difficult to accurately identify the optimal withdrawal pattern that matches specific peasant household types. This has resulted in a lack of consistency between the withdrawal patterns and the welfare demands of peasant households. Therefore, despite the significant allocation of public resources by the government in the implementation of rural homestead withdrawal policies, the effectiveness of these policies is limited. (3) Scholars mainly utilize case study analysis to explore peasant households' preferences for rural homestead withdrawal patterns. However, this method often falls short in accurately establishing the connection between different types of peasant households'

welfare demands and rural homestead withdrawal patterns.

To sum up, this study aims to follow the logical progression of "the evolution of homestead functions - the types of welfare needs of peasant households for homestead withdrawal - the bilateral matching between peasant households' types and homestead withdrawal patterns" from the perspective of land spatial planning regulation. Firstly, this study will categorize the types of peasant households' welfare needs and types of rural homestead withdrawal patterns. Secondly, it will construct a bilateral matching model between types of peasant households and withdrawal patterns for rural homesteads. Additionally, an indicator evaluation system will be designed to assess the preferences of both parties. Lastly, using survey data from peasant households in Peixian County, Xuzhou City, Jiangsu Province, and Dayu County, Ganzhou City, Jiangxi Province, this study employs an improved particle swarm optimization algorithm with a 0–1 knapsack strategy to address the matching problem and find the optimal solution. The purpose of this study is to design a rural homestead withdrawal pattern that meets the needs of peasant households' welfare development in the context of land spatial planning regulation policies, taking into account the resource endowment and welfare needs of the implementing entities and withdrawal entities of rural homestead withdrawal.

Compared with previous studies, three main innovations make this study necessary. (1) From the perspective of land spatial planning regulation policies, this study explores the bilateral matching mechanism between the types of peasant households' welfare needs and the types of homesteads withdrawal patterns. This study expands the dimension and depth of research on the Chinese homesteads withdrawal, and compensates for the lack of consistency between the homesteads withdrawal patterns designed in existing research and the welfare needs of peasant households. It also provides reference suggestions for establishing and implementing a long-term rural homestead withdrawal mechanism that is tailored to the actual development of peasant households and regions. (2) Based on external policy planning regulation and individual internal needs, this study identified the types of peasant households' welfare needs for rural homestead withdrawal under different geographical conditions, planning policies, and multi-level welfare needs, and summarized the main homesteads withdrawal patterns in China. This study not only supplements the shortcomings of comparative research on different homesteads withdrawal patterns in typical regions, but also makes up for the shortcomings of research in understanding the welfare needs of peasant households. (3) This study uses the bilateral matching model in the field of computer science and an improved particle swarm optimization algorithm for empirical analysis, expanding the application of the bilateral matching model in the field of resources and environment. In addition, this study also improved the applicability and effectiveness of the model for the specific research object of homestead withdrawal.

The remainder of this study proceeds as follows. Section 2 constructs the theoretical framework and outlines the welfare need types of peasant households for rural homestead withdrawal and types of rural homestead withdrawal patterns. Section 3 describes the study area, indicator selection, data sources, and research methods. Section 4 presents empirical analysis and test. Sections 5 presents the discussion. Finally, Section 6 presents the conclusions and policy implications.

2. Framework design and theoretical analysis

With the progressive evolution of rural social structure and the external policy environment, the homestead, serving as a secure haven for farmers, has gradually developed a series of novel functions. These functions include economic production, social security, and emotional attachment, and more [33–35]. Especially with the implementation of China's national land spatial planning regulation strategies and the deepening of the "separation of rights" reform in relation to homesteads, the functionalities of homesteads exhibit heterogeneity in rural areas with varying locational planning conditions and levels of economic development, as well as among peasant households with different degrees of non-agricultural employment and reliance on homesteads [23,36]. This will influence peasant households' subjective perception and recognition of the functionalities and value of homesteads, further resulting in diverse and hierarchical welfare needs for withdrawal from homestead. Different preferences will exist among peasant households for various withdrawal patterns of homestead. It is evident that choosing different withdrawal patterns for different types of peasant households presents a matching challenge. Bilateral matching should therefore be conducted, considering the compatibility of characteristics between the main body of homestead withdrawal and the implementing entity. The analysis framework is shown in Fig. 1.

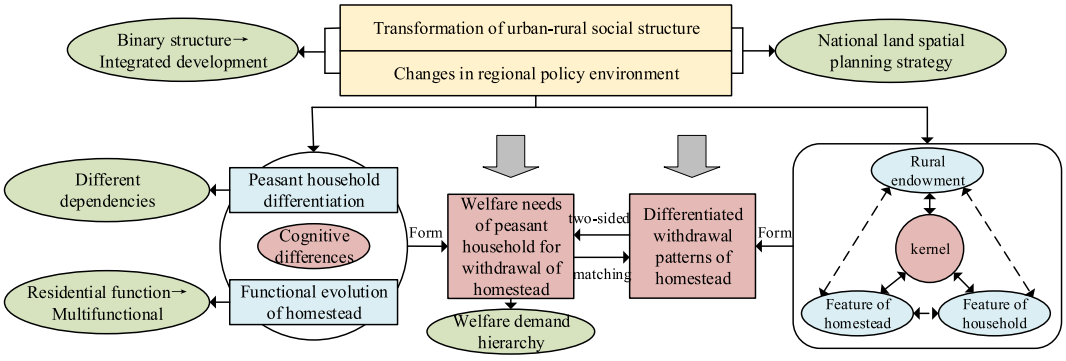

Fig. 1. Bilateral matching analysis framework.

Table 1
Classification of peasant households' welfare needs types from the perspective of land spatial planning regulationNotes: "+" represents the magnitude of the indicator value, and the same applies to the table below.

