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The production function socialization trend of rural housing land and its response to rural land planning in metropolitan suburbs from the perspective of rural space commodification

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An investigation of the changing production function of rural housing land can help to guide appropriate land use adjustment and rural land planning. Taking into account the layout characteristics from 2005 to 2018, we employed the structural equation model and the theory of planned behavior to analyze the differentiation mechanism of rural housing land production function based on survey data of 613 typical farmers in Pinggu District of Beijing. Our results show that, first, the production function intensity of rural housing land in Pinggu District fell from 0.327 to 0.126, and the coefficient of variation increased from 0.15 to 0.54. This indicates that the overall production function decreased but the spatial heterogeneity increased. Second, the production function of rural housing land gradually withdrew and socialized in villages, following the socialization evolution process of agricultural production function, industrial and commercial service function, and public service function. Third, the internal land use pattern of rural housing land is significantly influenced by the subjective norms and perceptual behavior control of farmers. The demonstrative norms of family and the prescriptive norms of village collective have significant effects on subjective norms, and the perceived behavioral control is significantly affected by income scale and structure, family size, and employment type. Finally, to further promote rural housing land management, it is necessary to optimize its prescriptive norms of the village collective, improve the farmers' income level and employment structure, and weaken the farmers' perceived difficulties. According to the different function socialization stages of rural housing land, rural land planning should coordinate the relationship between the production function socialization of rural housing land and the commercialization of rural space, and boost the revitalization of rural industry.

KEYWORDS

rural housing land, production function socialization of rural housing land, internal land use, commodification of rural space, rural land planning

1 Introduction

Land is a core element of urban and rural development (Long and Chen, 2021), and the improvement of land use function is an important way to implement the rural revitalization strategy. It is also an important perspective to measure the implementation effect of rural revitalization (Zhang and Li, 2020). Exploring the impact of micro-subject land use behavior on land use function change and clarifying the behavior response mechanism of actors have become important research directions of land system science, driven by the Global Land Project (GLP) (Tang et al., 2009; Verburg et al., 2009; Liang et al., 2019). Rural housing land is a multifunctional compound space that the rural population relies on for survival and development. It is also the core of the interaction and coupling of the man-land relationship in the rural regional system, presenting function diversity with different human needs (Jiang et al., 2016; Zhou et al., 2017). Clarifying the multifunctional characteristics of rural housing land is of great significance for promoting intensive and economical use of rural land, and for urban-rural integration development (Cloke and Edwards, 1986; MLRPRC, 2016; Liu, 2018; Yang et al., 2018).

Rural housing land is an important land use type and the traditional living form of farmers in the countryside (Long and Li, 2005; Jiang et al., 2007; Whittemore and BenDor, 2019), meeting the production and living needs of farmers (Wegren et al., 2008; Jiang et al., 2016; Qi et al., 2020), and occupying a large proportion of urban and rural construction land in developing countries with a large agricultural population (Liu and Li., 2017; The Department of Economic and Social Affairs of the United Nations Secretariat (UN DESA), 2018). Social and economic development; the accelerative flow of the urban and rural population, capital, and other factors (Liu, 2018); and the rapid change of rural land planning, peasant household structure, and personal characteristics have forced the unprecedented morphological evolution and function transformation of rural housing land (Skowronek et al., 2005; Long et al., 2007; Long et al., 2011; Zhou et al., 2019). The simple functions of agricultural production and villagers' residence have gradually shift to multiple and complex functions of production, processing, trade, sightseeing and leisure, and recuperation and vacation. The dominant function is gradually moving from social security to asset, which presents regional and individual differentiation. As the rural collective construction land with the largest area, the widest audience, and the most direct impact on interests, rural housing land has attracted increased attention from management departments and academic circles (Qu et al., 2021; Yuan et al., 2021).

Existing studies generally suggest that rural housing land has two basic functions: production and living. Meanwhile, some studies demonstrate usufruct function (Banski and Wesolowska, 2010; Song, 2012; Zhang, 2015). The function of rural housing land has mainly been studied by constructing evaluation models or according to the proportion of land use structure (Dahms, 1995; Fang, 2014; Jiang et al., 2022). Understanding the nature of rural housing land as a means of production is the basis for a breakthrough in the next-stage reform (Alger, 1993; Cohen, 2001; Jerzy and Monika, 2010; Zhu et al., 2017; Zhang and Liu, 2021). The function of rural housing land presents the evolution of "simple living function to both production and living function to regional differentiation of production and living function" (Feng and Yang, 2015). Comparative analysis has examined the function spatial differences of rural housing land in counties at different stages of industrialization but they have not analyzed the differences within counties (Jiang et al., 2016). The evolution of functional differentiation is the main aim of social and institutional change, citizens' property rights consciousness, and farmers' interest (Cobb, 1984; Chaney and Sherwood, 2000; Wasilewski and Krukowski, 2004; Nepal, 2007; Domon, 2011; Xia, 2017), which in turn has an impact on the environment (Hansen and Brown, 2005; Lambin and Meyfroidt, 2010). The functional evolution of rural housing land is influenced by the external environment, internal subjects, and their characteristics. External institutions and economic environment are background factors, while the internal subjects (i.e., the characteristics of farmers) are the direct factors (Qu et al., 2012; Zhao et al., 2019). However, a micro-mechanism analysis from the perspective of the farmers is still lacking. The existing studies mostly employ traditional logistic regression, which can analyze the dominant factors but is difficult to use to measure the potential variables related to farmer willingness.

This study takes the Pinggu District of Beijing as the research area. It analyzes the temporal and spatial variation characteristics of rural housing land production function based on the survey data of typical households, constructs the theoretical analysis framework of planning behavior (TPB), and employs a structural equation model (SEM) to analyze the factors that influence the production function of rural housing land from the perspective of bottom-up peasant household behavior. This study aims to introduce the theory of rural space commercialization to discuss the optimization path of the production function space of rural housing land in the process of rural land planning. It also aims to promote the function structure adjustment of rural housing land and alleviate the problem of land for village development.

