



Withdrawal and Transformation of Rural Homesteads in Traditional Agricultural Areas of China Based on Supply-Demand Balance Analysis

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Idle and abandoned rural homesteads not only waste land resources, they also affect the quality of life of farmers and occupy land that could be used for agricultural production and ecological space. Analysis of the supply–demand relationship of rural homesteads is an important prerequisite for the implementation of rural homestead withdrawal and transformation, which is important for improving rural residential quality and land-use efficiency, promoting sustainable development and the classified revitalization of rural areas. Based on high-resolution remote sensing images of typical villages in traditional agricultural areas, a participatory evaluation method was used to analyze the supply–demand balance of rural homesteads and to propose countermeasures for their withdrawal and transformation. The results showed that: 1) rural homesteads have gradually realized the separation of living space and production space, the living function has gradually been enhanced, the production function has gradually weakened, and the ecological aesthetic function has emerged. 2) Farmers' demand for rural homesteads is driven by various factors, including social and economic development level, lifestyle and livelihood. 3) There are a large number of idle or abandoned rural homesteads in traditional agricultural areas, with great withdrawal potential. The difference between the supply and demand of rural homesteads in use is obvious. The supply of living space of adobe house and mud-brick houses is less than the demand for them, and there is mixed use of space. The supply of production space for brick houses is less than the demand; in general, the supply of buildings is greater than the demand. 4) For rural homesteads still in use, exit and transformation strategies should be formulated according to the relationship between supply and demand, construction quality, spatial independence, and the wishes of farmers. The withdrawal and transformation of rural homesteads based on the balance between supply and demand is in line with the reality of rural development and the Chinese government's strategy of national rural revitalization.

Keywords: rural homesteads, supply and demand balance, withdrawal of rural homesteads, structural and functional evolution, transformation

1 INTRODUCTION

Human society has entered the urban age, with more than half of the global population living in urban areas, and this proportion is expected to reach two-thirds by 2050 (Malakoff et al., 2016; Lemoine -Rodriguez et al., 2020). In recent decades, rural decline has become an indisputable fact and a global problem (Dahms, 1995; Muilu and Rusanen, 2003; Markey et al., 2008; Hedlund and Lundholm, 2015; Li et al., 2019). As a developing country, China has experienced unprecedented rapid urbanization and industrialization since the start of reform and opening up in 1978, with the urbanization level rising from 17.92% in 1978 to 60.60% in 2019 (Bai et al., 2014; Dong et al., 2021). However, the countryside has long been exploited due to urban biased development policies (Li et al., 2019; Gao et al., 2020). This imbalance between urban and rural development has made the decline of rural China a serious problem for future generations (Muilu and Rusanen, 2003). On the one hand, there is a massive outflow of rural populations in search of better education, medical resources and employment opportunities. On the other hand, against the background of the urban-rural dual structure, with increasing household incomes, it is now common for people to return home from urban centers in order to build new or to improve existing housing. Due to the absence of rural planning, lax supervision and the absence of a rural homestead withdrawal mechanism, the rural population has decreased, but the area of homesteads has increased, and many rural homesteads have been left idle or even abandoned, forming a large number of “hollow villages” (Liu and Li, 2017). Along with these changes in farmers’ lifestyles and livelihoods, farmers’ functional demands for rural homesteads have become increasingly diversified, and rural homesteads now show the characteristics of transformation and multifunctional utilization (Jiang et al., 2016; Su et al., 2019; Zhao et al., 2019). In summary, idle, abandoned and multifunctional use rural homesteads not only result in wastage of land resources, they also affect the quality of life of rural residents and occupy land that could otherwise be used for agricultural production and ecological space.

Orderly withdrawal and transformation of rural homesteads is the key to solving these problems (Kong et al., 2018; jiali et al., 2021; Zhang et al., 2018). In order to guide this process and promote rural transformation and development, realize urban and rural integration, and improve the quality of life of rural residents, the state and relevant departments have introduced a series of policies and measures, including the construction of a socialism new countryside, the construction of beautiful countryside, the separation of rights, the reform of the three plots of land, and rural revitalization (Long et al., 2009; Tian et al., 2014; Alcock, 2019). Local governments have also explored the feasibility of withdrawal of rural homesteads on a large scale. However, in practice, due to insufficient consideration of the needs of farmers and one-sided pursuit of political achievements, farmers were having to live upstairs in some

areas and there was limited space for rural production development, as well as other problems, which is not conducive to the sustainable development of rural areas.

Rural homesteads have long been a focus of academic studies (Naldi et al., 2015), involving the rural human-land relationship (Dahms, 1995; Amcoff and Westholm, 2007; Chi and Ho, 2018; Cai et al., 2020), the structure and function of rural homesteads (Jiang et al., 2016; Qu et al., 2017; Yang et al., 2020; Cáceres -Feria et al., 2021) and the withdrawal of rural homesteads (Wu et al., 2018; Song et al., 2020; Liu et al., 2021). “Population decrease and land area increase” is a common phenomenon in China’s rural areas, but there are also the phenomena of “population decrease and land area decrease”, “population increase and land area decrease” and other types (Song and Liu, 2014; Zhu et al., 2020; Dong et al., 2021). Although from the perspective of land use, “population decrease and land area increase” is not conducive to the efficient use of land resources, from the perspective of human welfare, however, increase in land area for residential, industrial and public management services in rural areas is conducive to improving people’s livelihoods and the quality of the living environment (Qu et al., 2021a).

Rural homesteads have social security, benefit and retaining functions, and show obvious spatial differentiation (Qinglei et al., 2019). The social security function is strongest in the economically backward mountainous areas, and the benefit function is most prominent in the economically developed plain areas. With the development of both society and the economy, the function of rural homesteads has also changed (Zhu et al., 2014; Ma et al., 2018; Qu et al., 2021b). The production function has weakened, while the life function has strengthened (Jiang et al., 2016). The withdrawal of rural homesteads is affected by factors such as peasant household differentiation, generational differences and compensation methods (Chen et al., 2017; Liu et al., 2020). Pilot areas have begun to explore different modes of rural homestead withdrawal, but the long-term interests of farmers are often ignored (Kong et al., 2018).