Types of peasant households' welfare needs	Housing security	Monetary compensation	Livelihood subsidies	Policy participation	Infrastructure development	Public services	Employment support	Main characteristics of villages	Regional zoning
Economic-material-oriented	+	+++	+	++++	+++	++++	+	Villages with integration of urban and rural industries	Economic development priority areas
Social-service-oriented	++	++++	+	++	++++	+++	++++	Villages with integration of agriculture, culture and tourism	Ecological resource priority areas I
Welfare-assistance-oriented	++++	+	++++	+	++	++	++	Marginal villages with limited resources	Ecological resource priority areas II

2.1. Analysis of the welfare needs of peasant households regarding withdrawal of homestead from the perspective of land spatial planning regulation

From the perspective of land spatial planning regulation, due to subjective cognitive differences regarding the diverse values of homesteads in different functional planning areas, the peasant households' welfare needs with regard to withdrawal of homestead often exhibit multilevel characteristics. Land spatial planning regulation categorizes regional space into "economic development priority areas" and "ecological resource priority areas" ([37–39]; Song et al., 2019). The "economic development priority areas" mainly include priority development areas and key development areas, and the "ecological resource priority areas" mainly include restricted development areas and prohibited development areas [40]. The village types in the economically developed areas mainly include "villages with integration of urban and rural industries". Peasant households in these villages are greatly influenced by and benefit from the urban economy's impact and spillover effects. The asset attributes of homesteads are fully manifested. Peasant households have weak demand for basic welfare such as housing. The government's living subsidies for farmers are not very strong. However, they have expectations of participating in policy decisions, having monitoring rights, and receiving certain monetary compensation. The village types in the ecological resource priority areas mainly include "villages with integration of agriculture, culture and tourism" and "marginal villages with limited resources". In the "villages with integration of agriculture, culture and tourism", homesteads primarily serve basic residential, economic and production functions, with a lower degree of asset manifestation. Therefore, the primary welfare needs for peasant households in terms of homestead withdrawal are to ensure basic residential functionality and receive reasonable economic compensation and employment support when withdrawing homesteads. In the "marginal villages with limited resources" that lack scenic beauty, industries and resources, peasant households face poorer living environments and a higher prevalence of dilapidated housing. Their primary needs for homestead withdrawal may revolve around basic residential security, road construction, access to clean water for daily living, and other infrastructure services to achieve sustainable livelihoods. Based on this, this study divides the peasant households into three types: economic-material-oriented, social--service-oriented, and welfare-assistance-oriented, as shown in Table 1.

2.2. Analysis of homestead withdrawal patterns from the perspective of land spatial planning regulation

From the perspective of land spatial planning regulation, villages located in different planning areas have gradually developed three main patterns of withdrawal from homestead (see Table 2). These patterns, namely "asset replacement", "indicator replacement", and "monetary compensation", have emerged under the guidance of established institutional environments and varying village resource endowment conditions. (1) The "asset replacement" pattern refers to the exchange of rural homestead with high-rise properties within urban planning areas. This replacement pattern is based on an equal area replacement according to the building area of the houses. Peasant households ' identity changes from rural household registration to urban household registration, and those who are resettled in centralized locations are entitled to the same social public services such as education and healthcare as local urban residents. (2) The "indicator replacement" pattern refers to the village collective adopting the method of rearranging the homestead for building houses according to the unified planning of the homestead. It encourages villagers to voluntarily withdraw from their old homestead land. In this pattern, land indicators are reallocated based on village planning and statutory area standards. It mainly involves the rearrangement of land within the village and the redevelopment of old villages. This pattern promotes comprehensive land consolidation and improves the efficiency of land utilization by revitalizing the resources of homestead land within the village. (3) The "monetary compensation" pattern is a method of providing reasonable monetary compensation to villagers who voluntarily withdraw from homestead. This pattern is combined with rural land consolidation projects and provides compensation in the form of currency. The scope of monetary compensation includes land, buildings, and structures. It primarily targets households with multiple homesteads, households relocating to urban areas, and overseas Chinese communities to encourage the withdrawal of idle homestead land.

3. Research design

3.1. Problem analysis and research approach

Gale and Shapley proposed the theory of bilateral matching in 1962 [41]. The bilateral matching model, constructed based on this theory, aims to obtain an optimally stable match between two parties by considering the preference information of both sides towards the matching objects [42,43]. Today, the bilateral matching model has been widely applied in various research fields, such as education, psychology, and finance. It can generally be classified into three types: one-to-one bilateral matching, such as job matching and

Table 2
Classification of homestead withdrawal patterns from the perspective of land spatial planning regulation.

Withdrawal patterns of homestead	Withdrawal efficiency	Supportability	Difficulty	Complexity	Completion time	Main characteristics of homestead
Asset replacement	+++	++++	++	++	+++	Close to the urban
Indicator replacement	+++	+++	+++	+++	++	Close to the rural
Monetary compensation	+++	++	++	++	++++	Whole

marriage matching; one-to-many bilateral matching, such as teacher-student matching; and many-to-many bilateral matching, such as complex task and service matching. The scenario studied in this study, which involves matching the types of peasant households based on their welfare demands for homestead withdrawal with withdrawal patterns of homestead, is a one-to-one bipartite matching problem. However, due to the difference in the number of bilateral entities, each peasant household can select at most one withdrawal pattern of homestead for matching, while a withdrawal pattern of homestead can be matched with multiple peasant households. To optimize this model, the 0–1 knapsack strategy is employed, considering farmers as knapsacks and the withdrawal patterns of homestead as items to be placed in the knapsack. A multi-objective optimization model is established to maximize the preference of bilateral entities. Particle swarm optimization algorithm is used to solve the model, aiming to find the most optimal and stable match that satisfies the peasant households' needs for homestead withdrawal.