2 Theoretical underpinning

2.1 Land function

Land is a multifunctional complex problem and the concept of "production-living-ecological" space has been proposed from the perspective of land use function (De Groot, 2006; Liu et al., 2017). The land surface is commonly characterized by distinguishing different land cover types. The capacity of land to provide goods and services is referred to as land use functions, or ecosystem functions. The function division from the perspective of land use is economically oriented, which refers to people's arrangement, activities, input and acquisition of production, transformation and maintenance capacity for specific land use and cover types (Foley et al., 2005; Verburg et al., 2009). The function space of production, living, and ecology, covering biophysical processes, direct and indirect production, spiritual, cultural, leisure and aesthetic needs, and so on are the products of the synergistic coupling of natural system and social economic system (Li and Fang, 2016; Ghosh, 2021). Although the capacity of the land to provide goods and services is related to land cover, many other factors (including the spatial arrangement and temporal intensity of land use in the landscape) may be important. Therefore, land function change may not only result from local changes in land cover but can also be the result of changes in the broader context of the location without changes inland cover at the location itself (Verburg et al., 2009).

2.2 Production function identification of rural housing land

The rural courtyard is the center of the farmers' production and life, and was formed during the development of traditional farming and small-scale peasant economy. The function of rural housing land refers to the combination of the potency, property, efficacy in the farmers' land use process (Jiang et al., 2016). The deepening system reform of rural housing land is of great significance to the realization of the rural revitalization strategy. Understanding the nature of rural housing land as a means of production is the basis of the next step in promoting the breakthrough of rural housing land system reform. According to Marx, rural housing land provides laborers with a foothold and a place for activities. Rural housing land is a general means of labor and belongs to the means of production—without it, the labor process cannot be carried out (Zhang and Liu, 2021).

Rural housing land also has an important production function. For example, farmers can deposit grain, agricultural materials, and tools, do some farm work and production repair tools, develop a courtyard economy (e.g., the cultivation of grapes and other fruits, and development in the family sideline businesses such as raising pigs and chickens), and grow fruit and tea trees behind the house (Qu, 2020).

After the reform and opening up process, especially since the beginning of the twenty-first century, the rising demand of urban residents to return to nature, and travel to the countryside to relax and experience the interests of farming has led a large number of rural housing land in rural areas, especially in the suburbs of cities, to become an important place to operate "farmhouse entertainment" and develop the leisure tourism industry. China's rural housing land system reform since the 18th Congress has taken a substantial step forward and the central government has proposed the separation of ownership, qualification, and use rights of rural housing land. It has also explored the transfer system of use rights, and made every effort to revitalize idle rural housing land and idle agricultural houses. The series of policies that have been issued for this purpose is consistent with the property that rural housing land is a means of production (Zhang and Liu, 2021).

There is an intrinsic relationship between the function and land use structure of rural housing land. Furthermore, the evolution of internal land use structure is continuously adapting to the demand for function changes. The change of internal land use structure can be used to illustrate the function change of rural housing land. Drawing on the connotation of land use function (Liang et al., 2019), the production function of rural housing land can be divided into six subclasses based on the perspective of internal land use (Table 1).

2.3 The stages of the production function change of rural housing land and the commercialization of rural space

Production function socialization within village of rural housing land refers to the phenomenon that the production land of rural housing land has been gradually withdrawn and transferred to the village due to the changing livelihood characteristics of peasant households, thus reducing the production function of rural housing land and socializing in the rural areas by land planning. This process has developed gradually rather than overnight. The rural courtyard is the basic place for the farmers' production and life, and was formed by the development of Chinese traditional farming civilization and small-scale peasant economy. With the intensification of marketization, urbanization, and urban-rural population flow, the economic location of villages has changed and the social security system has been gradually improved. This has led many farmers to a non-agricultural livelihood and to the structural differentiation of family members. The property attributes of rural housing land are gradually highlighted, especially in those rural areas that have significant radiation effects from big cities.

According to studies on the commodification of rural space, one of the paths to realizing the commercialization of rural space

TABLE 1 The production function identification of rural housing land based on the perspective of internal land use.

1st level classes	subclasses	function description	internal land use
production function	planting (PPF)	engaged in fruit trees, vegetables, crops, and other cultivation	garden, fruits orchards
	breeding (PBF)	engaged in livestock and poultry breeding	animal house
	airing (PAF)	used for drying clothes, food crops, etc.	courtyard space
	productive storage (PPSF)	storage of agricultural products, agricultural machinery, goods, and other productive supplies	wing-room, a yard or gate
	rental (PRF)	the lease part of the land for profit	mainly wing rooms
	industry and commerce (PICF)	processing industry, barber, hotel, express service point, and other lands	mainly wing rooms

is the consumption of rural space by urban residents that is brought by reverse urbanization. In particular, rural tourism can attract people's imaginations (Wang, 2013). Under the influence of the commercialization of rural space, the requirements for value realization and value appreciation are becoming stronger (Wang, 2013). The farmer's quality of life has improved and the demand for improving the housing environment is increasingly strong.

According to the changing characteristics of the farmers' livelihood and the transformation process of utilization mode, the agricultural production land has first withdrawn from rural housing land and socializing the village, and has formed centralized and socialized functional spaces (e.g., breeding plants, plantations, and agricultural machinery stations) in the village. Later, non-agricultural production functions have also faced a similar path. Storefront houses, small processing industries, shops, barbershops, express delivery points, and other street layouts will be subject to unified planning and construction specifically for the development of industry and commerce, which forms a large-scale effect. The function of rural housing land is constantly differentiated, which shows a tendency of mixing to specialization. In addition, this rural housing land undertakes the residential function but not the production function thanks to the unified layout of rural land planning.