The above studies have drawn a large number of enlightening conclusions, providing a scientific reference for guiding the processes of the withdrawal and transformation of rural homesteads, which is of great importance. However, there are few studies on rural homestead withdrawal and transformation based on supply-demand balance analysis (Ma et al., 2019). Rational analysis of rural homestead supply and demand is the premise for the process of rural homestead withdrawal and transformation. In view of this, this study selected the traditional agricultural areas with a large potential for withdrawal of rural homesteads as the research area, evaluated the supply and demand of rural homesteads by means of field investigation based on high-resolution remote sensing images and participatory mapping, and then discusses the withdrawal and transformation of rural homesteads based on the supply-demand balance. We believe our results and conclusions will provide a scientific reference for orderly withdrawal of rural homesteads, improve the living standards of farmers, and protect the rural production development space.

TABLE 1 | Internal spatial structure and functions of a rural homestead.

Rural homestead function		Internal spatial structure of a rural homestead
First-level function	Secondary function	
Living function	Residential function Life service function	Bedroom Living room, dining room, kitchen, bathroom, toilet
Production function	Agricultural production function Agricultural production service function Nonagricultural production function	Colony house (chicken shed, hog house), vegetable plot Storage room Concession stand, oil shop
Ecological function	Eco-aesthetic function	Green planting space
Other potential functions	Potential functions	Courtyard

2 THEORETICAL FRAMEWORK AND METHODS

The conceptual framework employed in this study included four aspects: 1) analysis of the supply of rural homesteads; 2) analysis of the demand for rural homesteads; 3) analysis of supply–demand of rural homesteads; and 4) analysis of rural homestead withdrawal and transformation utilization based on the supply–demand balance.

2.1 Supply Analysis

The supply of rural homesteads is characterized by type, scale and quality. The interiors of rural homesteads are not homogeneous spaces, but are heterogeneous spaces divided up by farmers according to their particular needs. They are multifunctional compound units closely related to farmers' lifestyles, livelihoods and social science and technology levels. According to system theory, function is the external representation of structure, and structure is the internal basis of function; that is, structure determines function (Ma et al., 2019). Therefore, according to the internal spatial structure of a rural homestead, we can identify the function it carries and then analyze the types and scale of rural homestead supply. The quality of rural homestead supply can be evaluated on the basis of architectural quality, perfection of and independence of the functional space.

According to field research, a typical rural homestead in traditional agricultural areas usually includes the following: bedrooms, living room, dining room, kitchen, bathroom, toilet, courtyard, storage room, colony house, vegetable plot and green planting space, carrying four first-level functions of living, production, ecology and other potential functions. It also includes six secondary functions, specifically residential function, life service function, agricultural production function, agricultural production service function, nonagricultural production function, and eco-aesthetic function. The relationship between the internal spatial structure of a rural homestead and its carrying functions is listed in **Table 1**.

The bedroom is the most basic spatial structure in a rural homestead, is the rest space for farmers, and carries the residential function. The living room is the space for farmers' daily recreation, meeting guests and making friends, and carries the life service function. The dining room, kitchen, bathroom and toilet are the necessary spaces for daily meeting with others, and bear the life service function. The vegetable plot is the space for

farmers to grow vegetables in the courtyard to facilitate daily life and reduce living expenses, while the colony house, comprising such buildings as the chicken shed and hog house, is the space for farmers to carry out agricultural production activities in order to enrich food sources and increase income, both of which reflect the agricultural production function. The storage room is a place for farmers to store food and agricultural production tools and carries the agricultural production service function. Some rural homesteads also carry the function of multifunctional utilization, setting up a room to open a concession stand or oil shop, forming the nonagricultural production function. With improvements in living standards and yearning for a better life, farmers plant flowers and plants in their courtyards to beautify the environment, enhance sentiment and improve the quality of life, which carries the ecological aesthetic function. The courtyard is a flexible space, carrying other potential functions.

2.2 Demand Analysis

According to Maslow's theory of the hierarchy of needs, humans have five levels of need, arranged in a pyramid structure, which are, from the bottom up, physiological needs, security and safety needs, social needs, esteem and self-actualization (Maslow, 1943). Of these, physiological needs and security needs are low-level needs, while social needs, esteem and self-actualization are high-level needs. When the low-level needs are satisfied at least to a certain extent, the high-level needs then arise.

Farmers' need for rural homesteads also conforms to Maslow's hierarchy of needs theory, and there is a hierarchical need pyramid from low to high (**Figure 1**). When social and economic development is backward and materials are scarce, the rural homestead should first meet the physiological needs of farmers, that is, residential needs and the most basic life service needs. With social and economic development, in order to support the family, maintain and improve living standards and achieve sustainable development, a rural homestead should not only meet the physiological needs of farmers but should also meet the production needs of farmers, namely, their security needs. In addition, human beings are social animals, with a basic human need to contact and communicate with each other. Rural homesteads should meet the social needs of farmers, that is, the need for social space. When the problem of food and clothing is solved and people's material needs are basically satisfied, they begin to pay attention to the location and quality of rural homesteads and pursue a better quality of life, resulting in a