As shown in Fig. 2, each line connecting a peasant household to a withdrawal pattern of homestead represents a value, indicating the bilateral preference between them. The solid line represents the optimal matching path between the peasant households and the homestead withdrawal patterns. Peasant households calculate their preferences for withdrawal patterns of homestead based on the corresponding indicator set C_c, while withdrawal patterns of homestead calculate their preferences for peasant households based on the corresponding indicator set E_e. The matching between the two entities is performed based on these preference values, resulting in the optimal and stable matching set.

3.2. Research methods

3.2.1. Determination of indicator weights and preference calculation

(1) Combination weighting method

By constructing judgment matrices and conducting consistency tests, this study first utilizes the Analytic Hierarchy Process (AHP) to determine the subjective weights w_{ai} and w'_{ai} for indicator sets C_c and E_e, respectively. Then, the Maximum Entropy Principle is used to calculate the objective weights w_{ci} and w_{ei} for indicator sets C_c and E_e. Finally, the Combination weighting method is employed to calculate the final weights w_{zi} and w'_{zi}. The formula for the combination weighting calculation is as follows:

$$w_{zi} = \frac{w_{ai} w_{ci}}{\sum_{i=1}^{n} w_{ai} w_{ci}} \tag{1}$$

$$w'_{zi} = \frac{w'_{ai} w_{ei}}{\sum_{i=1}^{n} w'_{ai} w_{ei}} \tag{2}$$

In the above equations (1) and (2), w_{zi} is the weight of indicator set C_c, and w'_{zi} is the weight of indicator set E_e.

(2) Calculation of Bilateral Preference

Using the combination weights, calculate the preference of bilateral entities using the following equation:

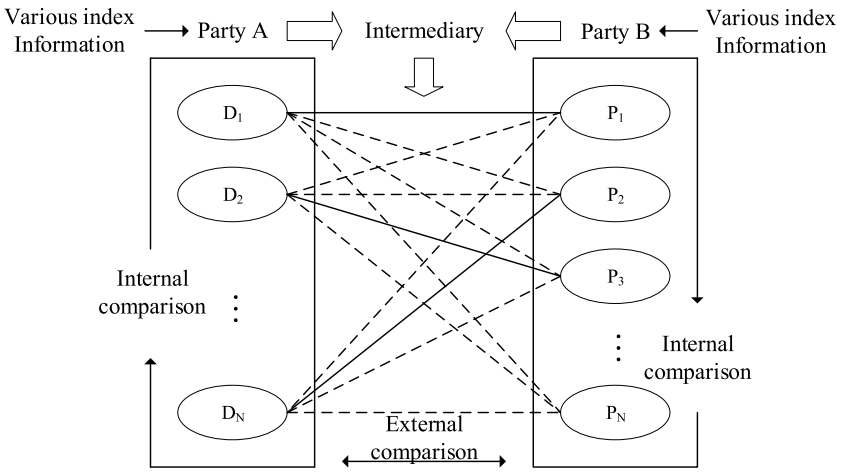

Fig. 2. One-to-One bilateral matching between peasant household types and withdrawal patterns of homestead.

$$R_{ij}^{'} = \sum_{c=1}^{C} R_{ij} w_{zi} \tag{3}$$

$$L_{ij}^{'} = \sum_{e=1}^{E} L_{ij} w_{zi}^{'} \tag{4}$$

In the above equations (3) and (4), $R_{ij}^{'}$ represents the preference of withdrawal patterns of homestead P_i given by peasant household type D_i in its characteristic indicator set C_c; $L_{ij}^{'}$ represents the preference degree of peasant household type D_i given by the withdrawal patterns of homestead P_i in its welfare demand indicator set E_e.

3.2.2. Bilateral matching model

Using combination weights and the preference of bilateral entities, a multi-objective matching model is constructed to maximize the preference of both parties. The calculation equation is as follows:

$$F = (Z_1, Z_2) \tag{5}$$

$$\max Z_1 = \sum_{i=1}^{m} \sum_{j=1}^{n} \alpha_{ij} x_{ij}, \max Z_2 = \sum_{i=1}^{m} \sum_{j=1}^{n} \beta_{ij} x_{ij} \tag{6}$$

$$\min |Z_1 - Z_2| = |\alpha_{ij} - \beta_{ij}| x_{ij} \tag{7}$$

In the above equations (5) and (6), Z_1 and Z_2 are the preferences of both parties, and x_{ij} is the decision variable. If the j-th type of withdrawal patterns matches the i-th type of peasant household, the value is 1. If the j-th type of withdrawal patterns does not match the i-th type of peasant household, the value is 0.

3.2.3. Improved discrete particle swarm optimization based on 0–1 knapsack strategy

(1) Strategy for the 0–1 knapsack problem

The 0–1 knapsack strategy is a policy formulated for a scenario where there is a knapsack with a capacity of V. There are n items with different values c and volumes w. The objective is to select the appropriate items to maximize the total value while ensuring that the total volume of the selected items does not exceed the capacity of the knapsack. In the strategy, each item has two states, namely whether it is placed in the backpack or not, so the variable x_i is introduced. When the i-th item is placed in the backpack, $x_i = 1$; When the i-th item is not placed in the backpack, $x_i = 0$. The basic assumptions are as follows:

$$x_i = \begin{cases} 1 & \text{the i} - \text{th item is placed in the backpack} \\ 0 & \text{the i} - \text{th item is not placed in the backpack} \end{cases} \tag{8}$$

Therefore, the objective function and constraint conditions of this strategy are as follows:

$$\begin{aligned} & \max W = \sum_{i=1}^{n} c_i x_i \\ s.t. \quad & \sum_{i=1}^{n} w_i x_i \le V \\ & x_i \in [0,1], i = 1, 2, ..., n \end{aligned} \tag{9}$$

Among them, W is the total value of the items placed in the backpack, c_i is the value of each item, and w_i is the volume of each item.