2.4 The evolution of the production function of rural housing land

Function change of rural housing land refers to the change of property rights, land use methods, and output capacity of rural housing land, which belongs to the change of recessive morphology of land use. This is an important reflection of land use morphological change, and is an important source of rural development and land use transformation (Dong et al., 2022).

The initial function state of rural housing land is social security. From the perspective of land use, there are two function transformation situations of rural housing land that are caused by land marginalization (Zhu F. K. et al., 2017). First, the economic benefits of agricultural production have been significantly lower than those of migrant workers in cities. Consequently, large numbers of the rural labor force have moved into towns looking for job opportunities as the farmers' opportunity costs rise. The number of part-time households and non-households in rural areas have gradually increased, which reduces the intensity of internal land use under the residential security function of rural housing. The utilization rate of rural housing land decreases or is even abandoned, thus forming the situation of lien function. Second, following the changing location conditions and land policy, the changing relationship between land supply and demand, and the asset properties of rural housing land gradually falling under the stimulation of the market, it is increasingly common to use rural housing land for industry and commerce, and the opportunity cost of self-occupation will increase. Thanks to the attraction of comparative income, some "rational farmers" will automatically change their livelihood mode and obtain an operating income from rural housing land, thus forming the production function and causing the change of the internal land use structure of rural housing land.

2.5 Planned behavior theory

In the theory of planned behavior (TPB), Ajzen added perceptual behavior control factors as prefactors affecting individual behavior intention based on rational behavior theory in 1985 and predicted an individual's actual actions for certain behaviors. The individual behavioral intention is jointly influenced by attitude, subjective norms, and perceived behavioral control, and there may be a related influence among these three factors. The individual's behavior is jointly determined by behavioral intention and perceived behavioral control (Ajzen, 1985; Zhong et al., 2013; Huang et al., 2014; Zhao et al., 2016).

The factors influencing attitudes in the theory of planned behavior can be divided into behavioral belief and results

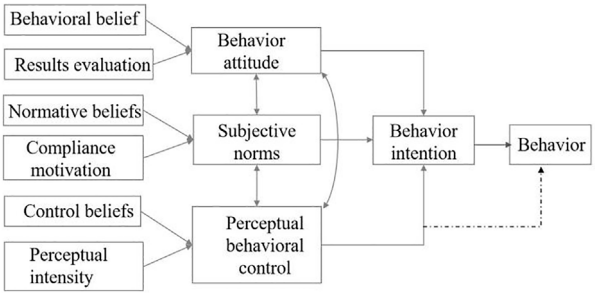

FIGURE 1
Conceptual model of the theory of planned behavior.

evaluation, which are used to measure the individual's recognition of behavior effects and the importance of these effects to individuals (Figure 1). Subjective norms can be divided into normative beliefs and compliance motivation. Perceptual behavioral control consists of two dimensions: control belief and perceptual intensity (Duan and Jiang, 2008). In recent years, the theoretical model of planned behavior has been widely studied and applied by social researchers to explain the characteristics of farmers' land use behavior, including farmland transfer and rural housing land withdrawal (Wan et al., 2017).

In this study, the production function intensity of rural housing land reflects the results of the farmers' land use behaviors. The influence of the farmers' attitudes, subjective norms, and perceived behavioral control on their intentions and behaviors is analyzed according to the conceptual model of TPB, which is the research hypothesis of this study.

1) The impact of behavior and attitude on production function intensity of rural housing land. Behavioral attitude refers to a person's positive or negative feelings toward the implementation of a certain behavior (i.e., an individual's conceptualized attitude toward the evaluation and definition of the determined behavior). Farmers mainly arrange all kinds of land in the rural housing land based on the actual demand of individuals and the family. When farmers think that production land can obtain more economic benefits, they will adjust the internal land use structure and thus enhance the function intensity.
2) The impact of subjective norms on the production function intensity of rural housing land. Subjective norms are the social pressures that are perceived by individuals to perform a particular behavior. A certain land use behavior of farmers will be affected by the family, neighbors, friends, and so on. The village collective also plays an important role in this behavior of the farmers.
3) The influence of perceptual behavioral control on the production function intensity of rural housing land. Perceptual behavioral control refers to the perceived difficulty of performing a particular behavior. Government policies have a guiding effect on household rural housing land use behavior. Household characteristics (e.g., age, occupation, education level, household size, household income, the proportion of non-agricultural income, rural housing land location, and other family conditions) may directly affect the farmers' perceptions of difficulty.

3 Materials and methods

3.1 Study area

Pinggu District is located in the Northeast of Beijing, between 40°02′~40°22′N and 116°55′21″~117°24′07″E. The area is located at the junction of Beijing, Tianjin, and Hebei provinces, with unique geographical conditions. It is an important node of the eastern development belt of Beijing and one of the important channels for the coordinated development of the Beijing-Tianjin-Hebei Urban Agglomeration (Zhou T. et al., 2018). It is 38.5 km from north to south and 40.25 km from east to west, covering a total area of 950 km^2, including 14 towns and two townships, and 275 administrative villages. The terrain is high in the north and low in the south, with the highest altitude of 1234 m (Figure 2).