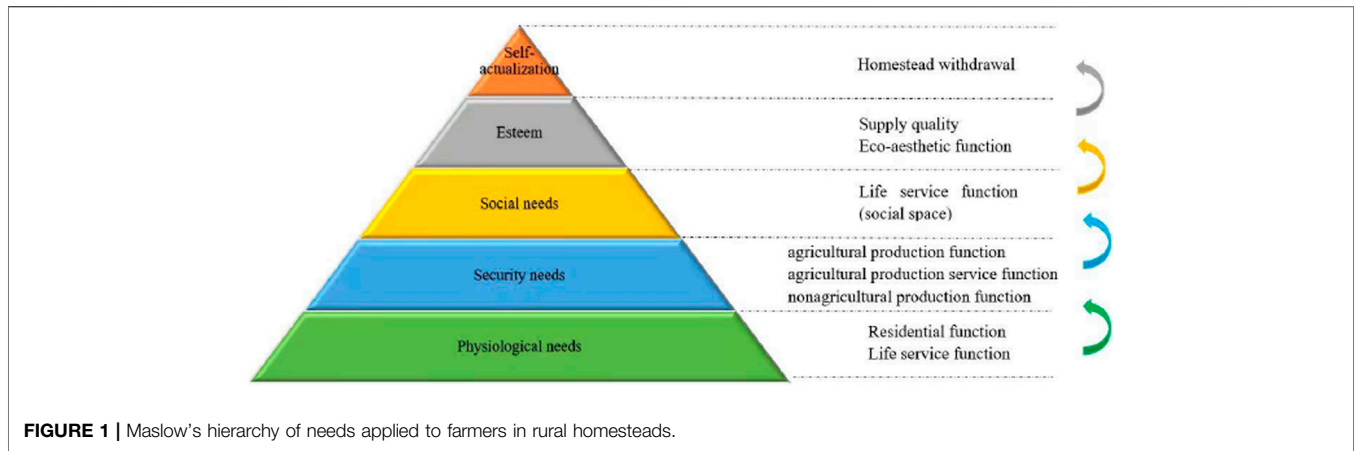


FIGURE 1 | Maslow's hierarchy of needs applied to farmers in rural homesteads.

TABLE 2 | Evaluation index of the supply–demand balance of rural homesteads in use.

Function	Space	Indicator	Calculation methodology and description	Relation between supply and demand
Residential function	Bedrooms	Number of bedrooms per capita	Number of bedrooms/(resident population – 1)	1: Supply and demand in balance >1: Supply exceeds demand <1: Supply is less than demand
Living service function	Living service space	Degree of perfection of living service space	$X = M/N$; N is 5; M is the number of central rooms, dining rooms, kitchens, bathrooms and toilets	1: Supply and demand are in balance >1: Supply exceeds demand <1: Supply is less than demand
Production function	Production space	Number of production space transformation uses	$X = N$; N is the number of production space transformations and utilizations, such as vegetable plots, colony houses and storage	0: Supply and demand in balance >0: Supply is less than demand
Ecological function	Eco-aesthetic space	Degree of space perfection	$X = N$; N is whether there is eco-aesthetic space; yes is 1, no is 0	0: Supply is less than demand 1: Supply and demand in balance

need for esteem and ecological aesthetics. The need for self-actualization can only come about when the levels of social and economic development and of farmers' self-awareness are both high. At present, this level of need is reflected mainly in voluntary withdrawal from idle, abandoned and over-occupied homesteads in response to government policies.

2.3 Supply–Demand Balance Analysis

Rural homesteads are built by farmers according to their production and living needs, and are divided into different internal spaces accordingly. Therefore, when rural homesteads are first built, the supply–demand relationship can be regarded as being in a state of balance. At this time, a rural homestead is both the embodiment of demand and the representation of supply. With the transformation and development of the social economy, the progress of science and technology, and changes in farmers'

production and lifestyles, farmers' needs will also be upgraded or will generate new demands, breaking the initial balance between supply and demand, prompting farmers to actively transform their homesteads, forming new spatial structures and utilization states, and then realizing a new dynamic balance between supply and demand. Therefore, the utilization status of rural homesteads, that is, idle, abandoned, multifunctional utilization or transformation utilization, is a direct reflection of the relationship between supply and demand.

Idle and abandoned rural homesteads indicate that supply is greater than demand. When the internal space of rural homesteads is transformed and utilized, or new functional space is created through reconstruction or new construction, the original balance between supply and demand is broken and the supply of the new functional space is less than the demand for it. Based on field research, according to the changes in the internal

structure and function of rural homesteads in traditional agricultural areas, and referring to relevant studies, indicators—such as the number of bedrooms per capita, the degree of improvement in living service space, and the degree of transformation and utilization of agricultural production space—were selected in order to evaluate the supply–demand relationship of rural homesteads in use (Table 2).

Bedrooms bear the residential function. According to current family structures and living habits in China, in general, parents need one bedroom and each child needs one bedroom. Therefore, the number of bedrooms per capita [number of bedrooms/(number of residents in household – 1)] can be used to represent the supply–demand relationship of residential functions. If the number of bedrooms per capita equals 1, the residential function is in balance with supply and demand. If the number of bedrooms per capita is greater than 1, supply exceeds demand. If the number of bedrooms per capita is less than 1, supply is less than demand.

Restricted by construction age, construction cost and other factors, there are mixed uses and a lack of life service spaces in rural homesteads, and the degree of improvement in life service spaces can be used to reflect the supply and demand relationship of the life service function. If the life service space is complete, supply and demand are in balance. If a certain life service space is missing, supply is less than demand. If the life service space is complete and the number of some spaces is greater than 1, supply is greater than demand. Due to changes in livelihoods, production and lifestyles, the internal space of rural homesteads is often transformed. This shows that the supply of space before the transition is greater than the demand, but the supply of space after the transition is insufficient. Therefore, the quantity of production space transformation can be used to reflect the perfection of the production function. If the amount of transformed space is 0, supply and demand are in balance. If the amount of transformation space is greater than 0, supply is less than demand.

At present, China is implementing a rural revitalization strategy, and ecological livability is one of the basic requirements. Therefore, the perfection of ecological function can be measured by the perfection of ecological aesthetic space. If the latter exists, the relationship between supply and demand is in balance. If there is no ecological aesthetic space, supply is less than demand.

2.4 Withdrawal and Transformation of Rural Homesteads

The supply of idle and abandoned rural homesteads is greater than the demand for them, and should be given priority for withdrawal. For the rural homesteads still in use, the supply–demand balance and supply quality of rural homesteads should be comprehensively considered, and a supply–demand adjustment strategy for rural homesteads should be formulated by classification. If supply is less than demand, farmers' needs cannot be met. The balance between supply and demand should be realized through the transformation utilization of internal space, followed by withdrawal and resettlement. If supply is

greater than demand, priority should be given to exiting in order to avoid waste and inefficient use of resources. From the perspective of supply quality, rural homesteads of low quality should be withdrawn first.