(2) Improved discrete Particle Swarm Optimization

The discrete Particle Swarm Optimization is an intelligent optimization algorithm that simulates the foraging behavior of birds (Venter and J, 2003 [44]). In this study, each peasant household to be matched is considered as a particle in a D dimensional search space. The objective function corresponds to the fitness value of each particle with its position and velocity. Each particle iteratively explores the search space at a certain rate, aiming to achieve the best matching solution. Assuming a D dimensional search space, we have a set of N peasant households, where the position of the i th particle is represented by $X_i = (x_{i1}, x_{i2}, ..., x_{iD})$, $i = 1, 2, \ldots, N$ which is a D dimensional vector, and the flight velocity of the i th particle is represented by $V_i = (v_{i1}, v_{i2}, ..., v_{iD})$, $i = 1, 2, \ldots, N$ which is also a D dimensional vector. The best position found so far by the i th particle is denoted as the individual best value $P_{best} = (p_{i1}, p_{i2}, ..., p_{iD})$, $i = 1, 2, \ldots, N$, while the best position found so far by the entire set is denoted as the global best value $G_{best} = (g_1, g_2, ..., g_D)$. When updating the individual and global best values, the particles update their position and velocity values. The calculation equation is as follows:

$$x_{it}(t+1) = w \times x_{ij}(t) + v_{ij}(t+1) \tag{10}$$

$$v_{it}(t+1) = w \times v_{ij}(t) + c_1 \times r_1(t) \times \left[p_{ij}(t) - x_{ij}(t)\right] + c_2 \times r_2(t) \times \left[p_{gi}(t) - x_{ij}(t)\right] \tag{11}$$

$$w = w_{\max} + (w_{\max} - w_{\min}) \times \left(2t \Big/ T_{\max} - (t/T_{\max})^2\right) \tag{12}$$

In the above equation 10–12, t is the number of iterations, c_1 and c_2 are the learning factors, also known as acceleration constants, w is the inertia weight, where $w_{\max}$ and $w_{\min}$ are the maximum and minimum inertia weights, $T_{\max}$ represents the maximum number of iterations, r_1 and r_2 are uniform random numbers within the range of [0, 1], v_{ij} is the velocity of the particle, and x_{ij} is the position of the particle. $i = 1, 2, \ldots, N$, $j = 1, 2, \ldots, D$. When the particle continuously updates its speed and position through the above two equations, finds a sufficiently good optimal matching solution or reaches the maximum number of iterations, and outputs the global optimal matching solution, the algorithm ends.

During the matching process between peasant households and withdrawal patterns of homestead, the values and changes of particles in the search space are limited to 0 and 1. In this context, 1 represents selecting the withdrawal pattern of homestead, while 0 represents not selecting the withdrawal pattern of homestead. The velocity v_{ij} of each dimension represents the possibility of each position x_{ij} taking a value of 1. Therefore, in the discrete particle swarm, the velocity v_{ij} update method for each particle still adopts the formula in the continuous particle swarm. However, the range of individual optimal value P_{best} and global optimal value G_{best} is [0, 1], and the position x_{ij} of each particle is updated as follows:

$$x_{ij} = \begin{cases} 1 & r < s(v_{ij}) \\ 0 & others \end{cases} \tag{13}$$

In the above equation (13), r is a random number generated from the $U(0,1)$ distribution, $s(v_{ij})$ is the probability of each particle velocity v_{ij} taking a value of 1, and the probability of each particle velocity v_{ij} taking a value of 0 is $1 - s(v_{ij})$, $s(v_{ij}) = 1/e^{(-v_{ij})}$.

3.3. Study area

Ganzhou is an important central city in underdeveloped areas of western China and a significant node city of China's Belt and Road initiative. It is located in the southern part of Jiangxi Province. In 2022, Ganzhou City had a GDP of 452.36 billion yuan. Xuzhou is the central city of the Huaihai Economic Zone in eastern China and also a crucial node city of China's Belt and Road initiative. It is situated in the northern part of Jiangsu Province. In 2022, Xuzhou City's GDP reached 845.78 billion yuan. As pilot areas for urban-rural integration in China, Dayu County in Ganzhou City and Peixian County in Xuzhou City were both listed as new pilot counties (cities, districts) for the reform of the national homestead system in 2020. Therefore, selecting these two areas for research has a certain level of representativeness (see Fig. 3).

3.4. Data

This study's research data mainly come from a rural survey conducted by our research group in Xuzhou City, Jiangsu Province, and Ganzhou City, Jiangxi Province from June to August 2023. The research group used random sampling to select the interviewed farmers

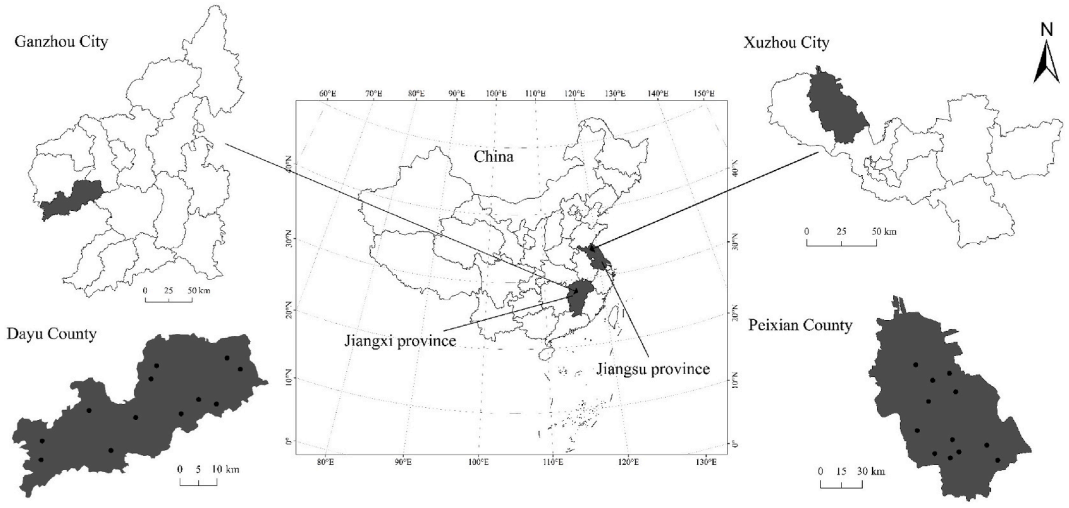

Fig. 3. Location of the case study area.