According to the different geomorphic characteristics, the whole region can be divided into plain, mid-level mountains, and mountainous areas. Each area accounts for about 1/3 of the total area under the jurisdiction. In 2018, the number of rural households is 109,000, and the proportion of the agricultural population in the corresponding landform is 0.22:0.59:0.19. Mountain scenery is beautiful, forestry, and tourism is more developed; mid-levels are the fruit production base; the plain area is the economic and cultural center of the whole region, and is the main producing area of grain and vegetables. In 2020, the GDP of Pinggu District was 28.41 billion yuan, and the tertiary industrial structure was 4.5:25.1:70.4. In the process of urbanization and industrialization, as the peri-urban area of the Beijing metropolis, Pinggu District has undergone a remarkable social and economic transformation. From 2005 to 2015, the total rural population decreased from 228,000 to 185,000, a decrease of 18.86%, while the area of rural residential land decreased from 6,180.12 ha to 5,713.96 ha, a decrease of 9.12% (Liu and Li, 2017). There is a significant transition phenomenon both in the rural settlements and population in this area.

3.2 Data sources

The data sources in this study include geospatial data, social and economic data, and farmer survey data. The geospatial data came from the geospatial data cloud and the Pinggu Branch of Beijing Municipal Planning and Natural Resources Commission, the socioeconomic data came from socioeconomic statistical Yearbook

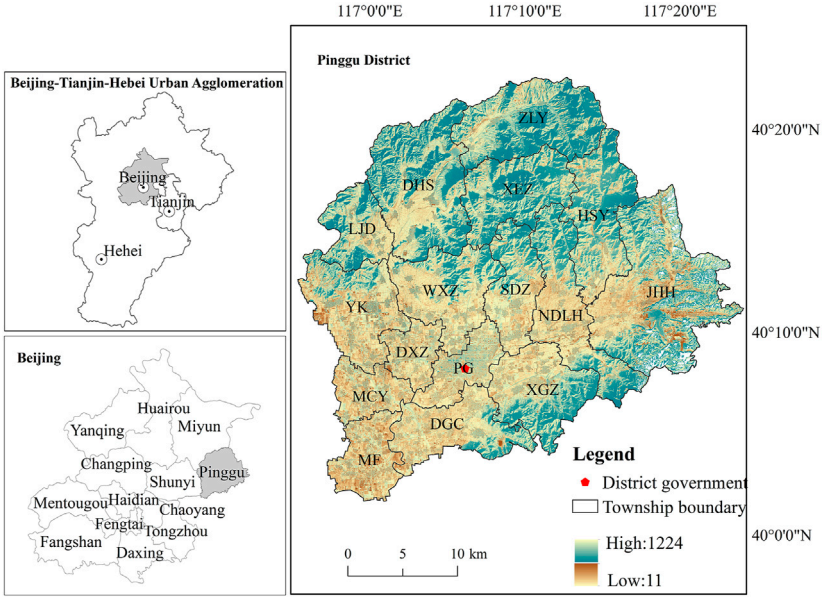

FIGURE 2
Location of Pinggu, Beijing, China (PG, DXZ, DGC, MCY, MF, WXZ, YK, LJY, DHS, XEZ, ZLY, HSY, SDZ, NDLH, XG-Z, and JHH are the name abbreviations of the townships in Pinggu, Daxingzhuang, Donggaocun, Machangy-ing, Mafang, Wangxinzhuang, Yukou, Liujiaying, Dahuashan, Xiongerzhai, Zhenluoying, Huangsongyu, Shandongzhuang, Nandulehe, Xiagezhuang, and Jinhaihu, respectively).

of the Pinggu District and rural economic management station, and the data of villages, farmers, and rural housing land came from survey interviews. A stratified random sampling method was adopted to select the interviewed farmers. The proportion of surveyed farmers in the corresponding topographic area was determined according to the proportion of agricultural households in the plain, mid-level, and mountainous areas (0.22:0.59:0.19).

Typical farmers were randomly selected from each layer in each topographic area according to the proportion of household rural housing land utilization obtained in the pre-survey. The sample points of peasant households have a better representation, reflect the utilization state of rural housing land in the whole region, and cover relatively comprehensive household housing characteristics. The questionnaire was established according to the theoretical model and a pre-survey was conducted for the specific situation of Pinggu District.

In 2005, the research group adopted participatory rural assessment (PRA) to carry out the field survey of farmers according to the differences of landform and location in Pinggu District. We employed a stratified sampling method in the town to select sample villages according to the level of geographical location and socioeconomic development. On the basis of the village survey in 2005, the research group went into the same typical villages in Pinggu District again in August and September of 2018, and selected the same number of household sites by sampling method as in 2005, and then conducted household survey in the form of semi-structured interviews. Through a questionnaire survey and interviews with village cadres and typical household farmers, relevant data of village, household and rural housing land were obtained, and the realistic performance of rural housing land function was observed and recognized.

Village research content: 1) characteristics of rural housing land in a village (i.e., the total scale of rural housing land, the proportion of farmers using rural housing land by self-occupancy, rental, idle, concurrently commercial and industrial operation, and multiple houses in one household); and 2) background conditions of the village (i.e., the distance between the village and the urban area, the geographical characteristics of the village, the economic characteristics of the village industry, the annual income, the total population, the proportion of non-agricultural population, the proportion of permanent population, and other population characteristics).

The contents of the household survey are as follows: 1) characteristics of household rural housing land (i.e., location, area, construction age, land use status, and construction cost of rural housing land); 2) household characteristics (i.e., total population, annual income, the proportion of non-agricultural income, and cultivated area); 3) the characteristics of the head of the household (i.e., the head of the household age, education level and occupation; Table 2); and 4) and the rural households' willingness to use the land for rural housing lands, their behavioral attitudes, and subjective norms.

Finally, approximately three typical villages were selected in each town, and 43 villages were effectively investigated,

TABLE 2 Measurement variable selection and descriptive statistics.