3 STUDY AREA AND DATA SOURCES

3.1 Study Area

Qianpozi village is located to the northeast of Changling Town, in Juxian County, Rizhao City, Shandong Province, approximately 0.5 km to the west of 225 Provincial Road, 1 km from Changling Town and 13 km from the county seat (Figure 2). Qianpozi village is flat, fertile and has a long history of farming. It is a typical representative of traditional farming villages in China. In 2018, the total population was 820. Most of the farmers were engaged in agricultural production, and the main crops were peanuts, corn and wheat. As a traditional agriculture-oriented village, the livelihoods of farmers there have evolved from agriculture-oriented to a combination of agricultural production and migrant work, gradually becoming nonagricultural and diversified, but with economic instability and poor risk-resistance. The main livelihoods of farmers include farming, migrant work, truck transportation, sole trader, and greenhouse planting, with a net per capita income of approximately 5,000 yuan.

Since the 1930s, Qianpozi village has experienced extensive and continual building of houses. The houses built in different periods witnessed the transformation and reconstruction of rural homesteads driven by demand and supply. The earliest still-existing houses in the village were built in the 1960s and 1970s, and the building materials were mainly adobe bricks (a building material of sun-dried earth and straw), so that the houses were known as adobe houses. The village experienced a house-building boom in the 1990s as productivity and the population both grew. The location and size of this new housing were arbitrary due to the lack of relevant construction standards, village planning and supervision. The building area was generally large, mostly about 280 m², and the building material was mostly mud brick, which is why they are known as mud-brick houses. In 2005, driven by the construction of a socialism new countryside, the village experienced another house-building boom. In this period, according to the requirements of a “clean village appearance,” the locations of houses were demarcated and the building scale was unified. The footprint of each house was 182 m², and the construction materials were upgraded to brick and concrete. The insulation and quality of construction of the houses were greatly improved, and these are known as brick houses. In 2011, the village committee developed and constructed a number of buildings, with a footprint of 162 m² and reinforced concrete construction materials, which were called buildings.

3.2 Data Sources

Between January 2019 and January 2021, our research group visited the research area in order to carry out several field investigations. With the help of the Two-step Road Outdoor Assistant software application (<https://www.2bulu.com>), research

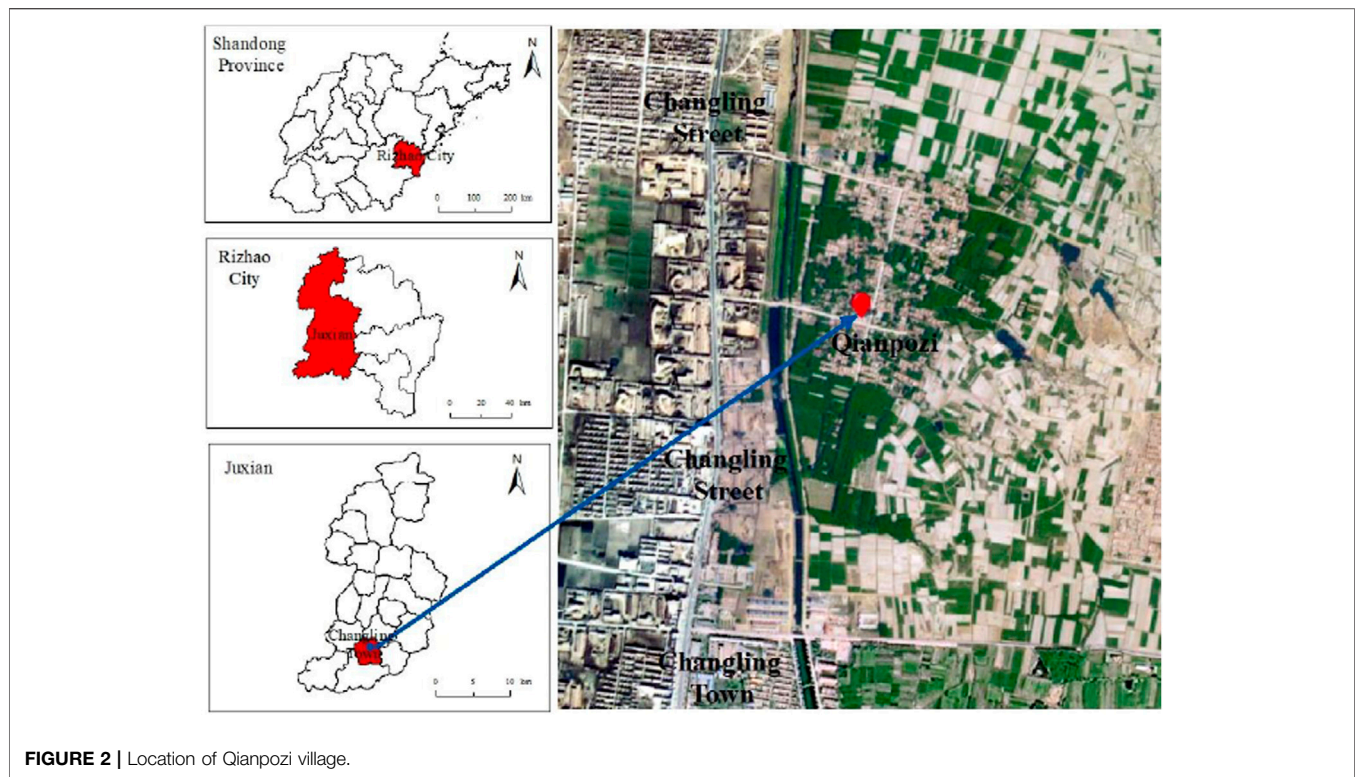


FIGURE 2 | Location of Qianpozi village.

routes, photos, house usage and spatial locations were recorded. Social and economic data related to village development were collected through discussions with village leaders, secretaries, accountants and farmers' representatives familiar with the village development, including middle-aged and senior people. Household investigations were conducted in order to collect data about household structure, income structure, employment structure and other micro-data, as well as internal spatial structure, architectural form, construction age and the building materials used in rural homesteads.