and applied Participatory Rural Appraisal (PRA) techniques. Based on designed questionnaires, interview coding, and guidelines, face-to-face semi-structured interviews were conducted with local farmers. The survey was conducted at the household level, with a total of 300 households interviewed. 289 questionnaires were collected, and after rigorous data cleaning to remove invalid questionnaires with inconsistencies or missing significant information, 210 valid questionnaires were obtained, resulting in a response rate of 70 %. For analysis purposes, the data from the 210 questionnaires underwent preliminary processing. Based on the content of farmers' welfare needs regarding rural homestead land withdrawal, the 210 households were classified into different types. Among them, 73 households were classified as having economic material needs, 70 households as having social service needs, and 67 households as having welfare assistance needs. Each type of household accounts for approximately one-third of the total population.

3.5. Variables

Preference degree is an important indicator of the bilateral matching process and serves as a reference for formulating the withdrawal patterns of homestead for peasant households. The rural homestead withdrawal pattern is designed by the implementing body based on the welfare needs of peasant households. Considering the heterogeneity of welfare needs among different types of peasant households and the characteristics of implemented withdrawal patterns of homestead, there are diverse factors that influence peasant households' preferences for different withdrawal patterns of homestead. This study constructs a preference degree evaluation index for peasant households' preferences for withdrawal patterns of homestead based on three dimensions: compensation system, compensation procedure, and compensation safeguards [3,24]. Six indicators, including openness, fairness, complexity, completion time, welfare benefit, and guarantee level, are used to assess farmers' preferences for homestead land withdrawal models. Based on the comprehensive reflection of peasant households' endowments, development positioning, and composition structure, the types of peasant households' welfare needs for homestead withdrawal are manifested in their resources and capabilities. The study constructs a preference degree evaluation index for the homestead withdrawal patterns (implementing body) based on three dimensions: economic condition, labor intensity, and social factors [7,45]. Six indicators, including economic status, farming level, dependency ratio, family structure, policy participation, and social interaction frequency, are used to evaluate the preference degree of peasant households for the homestead withdrawal patterns. In conclusion, this study establishes a bilateral preference degree evaluation index system (Tables 3 and 4) for peasant households and homestead withdrawal patterns.

4. Results

To better understand the preferences between different types of peasant households and withdrawal patterns of homestead based on welfare needs, the author conducted field visits to 12 villages in Peixian County and Dayu County. A total of 20 experts from universities, enterprises, and government departments were organized to evaluate the types of peasant households and withdrawal patterns of homestead. Based on the data obtained from 210 questionnaire surveys, the preference order information of the bilateral subjects was obtained. This study uses the combination weight method to calculate the weights of each indicator. By combining the indicator weights with the simulated preference order information, the preference degree of the matching bilateral subjects is calculated. The improved discrete particle swarm optimization algorithm based on the 0–1 knapsack strategy is then applied to solve the matching problem. Finally, this study proposes the optimal withdrawal patterns of homestead for different types of peasant households based on their welfare needs.

4.1. Calculation of preference degree for bilateral entities

Firstly, the combination weights for evaluating the indicators of peasant households and withdrawal patterns of homestead are calculated using a combination weighting method based on subjective and objective criteria. The weights of the indicators are shown in Table 5. Based on the evaluation values of peasant households for the indicators of withdrawal patterns and their corresponding weights, the preference degrees of peasant households for the withdrawal patterns are calculated using Equation (3), as shown in Table 6. Similarly, based on Equation (4) and the evaluation values of withdrawal patterns for peasant households and their corresponding weights, the preference degrees of withdrawal patterns for peasant households can be calculated, as shown in Table 7.

Table 3
Indicators evaluation system of peasant households for homestead withdrawal patterns.

Evaluation dimension	Indicator	Meaning of indicator	Indicator Description
Compensation system	Openness	Whether the compensation system open	1 "very weak"
	Fairness	Whether the compensation system fair	2"weak"
Compensation procedure	Complexity	Number of departments handling the procedures for withdrawing homestead	3"neutral"
	Completion time	The completion time of the homestead withdrawal program	4 "strong"
Compensation safeguards	Welfare benefit	Whether the expected welfare benefits have increased	5 "very strong".
	Guarantee level	Whether the guarantee conditions have been improved	

Table 4
Indicators evaluation system of homestead withdrawal patterns (implementing body) for peasant households.

Evaluation dimension	Indicator	Meaning of indicator	Indicator Description
Economy	Economic status	Average disposable income of peasant households	1 “very weak”
	Farming level	The ratio of average annual agricultural income to total annual income of peasant households	2“weak”
			3“neutral”
Society	Social frequency	Social frequency with relatives, friends, and neighbors	4 “strong”
	Policy participation	Willingness to actively participate in the policy of withdrawing homestead	5 “very strong”.
Labor	Dependency ratio	The ratio of non-working population to total population in peasant households	
	Family structure	Average education years of farmers	

4.2. Bilateral matching model results and analysis

In order to maximize the preference degree of bilateral subjects, a bilateral matching model is established based on the previous analysis. Three withdrawal patterns of households are matched with three types of peasant households, totaling 210 peasant households. Due to the differences in the number of bilateral subjects, each type of peasant households selects at most one withdrawal patterns of households for matching, while a withdrawal pattern of households can be matched with multiple peasant households. The model is optimized using the 0–1 knapsack strategy and implemented using the MATLAB 2020 software by programming the improved discrete particle swarm optimization algorithm. The results are shown in Table 8 below.