Latent variables	Serial number	Measured variable	Mean value	Standard deviation
Behavior attitude	BA1	I think the production function should be one of the important functions of rural housing land	3.68	0.91
	BA2	I think more productive land can improve the quality of living	4.63	0.97
	BA3	I think the separation of production function from rural housing land is beneficial to rural land planning	3.57	0.87
Subjective norms	SN1	The family thinks more land should be used for production	4.81	0.82
	SN2	Relatives and friends support the enhancement of productive land	4.25	0.79
	SN3	Village collectives encourage to engage in production activities on rural housing land	3.96	0.94
Perceptual behavioral control	PBC1	There are plenty of funds	3.79	0.83
	PBC2	Family population	4.78	1.71
	PBC3	Household non-farm income share	0.76	0.27
	PBC4	Household head education level	2.87	2.09
	PBC5	The householder age	55.22	12.51
	PBC6	Householder job type	3.56	2.93
Householder intend	HI	I think we should increase the area of production land in the rural housing land	4.16	0.85
Householder behavior decision	HB	The production function intensity of household rural housing land	9.34	5.98

Note: Household head education level: primary school and below = 1, junior middle school = 2, high school or special secondary school = 3, junior college or above = 4; type of work: fallow at home = 1, farmer = 2, part-time farming = 3, temporary worker = 4, individualization = 5, officer = 6.

covering 16 townships. Based on the characteristic of rural housing land, a typical survey method was adopted to select 15 households from each village to carry out the household survey to investigate the basic situation of farmers' families and the area and utilization of rural housing land, and a total of 613 households were effectively investigated, 132 in the plain area, 362 in the mid-level area and 119 in the mountainous area.

3.3 Methods

3.3.1 Production function calculation of rural housing land

From the perspective of internal land use, farmers conduct production and operation activities in the courtyards, and the production function can be measured by the proportion of profitable land area, such as planting land, breeding land, industrial and commercial land, and productive storage land, airing land and lease land.

$$F_P = \sum_{i=1}^{6} A_{Pi} \Big/ A, \tag{1}$$

where $F_P$is the production function intensity of rural housing land to illustrate the scale benefit, $A_{P)}$ is the area of subclasses, and A is the total area of farmer's rural housing land (Eq. 1).

3.3.2 The production function evolution type judgment of rural housing land

The utilization rate of rural housing land is introduced to judge the utilization degree of the first case; namely, the residential security function of rural housing land:

$$\Delta EU = EU_i - EU_{i-1} \leq 0, \tag{2}$$

where EU_i is the utilization rate of rural housing land in a year i, $EU_{i\text{-}1}$ is the utilization rate of rural housing land in year i-1, and $\triangle EU$ is the change of land utilization rate under the condition that the use or function of rural housing land remains unchanged.

The rural housing land own-occupancy rate is introduced to analyze the structural characteristics of internal land use under the change of rural housing land use or function:

$$\Delta L = L_i - L_{i-1} \leq 0, \tag{3}$$

where L_i is the owner-occupancy rate of rural housing land in a year i (the proportion of internal owner-occupancy area), $L_{i\text{-}1}$ is the rural housing land owner-occupancy rate in year i-1, and $\triangle L$ is the change amount of rural housing land owner-occupancy rate under the change of use or function of rural housing land.

3.3.3 Factors influencing the production function of rural housing land under the characteristics of peasant households

(1) Model specification

The attitudes, subjective norms, and perceived behavioral control that affect farmers' land use behavior are latent variables, which are not convenient for direct observation. Structural equation modeling (SEM) is a statistical analysis method that can be used to establish, estimate, and test causal relationship models, which includes manifest variables—it also contains latent variables that cannot be directly observed (Hou et al., 2014).

The SEM was constructed based on the above assumptions. To test the causality in the model, an empirical test analysis was conducted on the model through a structural equation. The SEM with latent variables is composed of a measurement model and a structural model. Wherein, the measurement model expresses the relationship between indicators and potential variables, which is usually expressed as:

$$X = \Lambda x\xi + \delta,$$
$$Y = \Lambda y\eta + \varepsilon, \quad (4)$$

where $X$is the vector composed of exogenous observation variables, and ξrepresents exogenous latent variables; $Y$is the vector composed of endogenous observed variables, and ηrepresents endogenous latent variables; Λ§represents the factor load matrix of exogenous observation variables on exogenous latent variables, $\Lambda y$is the factor load matrix of endogenous observation variables on endogenous latent variables, and the two matrices represent the relationship between latent variables and observed variables. δ *and* ε are the residual matrices of the measurement model.

The relationship between latent variables is usually expressed as in the following structural equation:

$$\eta = \beta\eta + \Gamma\xi + \zeta, \quad (5)$$

where $\beta$is the mutual effect coefficient of endogenous latent variables; $\Gamma$is the effect coefficient of exogenous latent variables on endogenous latent variables; and ζrepresents the residual term of the structural equation, reflecting the unexplained part of η in the equation.

(2) Scale design

Based on the theoretical analysis framework of planned behavior, this study refers to relevant research results (Fang, 2014; Wan et al., 2017; Zhao et al., 2019) that are based on field research and interviews with farmers, and three latent variables. Their corresponding observable variables were designed and established from the perspectives of representativeness of driving factors and regional differences. Measurement methods adopt the Likert-scale scoring method, options are "completely disagree," "not agree," "not sure," "agree," and "completely agree," adopt positive assignment, respectively 1, 2, 3, 4, and 5 (including family population, the proportion of non-agricultural income, household culture degree, age and head of the household heads work types for actual values). The specific items are shown in Table 2.

4 Results and analysis

4.1 Temporal and spatial characteristics of rural housing land production function

4.1.1 Overall characteristic

According to the analysis, from 2005 to 2018, the production function decreased from 0.327 to 0.126 at a rate of 62%, and the coefficient of variation increased from 0.15 to 0.54 at a rate of 260%. This indicates that the overall production function decreased but the spatial heterogeneity increased. The productive storage function is the highest in 2005, followed by the function of airing and breeding. The total proportion was 95.4%. Airing was the highest among the production functions in 2018, followed by leasing, commercial, and industrial functions, which account for 80% of the total. From 2005 to 2018, the decrease in rural housing land production function in Pinggu District was mainly caused by the decrease of the productive storage, breeding and airing functions, while the rental, concurrently commercial and commercial functions, and planting functions showed an increasing trend (Figure 3).