4 RESULTS

4.1 Internal Structural Changes and Functional Transformation of Rural Homesteads

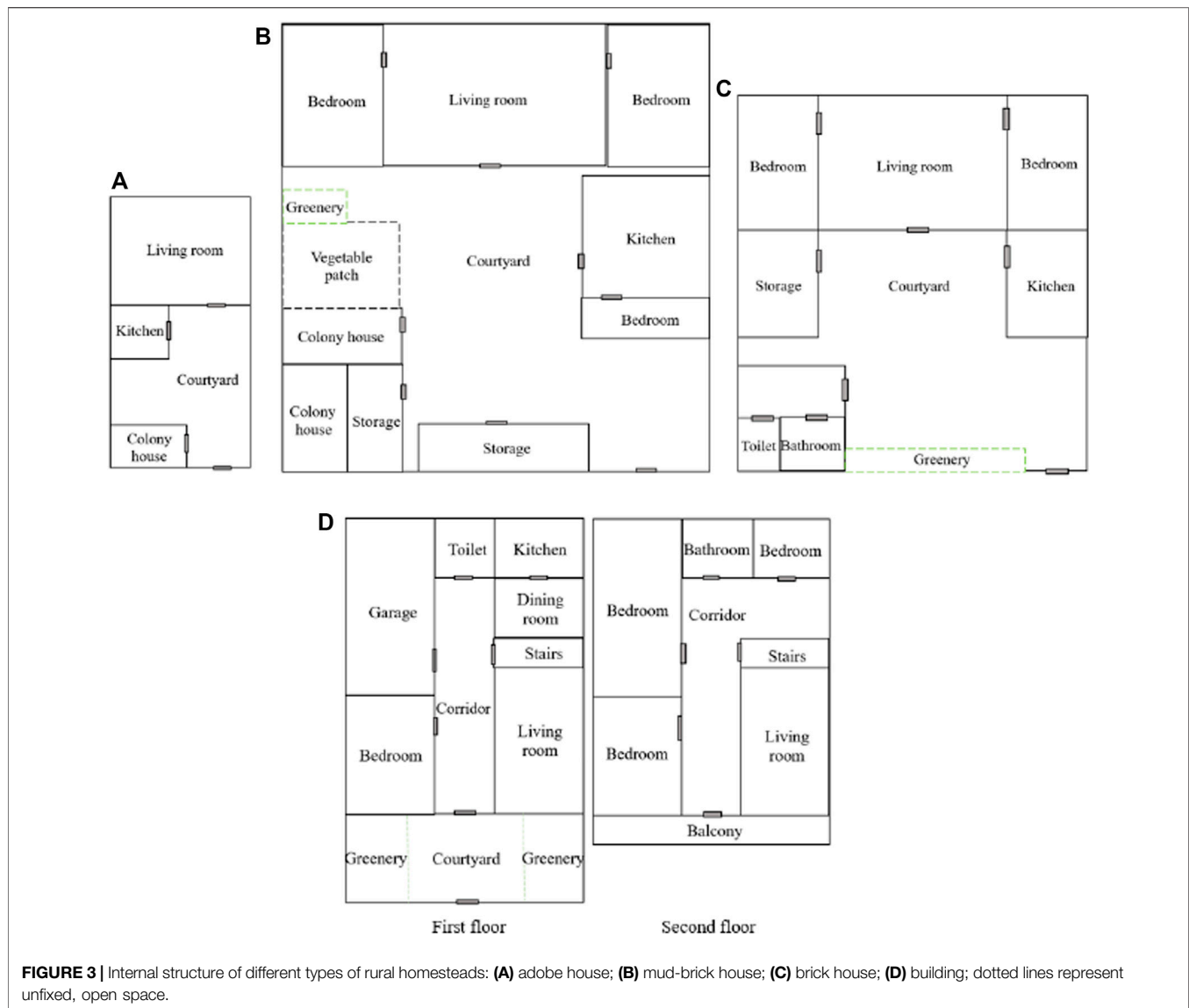
4.1.1 Adobe Houses

Adobe houses are small in area, simple in their internal spatial structure, mixed and imperfect in function and poor in quality (Figure 3A). The area of this type of house is typically no more than 50 m², composed of four main types of space: living room, kitchen, colony house and courtyard. Of these, the areas of the living room and courtyard are large, 20 and 22 m², respectively, and the area of the kitchen and colony house are small, both approximately 4 m². During this period, no independent bedroom or dining room was built. The living room is a comprehensive space for living, eating, making friends and receiving guests, carrying the residential and life service

functions. The kitchen is used mainly for cooking, thus carrying the life service function. The colony house is used mainly to raise chickens, ducks and other poultry, thus carrying the agricultural production function. In summary, adobe houses are intended to serve mainly the residential and living service functions.

4.1.2 Mud-Brick Houses

The area of a mud-brick house is significantly larger than that of an adobe house, the internal space structure is richer, the independence of functional space is enhanced, and the degree of perfection and the quality of construction are both improved (Figure 3B). The area of a mud-brick house increases to approximately 280 m². In contrast to the internal structure of the adobe house, the bedrooms in a mud-brick house are separated from the living room to form an independent space. In addition, planting and storage space are added, forming seven types of space altogether. Of these, the area of the courtyard is the largest, approximately 94 m². The bedroom and living room are also relatively large, 58 and 56 m², respectively, and the areas of the storage space and kitchen are 24 and 16 m², respectively. The area of the colony house and planting area are the smallest, both 12 m². From the perspective of the functions carried by each space, the living room no longer has the residential function, but carries the living service function only. The bedroom becomes an independent space, carrying the residential function. Planting space is used mainly for planting fruits and vegetables, carrying the agricultural production function. Storage space is used mainly for grain storage and stacking agricultural machinery and tools, and carries the agricultural production services function. The



kitchen, colony house and courtyard are all used, and carry the same functions as before.