From Tables 8 and it can be observed that: (1) Among economic-material oriented peasant households, 41 households are matched with the “monetary compensation” withdrawal pattern, resulting in an overall satisfaction score of 203.55 for both parties. 18 households are matched with the “indicator replacement” withdrawal pattern, resulting in an overall satisfaction score of 76.53.11 households are matched with the “asset replacement” withdrawal pattern, resulting in an overall satisfaction score of 41.26. (2) Among social-service oriented peasant households, 27 households are matched with the “monetary compensation” withdrawal pattern, resulting in an overall satisfaction score of 131.85.42 households are matched with the “indicator replacement” withdrawal pattern, resulting in an overall satisfaction score of 201.92. Only 7 households are matched with the “asset replacement” withdrawal pattern, resulting in a significantly lower overall satisfaction score of 22.49. (3) Among welfare-assistance oriented peasant households, 12 households are matched with the “monetary compensation” withdrawal pattern, resulting in an overall satisfaction score of 62.28.16 households are matched with the “indicator replacement” withdrawal pattern, resulting in an overall satisfaction score of 80.48.39 households are matched with the “asset replacement” withdrawal pattern, resulting in an overall satisfaction score of 141.79. It can be observed that among households with economic material needs, the “monetary compensation” withdrawal pattern has the highest number of matches and the highest overall satisfaction score for both parties. Among households with social service needs, the “indicator replacement” withdrawal pattern has the highest number of matches and the highest overall satisfaction score. For households with welfare assistance needs, the “asset replacement” withdrawal pattern has the highest number of matches and the highest overall satisfaction score. Based on this research sample, it is found that the “monetary compensation” and “indicator replacement” withdrawal patterns have higher overall satisfaction scores, while the “asset replacement” withdrawal pattern has a lower overall satisfaction score.

Based on the optimal satisfaction results obtained from one-to-one bilateral matching, adopting the “monetary compensation” withdrawal pattern for all households in the sample with economic material needs yields an overall satisfaction score of 295.56. However, if a combination of the three models is used, the overall satisfaction score increases to 321.34. Similarly, for all households in the sample with social service needs, adopting the “indicator replacement” withdrawal pattern results in an overall satisfaction score of 321.59. When the three models are combined, the overall satisfaction score further improves to 356.26. This relationship also holds for households with welfare assistance needs. The overall satisfaction score for a single match with the “asset replacement” withdrawal pattern is 249.58, whereas the overall satisfaction score increases to 284.55 when the three models are combined. This indicates that, for this sample, a combination of diverse withdrawal models can further enhance the overall satisfaction. However, in practice, if the conditions do not allow for a diversified combination of withdrawal models, the recommended one-to-one matching is as follows:

Table 5
Indicator weight.

Indicator type	Indicator	Indicator weight	Indicator type	Indicator	Indicator weight
Peasant households for homestead withdrawal patterns	Economic status	0.15	Homestead withdrawal patterns (implementing body) for peasant households	Economic status	0.21
	Farming level	0.16		Farming level	0.15
	Social frequency	0.24		Social frequency	0.17
	Policy participation	0.18		Policy participation	0.12
	Dependency ratio	0.12		Dependency ratio	0.19
	Family structure	0.15		Family structure	0.16

Table 6
Preference degree of peasant households for withdrawal patterns.

Withdrawal patterns	Economic-material oriented peasant households									
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
P_1	7.87	6.12	5.47	7.54	4.87	5.98	2.85	8.79	4.95	5.67
P_2	5.48	5.39	5.12	3.66	4.26	4.32	5.98	5.21	3.26	1.26
P_3	6.12	2.18	3.25	4.58	2.58	3.98	4.32	2.14	1.59	3.25
Withdrawal patterns	Social-service oriented peasant households									
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
P_1	4.25	5.35	1.89	4.98	5.47	2.17	4.12	6.16	5.21	4.83
P_2	5.86	7.58	5.69	6.74	4.98	5.12	5.89	6.29	7.14	6.51
P_3	2.86	4.23	2.14	3.98	5.11	4.39	2.52	5.24	2.24	3.42
Withdrawal patterns	Welfare-assistance oriented peasant households									
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}
P_1	2.58	2.98	4.96	5.33	3.25	6.02	4.98	6.47	5.09	5.03
P_2	4.23	5.11	4.87	4.12	6.19	3.87	4.66	5.34	4.12	2.36
P_3	6.25	7.21	5.24	6.58	5.45	7.48	6.81	7.12	6.49	4.29

Notes: P1, P2, and P3 represent three types of homestead land withdrawal models: “monetary compensation”, “indicator replacement,” and “asset replacement”, respectively. Due to limited space, 10 households from each type were selected and listed in the table below.

Table 7
Preference degree of withdrawal patterns for peasant households.