The six sub-functions show a different change process, which reflects the change in regional industrial development and the farmers' livelihood. Specific analysis shows that the planting function was enhanced but the spatial heterogeneity was reduced, and the high-value area was transferred from the mid-level mountains to the mountainous areas and suburbs. This may be caused by the decrease in the area of cultivated land in the region and the farmers use the rural housing land to grow some vegetables for food. The breeding function and spatial heterogeneity decreased, and the high-value area shifted from mountainous areas and urban areas to mid-mountain areas.

On the one hand, this was due to the government's pollution control policies for livestock and poultry breeding, which limits breeding activities in rural housing land; on the other hand, it was also due to the upgrading of farmers' livelihood and their demand for a good living environment. The airing function decreased but the spatial heterogeneity increased, and the high-value area shifted from the mountainous area to the urban plain. This was mainly due to the decrease of the arable land area that was used by the farmers, the diversification of livelihood from single farming, coupled with the increasing number and area of housing. The productive storage function is reduced, the spatial heterogeneity is significant, and the high-value areas are still mountainous and mid-mountainous.

This is mainly due to the transformation of the mode of production, which led to a decrease in the proportion of agricultural production activities, and the changes in the

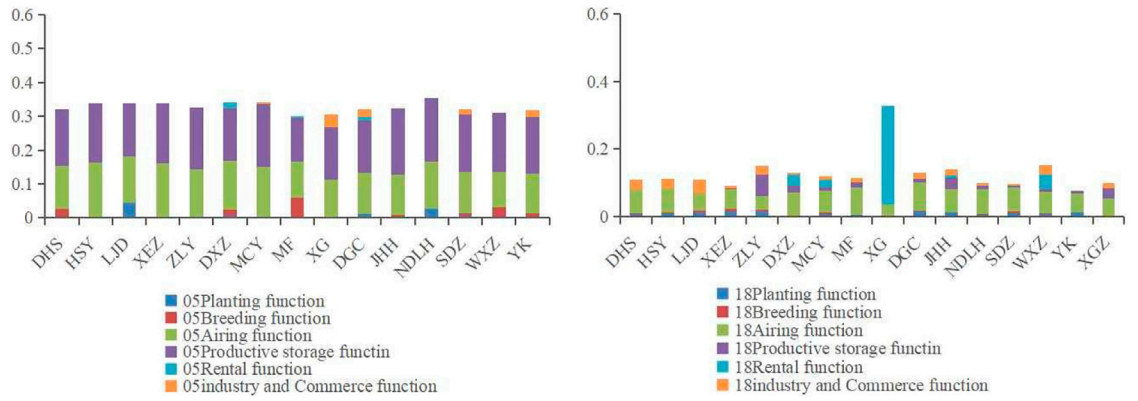

FIGURE 3
Internal sub-production functions of rural housing land in each town of Pinggu District.

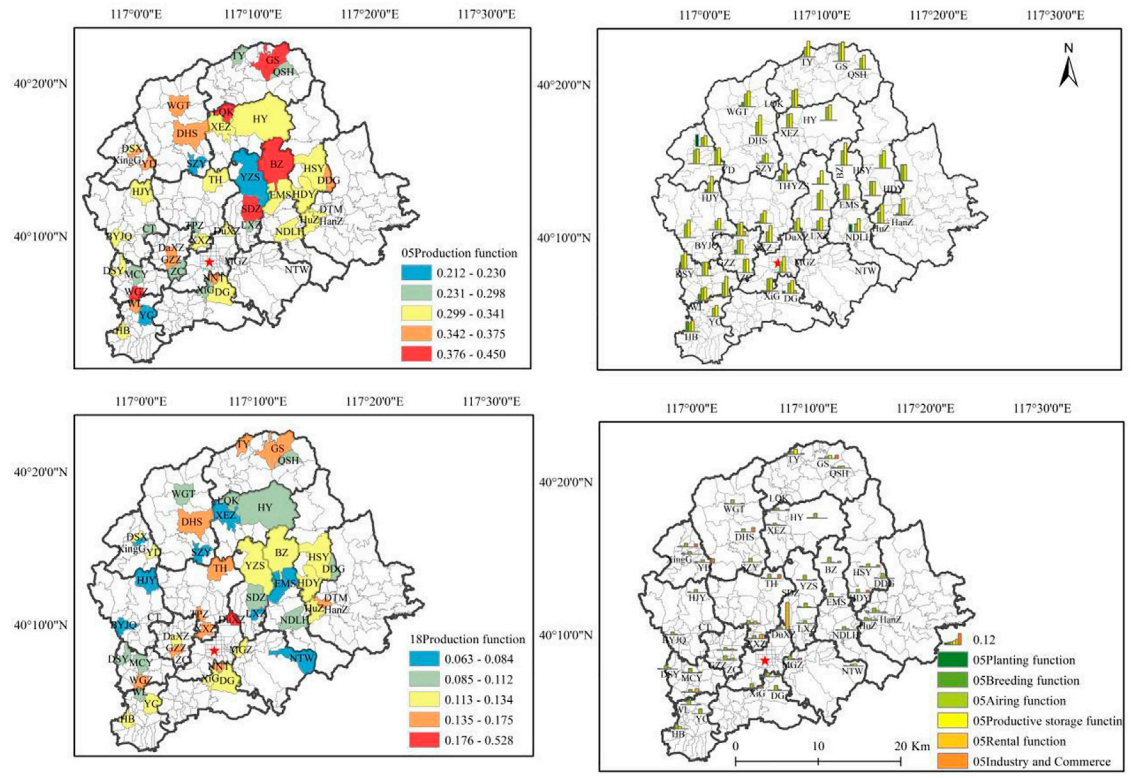

FIGURE 4
Production function and its sub-function space distribution.

economically developed plain areas are more drastic than those in the economically-backward mountainous areas. The leasing function was enhanced and the spatial heterogeneity increased. The high-value area is still near the urban area. This is mainly due to the rapid development of the suburban economy, which attracts the employment of migrants, resulting in frequent rental activities. The high-value area transferred from urban areas to mountainous areas. This was mainly due to the

development of tourism in some villages in mountainous areas and the increase in rural entertainment.