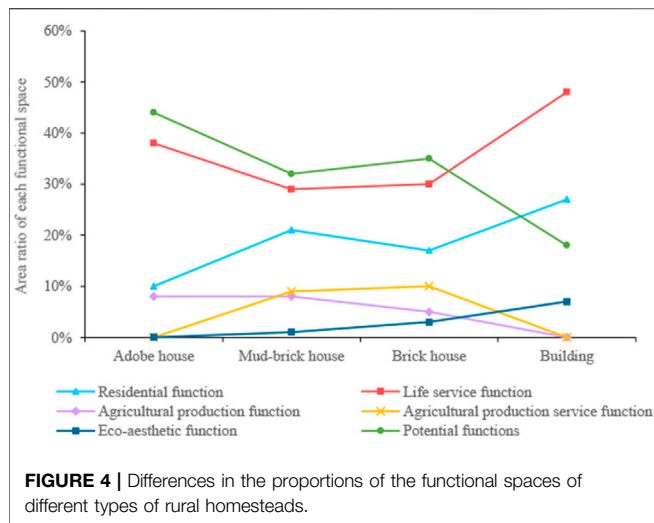
4.1.3 Brick Houses

Compared with mud-brick houses, the area of brick houses is significantly reduced, but the internal spatial structure is more reasonable, the functional zoning is more perfect, and the quality of construction is further improved (**Figure 3C**). The area of this type is uniform and reduced to approximately 182 m², including seven main types of space, namely living room, bedroom, kitchen, storage room, bathroom, toilet and courtyard. Of these, the courtyard area is the largest, at 74 m². The living room and bedroom are 35 and 30 m², respectively. The kitchen and storage area are both 12 m², and the bathroom and toilet areas are both 4 m². Due to the reduced size, this type of house no longer has space for agricultural cultivation inside, which is transferred to the outside of the house. A separate bathroom and toilet are

created to support living services. The uses and functions of the living room, bedroom, kitchen and storage room remain unchanged.

4.1.4 Buildings

The floor area of a building is further reduced, and the internal spatial structure and function are further optimized (**Figure 3D**). The building type is a two-story villa with a loft, covering an area of approximately 105 m². A separate living room, dining room, toilet, bathroom and garage are added. Of these, the living room area is 50 m², the bedroom area is 48 m², the dining room and kitchen areas are both 6 m², the bathroom and toilet areas are both 4 m², the garage area is 18 m², and the courtyard area is 44 m². During this period, the separation of the various functional spaces was the most perfect, including the residential, living service, agricultural production, production service and ecological aesthetics functions.



In summary, the area of the rural homestead experienced a process of first increasing and then decreasing from single-layer to multilayer three-dimensional utilization. In terms of spatial structure, the bedroom, dining room and living room are independent, as well as the separation of living space and production space. In terms of spatial proportion, the proportions of the living, living service and ecological aesthetic functions all increased, while the proportions of the potential, agricultural production and agricultural production service functions all decreased (Figure 4). In terms of functional changes, the dominant space of the rural homestead has changed from the living service function space and potential function space to the living space, and the ecological aesthetic function has emerged. It can be seen that the rural homestead is more efficient in use, with a more reasonable internal structure, more perfect functions and a better quality of construction.

4.2 Demand Analysis

Farmers' demand for rural homestead structure and function is closely related to the social and economic development level, farmers' livelihoods, income levels and other factors, with obvious differences in different periods (Table 3). Adobe houses were built in the 1960s and 1970s. Due to backward social and economic development, low production capacity, lack of materials and limited funds, rural homesteads were limited to

meet the most basic needs of farmers for living, life services and simple agricultural production. Therefore, the main demand space includes bedroom, living room, dining room, kitchen and colony house.

Mud-brick houses were built in the 1990s, following 10 years of reform and opening up, during which China's social and economic development improved greatly. The implementation of the household contract responsibility system in rural areas has liberated productive forces, stimulated the enthusiasm of farmers, greatly improved agricultural productivity, promoted the vigorous development of agricultural production and the rural economy, and generated a demand for the storage of food and agricultural production tools (Zhou et al., 2020). In addition, the livelihoods of farmers during this period were dependent mainly on agricultural production. In order to facilitate living, enrich food sources and reduce living expenses, farmers are now growing vegetables in their courtyards, and colony house breeding has also now expanded from chickens and ducks to pigs, cattle and sheep. Therefore, the rural homestead in this stage should meet the needs of farmers for residence, life services and agricultural production, and the main spaces needed include the bedroom, living room, dining room, kitchen, colony house, storage room and green planting space. It is worth mentioning that, in recent years, farmers have generally placed or planted green plants in the courtyard, which increasingly fulfills the need for ecological aesthetics.

In the 21st century, with the development of social and economic transformation, changes in urban and rural factors is accelerating, and the livelihoods of farmers are gradually becoming more diversified and nonagricultural. As a result, the demand for agricultural production from rural homesteads has gradually decreased, and more attention has been paid to the perfection and quality of construction of the residential and life service functions of rural homesteads. During this period, the main spaces required included bedrooms, living rooms, dining rooms, kitchens, storage rooms, toilets and bathrooms. Like mud-brick houses, this type of rural homestead has also included ecological aesthetic space in recent years.

The buyers of buildings are mainly young people and farmers with better economic circumstances, and their need for rural homesteads is basically the same as that for urban housing. Agricultural production space is no longer required as part of housing, and living space has taken the lead, as well as the quality of living space. Due to better economic circumstances, private

TABLE 3 | Differences in the internal space demands of rural homesteads in different periods.

Demand space	Adobe house	Mud-brick house	Brick house	Building
Living space	Bedroom, living room, dining room, kitchen, toilet and bathroom	Bedroom, living room, dining room, kitchen, toilet and bathroom	Bedroom, living room, dining room, kitchen, toilet and bathroom	Bedroom, living room, dining room, kitchen, toilet, bathroom and garage
Production space	Colony house, storage	Colony house, storage and planting space	Storage and planting space	—
Ecological space	—	—	Green planting space	Green planting space
Other space	Courtyard	Courtyard	Courtyard	Courtyard

cars have become an important means of transportation, and the garage has become a necessary space. Therefore, the main spaces needed include the bedroom, living room, dining room, kitchen, toilet, bathroom, garage and green planting space.