Economic-material oriented peasant households	Withdrawal patterns of households			Social-service oriented peasant households	Withdrawal patterns of households			Welfare-assistance oriented peasant households	Withdrawal patterns of households		
	P_1	P_2	P_3		P_1	P_2	P_3		P_1	P_2	P_3
D_1	7.12	4.23	2.36	D_1	5.24	6.32	4.96	D_1	4.21	4.26	5.77
D_2	6.18	4.25	4.95	D_2	3.56	4.95	2.84	D_2	3.98	3.45	4.78
D_3	4.85	5.53	5.21	D_3	6.23	5.98	4.23	D_3	4.21	4.93	5.67
D_4	5.84	3.23	3.14	D_4	3.21	6.78	5.01	D_4	4.39	5.21	7.01
D_5	6.14	4.85	3.28	D_5	2.86	5.74	3.54	D_5	5.01	4.54	5.25
D_6	6.08	5.21	5.01	D_6	3.54	7.82	4.23	D_6	4.23	5.21	4.89
D_7	5.49	4.78	4.32	D_7	4.12	5.41	3.68	D_7	3.19	4.21	5.96
D_8	3.58	4.12	5.25	D_8	3.87	5.47	4.19	D_8	3.52	4.11	5.10
D_9	4.59	2.89	3.61	D_9	2.95	4.78	2.32	D_9	5.21	6.98	7.23
D_{10}	5.24	4.23	2.86	D_{10}	3.54	5.28	3.18	D_{10}	3.62	4.99	5.36

Table 8
Bilateral matching results.

Withdrawal patterns of households	Economic-material oriented peasant households	Social-service oriented peasant households	Welfare-assistance oriented peasant households	Preference
Monetary compensation	41 households (203.55)	27 households (131.85)	12 households (62.28)	397.68
Indicator replacement	18 households (76.53)	42 households (201.92)	16 households (80.48)	358.93
Asset replacement	11 households (41.26)	7 households (22.49)	39 households (141.79)	205.54
Preference	321.34	356.26	284.55	962.15

Notes: The preference values are in parentheses.

matching “monetary compensation” withdrawal pattern with economic-material oriented peasant households, matching “indicator replacement” withdrawal pattern with social-service-oriented peasant households, and matching “asset replacement” withdrawal pattern with welfare-assistance-oriented peasant households.

This study further analyzes the reasons for the matching between the types of peasant households and the corresponding withdrawal patterns of rural homesteads. First, matching the economic-material-oriented peasant households with “monetary compensation” withdrawal pattern. This may be because monetary subsidies are mainly targeted at groups with multiple households, those who have moved into urban areas, and overseas Chinese. This pattern is relatively fast, has less controversy, and can be resolved immediately without any follow-up issues. If sufficient monetary compensation can be obtained, the relocated households can choose to purchase houses that meet their requirements for location, orientation, area, and other requirements without any restrictions. In addition, capable relocated individuals can also use this money for entrepreneurship, investment, and other purposes to revalue their currency. Second, matching the social-service-oriented peasant households with “indicator replacement” homesteads. This may be because the asset replacement pattern promotes the integrated development of cities and villages through the radiation effect of

urbanization. This pattern takes into account the practical needs of regional economic structure adjustment and industrial transformation and upgrading, and optimizes the spatial pattern of regional ecology, life, and production. After the withdrawal of homesteads, local governments can coordinate employment arrangements, social security, public support, and other work to promote the urbanization of farmers. Third, matching "asset replacement" withdrawal pattern with welfare-assistance-oriented peasant households. This may be because welfare-assistance-oriented peasant households are typically older couples living alone in rural areas, with their children living in cities or working in other places. Therefore, the "indicator replacement" homestead withdrawal pattern is more in line with the needs of welfare assistance oriented families. Because this pattern can achieve unified planning and construction of villages, as well as centralized resettlement and relocation of farmers. This approach not only ensures the well-being of peasant households in terms of production and daily life, but also helps to achieve the government's goal of improving the living environment in rural areas.

5. Discussion

From the perspective of land spatial planning regulation, based on field survey data from 210 peasant households in Xuzhou, a developed region, and Ganzhou, an underdeveloped region in China, this study summarizes the different types of welfare needs of peasant households and the basic patterns of China's homestead withdrawal. The study has found the optimal matching method between the above two, which to some extent compensates for the shortcomings of previous research.

First, this study explores the relationship and rational matching between different withdrawal patterns of homestead and the welfare needs of peasant households under the context of land spatial planning regulation policy. In fact, the heterogeneity of peasant households' endowments and external policy conditions has been confirmed in previous studies to result in different preferences for homestead withdrawal compensation and policies [3,30,46]. However, there has been a lack of systematic research on the supply-demand matching relationship between peasant households' needs and homestead withdrawal patterns, leading to limited implementation performance despite the significant allocation of public resources to homestead withdrawal measures. Although there have been studies that examine the homestead withdrawal mechanism from aspects such as peasant households' endowments and happiness, analyzing solely from one aspect may lead to certain biases [10,26,47]. This study categorizes peasant households based on their welfare needs and summarizes the main homesteads withdrawal patterns at present. The study suggests that for economic-material oriented peasant households, the "monetary compensation" withdrawal pattern is appropriate. For social-service oriented peasant households, the "indicator replacement" withdrawal pattern is recommended. Lastly, for welfare-assistance oriented peasant households, the "asset replacement" withdrawal pattern is advisable. This result also provides effective support for the research conducted by Hong et al. (2017) and Xie et al. [48], emphasizing the need to design differentiated homestead withdrawal policies for different types of farming households. In addition, during the research process, we discovered that there is a certain number of farming households expressed dissatisfaction with the homestead withdrawal patterns formulated by the local government. According to observations, during the process of homestead withdrawal, the simplified homestead withdrawal pattern formulated by the local government cannot meet the all peasant households' welfare needs. This also confirms the analysis results of this study: combining multiple homesteads withdrawal patterns can further improve the overall satisfaction of both parties.