Due to the superior location, the leasing and commercial functions of rural housing land appear and strengthen in the developed plain area, near the industrial park or in the mountain tourist area. In the less developed areas, farmers have lower income and are more dependent on agricultural production (e.g., planting, breeding, productive storage, and airing) in the housing, and the land is relatively large. In the developed plain suburbs, while the agricultural production function weakened, the non-agricultural production function (concurrently as industry and commerce, lease) strengthened (Figure 4). This is consistent with the results of Qu and Zhu (2015), but different from those of Song (2012). This study also found that the production function of individual household rural housing land may be very low in the inner suburbs of the plain and high in the mountainous area or the outer suburbs. Therefore, in addition to the spatial differences, the functional ratio of rural housing land may be related to the characteristics of the farmers, which requires further analysis.

4.1.2 Typical evolutionary process

The production function evolution types of rural housing land can be identified by the changes in the characteristics of the internal land use structure at the beginning and end of the study. From 2005 to 2018, the production function change process of rural housing land in Pinggu District can be divided into three typical types: T1, T2, and T3. There are 22 households in T1 type, accounting for 3.59% of the total number of surveyed households. The utilization rate of the rural housing land improved; that is, $\triangle EU \geq 0$. There are only two households in the T2 type, accounting for 0.33% of the total number of surveyed households. In this type, the rural housing land is generally used for industrial and commercial activities from the idle and abandoned state. Therefore, $\triangle EU = EUi > 0$, but the proportion of the internal self-occupied area is still 0; that is, $Li{=}Li\text{-}1 = \triangle L = 0$. There are 42 households in T3 type, accounting for 6.85% of the total number of surveyed households. Both the rural housing land utilization rate and the owner-occupancy rate may increase or decrease, but the utilization rate is not 0 and the owner-occupancy rate is not 100%.

From the perspective of topographic differences, the proportion of T3 type in the plain area is 10.61%, which higher than the regional average and other topographic areas. The proportion of T1 type also reaches 4.55%, which is mainly distributed in Daxingzhuang, Duxinzhuang, and Machangying. From 2005 to 2018, the proportion of rural housing land production function showed an upward trend, increasing by 5.3%. The proportion of T1 type was the lowest among the topographical areas in the mid-level mountains, mainly distributed in Taihou village, Donggao village, and Xiaoxinzhai village, while the proportion of T2 type was 0.

From 2005 to 2018, the proportion of production functional rural housing land in the mid-levels increased by 2.48%. The proportions of T1 and T2 in mountainous areas were 5.88 and 0.85%, respectively, which were the largest among all topographic areas. T1 is mainly distributed in Heidouyu, Dahuashan, and Guancun, while T2 is located in Huayu village, and the proportions of T3 were the smallest among all topographic areas. The proportion of production functional rural housing land in mountainous areas increased by 5.89% (Table 3).

The main feature of the T1 type is that rural housing land produces a production function under the original residential security function. From the perspective of internal land use, it is reflected in the proportion reduction of the internal self-occupied area based on the improvement of the utilization rate of the rural housing land. The utilization rate of rural housing land increased by 6.7%, and the proportion of the internal self-occupied area decreased by 42.8% (Figure 5).

The inousing land changed, and the intensity of productive storage, lease, and industrial and commercial land increased by 0.9, 32.4, and 10.4%, respectively. The location conditions of such rural housing land are good, the labor force of peasant households is sufficient, and the property of rural housing land has the objective conditions to realize. The types of land used in rural housing land are rich and the conversion between the types of land used occurs, which is mainly reflected in the conversion of land space originally used for living and living storage to goods storage, house rental, and industrial and commercial operation for operating profit. The internal living land space is compressed and profitable land space gradually manifests. The T1-type marked land inside the rural housing land is used for both industry and commerce, which is rented and represented by a farmhouse.

The main feature of the T2 type is that the rural housing land is revitalized from the idle and abandoned state to stimulate the realization of its asset value, thus forming the profit function. From the perspective of internal land use, the rural housing land utilization rate increases from 0 to a value between 0 and 1, but the proportion of self-occupied areas generally remains at 0. According to the analysis of the change of the internal land use structure of the rural housing land in Pinggu District, under this type, the utilization rate of the rural housing land increased by 45.4%, while the intensity of rental land increased by 45.4%. The general location conditions of this type of rural housing land are superior and the overall construction quality is good. In addition, the internal land type is rich, which has the conditions for direct utilization. This is mainly reflected in land types leased out and used by the tenants for living or engaging in goods storage, industrial and commercial operation, and other activities, and the profitable land space gradually becomes obvious. Therefore, it can be concluded from this analysis that T2-type homelands in Pinggu District are mainly distributed in Yingcheng village, Xigao village, Magezhuang village, and other villages in the

TABLE 3 Basic information on conversion type of rural housing land production function.