4.3 Analysis of the Supply–Demand Balance of Rural Homesteads

4.3.1 Long-Term Idle and Abandoned Rural Homesteads

Long-term idle and abandoned homesteads are in a state of oversupply. Qianpozi village has a large number of the latter, mainly adobe houses, but also some brick houses, distributed mainly in the central and northern parts of the village. As many as 71 rural homesteads are idle or abandoned, accounting for 18.93% of the homesteads, including 51 adobe houses and 20 brick houses, with a total area of 7,700 m². Adobe houses are occupied mostly by the elderly. Due to the demise of the latter and to improvements in the living conditions of new houses, most of the adobe houses are now idle or abandoned. Brick houses have not been built for a long time, and some of the remaining ones are of good quality. However, as homeowners settle in cities and towns as a result of educational or employment needs, these houses have been idle and are scattered throughout several villages.

4.3.2 Multifunctional Use of Rural Homesteads

Multifunctional utilization of rural homesteads reflects the fact that the supply of some functions is less than the demand for them. There are only four multifunctional homesteads in Qianpozi village, accounting for only 1% of the total number of houses, scattered along the main street, all of which are brick houses. Of these, three are mixed use of concession stands and homesteads, with homogeneity and competition. The total area is 728 m², and the total area engaged in business activities is approximately 260 m². One homestead has mixed use of an oil workshop and a homestead, with a total area of 182 m² and an oil workshop activity area of 80 m². Concession stands and oil workshops are newly built or rebuilt by farmers in the original homestead according to their production and development needs.

4.3.3 Other Rural Homesteads in Use

Adobe houses are small in scale, poor in quality and low in comfort level, and are generally occupied by the elderly. The relationship between supply and demand mainly shows that the supply of living space is less than the demand for it, functional space is not independent, and living space and production space are mixed. The degree of improvement in living space is 4/6. The living room is a complex of bedrooms, living room and dining room, bearing the corresponding functions of the three, but each functional space co-exists in a large space, lacking independence. The living space lacks a toilet and bathroom, and the corresponding functions are realized through the mixed use of a colony house and a courtyard. With increasing age, the health of farmers decreases and their ability to work also decreases, so that they only raise poultry in the colony house. As a result, production space is balanced between supply and demand.

The mud-brick houses are large but poorly laid out, and are mostly occupied by middle-aged people. The relationship between supply and demand mainly shows that the supply of living space is less than the demand. The degree of independence between functional spaces within the living space and between living space and production space has been improved. The degree of perfection of living space is 4/6. There is still a lack of toilets and bathrooms, the toilets are still mixed with the colony house, while the bathrooms are made possible by a subsequent extension. Although the demand for agricultural production space increases due to increases in productivity, the courtyard space is large, and farmers have opened up part of the space in the courtyard in order to grow vegetables. At present, there is no transition utilization, and the relationship between supply and demand of agricultural production space is balanced.

The scale of brick houses is moderate, their layout is more reasonable, and are mostly occupied by young people. The relationship between supply and demand mainly shows that the supply of production space is less than the demand, but the degree of independence of each functional space is significantly enhanced, and the separation of living space and production space is realized. Independent bathrooms and toilets have appeared in the living space, and the demand for living space has been met, realizing the balance between supply and demand. Due to the small scale of houses built in this period and the hardening of the ground inside the homesteads, the demand for vegetable planting could not be met, prompting farmers to transfer the function to the outside of the homestead. In addition, farmers generally grow green plants in the courtyard to beautify their environment.

Buildings are improved housing with the highest levels of quality and comfort, and lived in mostly by young people with better economic circumstances. The supply-demand relationship is manifested mainly as supply being greater than demand. The building type has shown the appearance of independent bedrooms, living room, dining room, the separation of space, the addition of a garage, the living space is perfect and independent, but their supply is greater than the demand for them, resulting in part of the space failing to be fully used. Agricultural production space disappears, but a special space is set up in the yard for planting and raising green plants, so that the supply and demand of ecological aesthetic space is balanced.

4.4 Withdrawal and Transformation of Rural Homesteads Based on Supply-Demand Analysis

The supply of idle and abandoned rural homesteads is greater than the demand for them, with a total area of 7,100 m², and therefore their occupants should be given priority for exiting. For rural homesteads in use, the balance between supply and demand, spatial independence, building quality, scale and layout should all be comprehensively considered in order to formulate appropriate withdrawal and transformation strategies by classification.

The supply of adobe houses is less than the demand for them, the degree of spatial independence is poor, the construction quality is low, the scale is small, the layout is scattered, and

thus priority should be given to exit strategies and, through centralized resettlement, improving the quality of living. The supply of some of the living space of mud-brick houses is less than the demand, and the related functions are realized through the mixed use of other spaces. The quality of supply and demand balance is low, and there is supply and demand dislocation. However, the scale of mud-brick houses is very large, and the balance of supply and demand can be realized and optimized through internal modification or transformation. When farmers have the intention to withdraw from rural homestead, they should give priority to withdraw to improve land use efficiency. The brick houses lack mainly space to grow vegetables. However, with the nonagricultural and diversified development of livelihoods, this demand will gradually weaken, and supply and demand will achieve balance. Moreover, the architectural quality and the degree of separation of functional space are both relatively high. Therefore, brick houses can be kept in their current state of use and can be withdrawn when farmers decide to withdraw. The supply of buildings is greater than the demand for them, part of the space is not reasonable to use, and should be combined with actual demand, reasonable configuration and transformation utilization. For example, use existing space to set a study. Although there is a certain level of waste incurred by this type of building, they have a short construction time, achieving high quality and complete functionality. Therefore, the current state of utilization should be maintained.

For the rural homestead in use, even if the supply of its internal space is greater than the demand, farmers cannot be forced to withdraw from the rural homestead as long as the demand of farmers still exists. Rural homestead withdrawal should not be too hasty. A natural exit, though slow, can be a safe measure if properly guided by the government.

5 DISCUSSION

5.1 Factors Affecting the Supply–Demand Balance of Rural Homesteads

The balance between the supply and demand of rural homesteads is a dynamic process, which is the result of many factors. Population size, farmers' incomes, livelihood, lifestyle and social and economic development level are the main factors affecting demand, while supply is affected by social and economic development level and the system used for homestead management.