Second, this study was conducted in the context of China's land spatial planning regulation policies, and classified different types of peasant households based on their welfare needs for homestead withdrawal. The types of peasant households are identified as economic-material oriented, social-service oriented, and welfare-assistance oriented. This research result can effectively compensate for the lack of consistency between the homesteads withdrawal optimization strategy designed in existing research and the peasant households' welfare needs. Furthermore, existing research indicates the correlation between homestead withdrawal patterns and regional socioeconomic development, government financial capacity, and farmers' preferences [49,50]. However, there hasn't been a comprehensive summary of commonly used homestead withdrawal patterns in China. This study provides an overview of the main withdrawal patterns in rural China and divides them into three categories: "monetary compensation", "asset replacement", and "indicator replacement". These findings can offer theoretical support and practical references for the reform of homestead withdrawal mechanisms in China as well as for rural land use transformation in other countries.

Third, existing studies have shown that most bilateral matching problems are in complex social contexts, requiring consideration of various types of evaluation information and attention to the perceived value of the matching subject [51,52]. The bilateral model constructed in this article first utilizes a subjective and objective weighting method, utilizing multiple evaluation indicators to help bilateral matching entities more accurately and scientifically reflect preference needs. Secondly, considering the non-uniformity of dimensions between the supply and demand sides, the particle swarm optimization algorithm improved by the 0–1 knapsack strategy is used to solve the traditional bilateral matching model. On the basis of traditional particle swarm optimization algorithms, this method simplifies the iterative calculation of particle swarm velocity and displacement updates, making the particle swarm move faster towards the optimal solution during the update process, achieving good convergence results, and thus obtaining the optimal stable matching formula. Compared to traditional methods [53], this method improves the operational accuracy and local optimization ability to a certain extent, avoiding the defects of premature convergence and slow convergence speed. This method can be applied to multi category composite resource matching problems, such as matching housing supply with buyer demand, matching population with economic resources, etc., which helps enterprises, organizations, and individuals make judgments and decisions in actual bilateral matching.

However, this study still has some limitations. Firstly, due to the implementation of China's rural revitalization policy, there is diversity and uncertainty in rural development, leading to differences in both peasant households' demands and withdrawal patterns of homestead across different regions. This study only analyzes Ganzhou City in the western region and Xuzhou City in the eastern

region, identifying three primary types of peasant households' demands and three feasible withdrawal patterns of homestead. However, it did not completely control for the aforementioned factors of variation. Therefore, there is further room for improving the applicability of the research conclusions, and this study only provides a perspective and empirical support for the study of homestead withdrawal applicability. Secondly, in the bilateral matching model constructed in this study, we only identified a single homestead withdrawal pattern that best suits each type of peasant households. Although it was observed that a combination of diversified withdrawal patterns can further enhance overall satisfaction, the current limitations of regional resource endowments and land use planning restrict the implementation of diversified withdrawal pattern combinations. In future research, we can consider how to combine withdrawal patterns of homesteads. However, our research findings provide decision-making materials for the reform and practice of homestead withdrawal in China, promoting voluntary and orderly withdrawal of homesteads by peasant households.

6. Conclusions and policy implications

In China, providing different withdrawal patterns for rural homestead withdrawal based on peasant households' diverse welfare needs may be a key factor in determining whether peasant households voluntarily choose to withdraw from their homesteads. Due to the ongoing exploration stage of homestead withdrawal reform in China and the incomplete nature of the homestead withdrawal mechanism, there is limited available data, resulting in few previous studies examining the match between different types of peasant households and withdrawal patterns of rural homestead. From the perspective of land spatial planning regulation, based on field survey data from 210 peasant households in Xuzhou and Ganzhou, this study summarizes the types of welfare needs of farmers for rural homestead withdrawal and the main models of homestead withdrawal. Then, this study constructs a bilateral matching model between withdrawal patterns for rural homesteads and peasant households, and uses a discrete particle swarm optimization algorithm improved on the 0–1 knapsack strategy to solve the matching model, aiming to find the optimal homestead withdrawal patterns that match the types of peasant households. Empirical research shows that:

(1) According to the welfare needs of peasant households in different planning areas for the withdrawal of homesteads, the types of peasant households can be divided into three categories: economic-material-oriented, social-service-oriented, and welfare-assistance-oriented. Under the guidance of established institutional environment and varying resource endowments in different villages, the rural homestead withdrawal patterns mainly consist of three types: "asset replacement", "indicator replacement", and "monetary compensation". The matching of withdrawal patterns for rural homesteads and types of peasant households conforms to the principle of comparative advantage.
(2) Matching the "economic-material-oriented" peasant households with the withdrawal pattern of "monetary compensation", matching the "social-service-oriented" peasant households with withdrawal pattern of "indicator replacement", and matching the "welfare-assistance-oriented" peasant households with the withdrawal pattern of "asset replacement".
(3) The bilateral overall preference of the combined withdrawal pattern for rural homesteads is higher than that of the single withdrawal pattern for rural homesteads.

We can draw a few policy implications from our empirical results: When withdrawing homesteads from villages, the government's designed homestead withdrawal patterns should consider the value perception and actual needs of most collective members of peasant households to improve the accuracy of supply and demand matching. On the one hand, reasonable material compensation should be given to farmers based on property losses to avoid a significant decline in their quality of life due to institutional changes; On the other hand, understanding the service and assistance welfare needs of peasant households, optimizing their development space and power protection, and improving the welfare benefits of homestead withdrawal to enhance performance. To avoid the blindness of individual choices, local governments should combine the subjective needs of farmers and objective location conditions, and formulate exit models for homesteads according to local conditions. In addition, the government can further meet the welfare needs of peasant households by combining different homestead withdrawal patterns in the process of promoting the withdrawal of homesteads.

CRediT authorship contribution statement

Di Zhu: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Yinghong Wang:** Writing – review & editing, Funding acquisition, Conceptualization. **Qian Niu:** Methodology, Investigation. **Zebin Wu:** Investigation. **Lijun Wu:** Software, Resources.

Declaration of competing interest

All authors disclosed no relevant relationships.

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Appendix A. Supplementary data

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