Population size directly affects demand for rural homesteads: the greater the population, the greater the demand. Household income is also an important factor affecting demand. As farmers' incomes rise, so does their need for improved housing. The scale, structure and function of rural homesteads are closely related to farmers' livelihoods. Before 2005, the latter were derived mainly from agricultural production, so demand for grain storage was high, and storage space in rural homesteads was large. With the differentiation, diversification and nonagricultural nature of farmers' livelihoods, the demand for storage room gradually decreased, while ecological aesthetic space increased. Lifestyle

also has a great impact on the demand for farmers' homesteads. At present, many young people from the countryside have accustomed themselves to an urban lifestyle and have bought apartments in cities instead of building rural homesteads. The level of social and economic development has a profound impact on rural homestead demand. When the level is low, demand becomes the most basic demand of living. With improvement in social and economic development, homestead demand shows diversified characteristics. In recent years, farmers have been increasingly pursuing a higher standard of living, paying more attention to quality of life, and thus rural homesteads have gradually regained their living function.

The level of social and economic development affects not only demand but also supply. If the level is backward, the development of productive forces becomes insufficient, and the supply is therefore insufficient. With improvement in social and economic development, productivity develops rapidly, and the supply is sufficient. At present, China implements a rural homestead management policy of "one family, one house, legal area," which defines the quantity and scale of homestead supply.

5.2 Implications of Rural Homestead Withdrawal

Rural nonagricultural industries in traditional agricultural areas are underdeveloped, and there is insufficient endogenous driving force for development. Under the push and pull of urban and rural areas (Zhang et al., 2019), the rural population has been greatly reduced. However, rural homesteads themselves are immovable assets. Changes in the state of rural homesteads have the characteristics of lag, consumption and passivity. Therefore, farmers' willingness to withdraw is weak, and the motivation for vacating rural homesteads is also weak. Idle and abandoned homesteads are a helpless and rational choice for farmers (Kong et al., 2018; Dong et al., 2021).

The key to realizing an orderly withdrawal from homesteads is to stimulate, guide and increase farmers' willingness to withdrawal from them (Chen et al., 2017; Zhang et al., 2018; Cao et al., 2019). A combination of rewards and punishments should be adopted to guide farmers to gradually withdraw in an orderly fashion from idle and abandoned homesteads. On the one hand, collecting fees for idle resources forces farmers to withdraw from idle and abandoned homesteads. On the other hand, by referring to the pilot experience of separating the three rights to homesteads, we guarantee farmers' homestead qualification rights, reward farmers who voluntarily withdrawal, and persuade remaining farmers to voluntarily withdrawal idle and abandoned homesteads.

The structure and function of rural homesteads are the result of a dynamic balance between supply and demand against the specific background of social and economic development, which is appropriate for farmers' lifestyles and livelihoods. Therefore, the withdrawal of rural homesteads should fully consider the needs of farmers and not be carried out too hastily. According to the relationship between supply and demand, rural reconstruction needs to be established, and then rural homesteads should be withdrawn in a classified, orderly and

timely manner. Demand by farmers for rural homesteads in traditional agricultural areas is based mainly on basic living needs, living services and agricultural production, while demand for nonagricultural production is relatively low. The construction of rural homesteads needs to combine changes in farmers' lifestyles and livelihoods, employ forward-looking and diversified design, and meet the production and living needs of farmers now and in the future.

There are few multi-functional rural homesteads in traditional agricultural areas, and the service content and scope are limited, which means that rural vitality is low. Therefore, strengthening the cohesion of rural population, improving the attractiveness of rural areas and inspiring rural vitality are effective ways to solve the problem of idle and abandoned of rural homestead.

5.3 Limitations and Future Research

In this paper, a typical village in China's traditional agricultural area is selected to analyze the structure and function evolution of rural homestead and its supply-demand relationship. Although this is a common approach in rural geography (Wang et al., 2016; Yao and Xie, 2016; Zhang et al., 2017; Su et al., 2019). However, China's traditional agricultural area is vast, and a typical village is taken as the representative of the study, which inevitably leads to the problem of under-representation. Plenty of case studies are still needed in the future. In addition, it is an interesting study to compare a typical Chinese village with a typical foreign village, which may provide more valuable information.

6 CONCLUSION

Based on changes in the internal structure and function of rural homesteads, this study analyzed the evolution of rural homestead supply by taking typical villages in traditional agricultural areas as case studies. Using Maslow's theory of needs as a reference point, combined with the internal structures of different types of houses when they were initially built, the changes in rural homestead demand were clarified. Finally, according to the current situation of rural homestead utilization, the relationship between supply and demand was evaluated and countermeasures and suggestions for rural homestead withdrawal and transformation were proposed. The main conclusions are as follows:

- (1) From the 1970s to the present, rural homesteads in traditional agricultural areas have experienced four periods of changes in construction: from adobe house to mud-brick house to brick house and, finally, to building. The scale of rural homesteads changed from small to large and then to intensive use. Their internal structure has changed to "simply-enriched-simply-optimized." The independence of each functional space within the overall living space has

gradually been enhanced, and the separation of living space and production space has been realized. The living function has gradually been enhanced, the production function has gradually been weakened, and the ecological aesthetic function has emerged.

- (2) Demand by farmers for rural homesteads is the result of the combined effects of the levels of social and economic development, lifestyles and livelihoods.
- (3) There are a large number of idle and abandoned homesteads in the study area, accounting for 18.93% of the total number of homesteads, and showing obvious hollowing characteristics. The number of multifunctional rural homesteads is small, only four. The service scope is limited to the residents of the village, the service content is mostly limited to farmers' living and production activities, and homogeneity is obvious. This shows a lack of vitality in the countryside. There are obvious differences between the supply and demand of rural homesteads in use.
- (4) In traditional agricultural areas, idle and abandoned homesteads should be given priority for withdrawal. For those rural homesteads still in use, withdrawal strategies should be formulated according to the supply-demand balance, construction quality, spatial independence, combined with farmers' wishes.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

Conceptualization, GD; methodology, GD and HC; formal analysis, GD and HC; data curation, HC and YG; writing—original draft preparation, GD and HC; writing—review and editing, GD and RZ; visualization, GD and RZ; supervision, GD and RZ. All authors have read and agreed to the published version of the manuscript.

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