	T1	T2	T3
Criteria	$\triangle EU \geq 0$, $\triangle L < 0$	$\triangle EU > 0$, $Li=Li\text{-}1 = \triangle L = 0$	$EU \neq 0$, $L \neq 100\%$
The amount and proportion of changes in plain areas	6, 4.55%	1, 0.75%	14, 10.61%
The number and proportion of changes in mid-levels	9, 2.48%	—	22, 6.08%
The number and proportion of changes in mountainous areas	7, 5.88%	1, 0.85%	6, 5.04%
The number and proportion of changes in the whole district	22, 3.59%	2, 0.33%	42, 6.85%

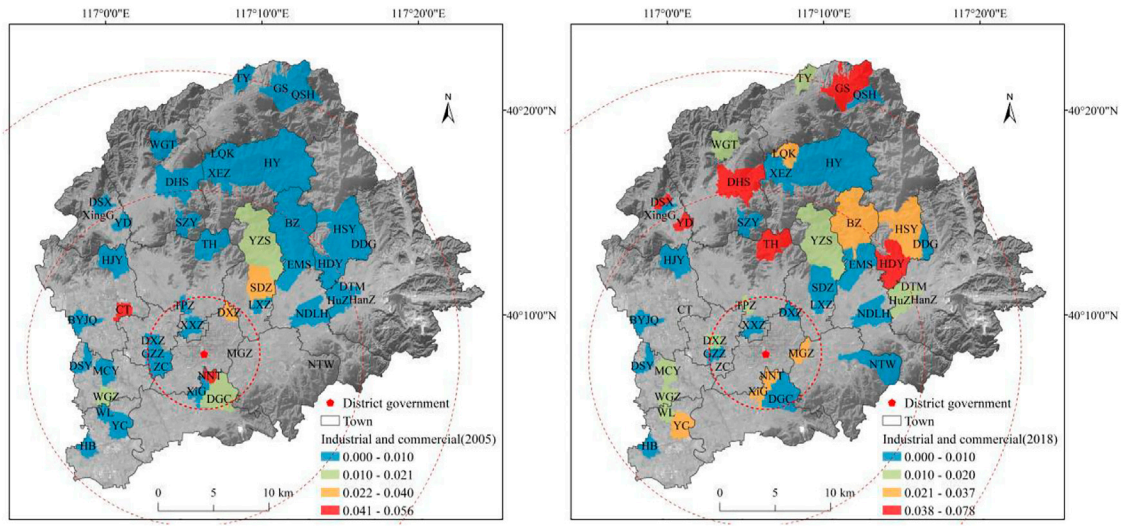

FIGURE 5
The change of the signalized land class inside the rural housing land under the type T1.

TABLE 4 The change of the signalized land class inside the rural housing land under the type T3.

Type of land use		In 2005		In 2018		△EU, △L (%)
		Area (m^2)	Proportion (%)	Area (m^2)	Proportion (%)	
Utility room	Productive storage land	16	7.13	6	2.50	△EU = 4.52, △L = −6.77
Facility	Dry land	30	13.37	9	3.74	
Land for planting		1.6	0.72	2.8	1.17	
Land for farming		8	3.57	3	1.25	
Lease the land		2	0.89	30	12.48	
Industrial and commercial land		3	1.34	25	10.40	

suburbs of the urban area. The internal marked land type is the emergence and enhancement of leased land.

The main characteristic of the T3 type is that the functional type attribute of rural housing land keeps the profit function unchanged. From the perspective of internal land use, it reflects that the utilization rate of rural housing land and the proportion of owner-occupied area may fluctuate, but the utilization rate is not 0 and the proportion of the owner-occupied area is less than 100%. According to the change analysis of land use structure inside the rural housing land in Pinggu District, under this type, the utilization rate of rural housing land increased by 4.52% and the intensity of planting land increased by 75%, which may be

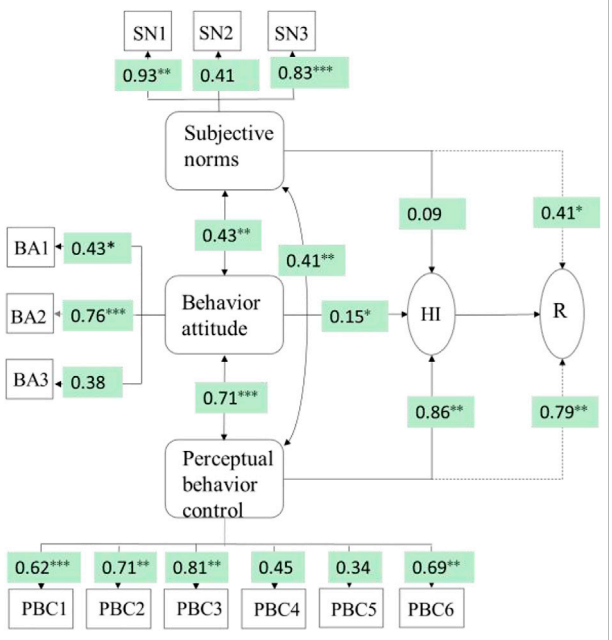

FIGURE 6
Measure the standard factor load of the model and the path coefficient of the structural model. (***, ** and * significant at the level of 1, 5, and 10%, respectively; χ^2/df = 1.021 (is the chi-square test of goodness of fit, and its value ranges from 1 to 3), RMSEA = 0.025 (root mean square of the approximation error, the value range is < 0.08), GFI = 0.907 (is the goodness of fit index, and the value range is > 0.9), CFI = 0.974 (comparison fitting index, value range >0.9), IFI = 0.912 (incremental fitting index, value range >0.9).

caused by the fall of the area of cultivated land in the region, and the farmers used the rural housing land to grow some vegetables for food (Table 4).

The intensity of land used for breeding decreased by 62.5%. On the one hand, this was due to the government's pollution control policies on livestock and poultry breeding, which restricted breeding activities in rural housing land. On the other hand, it was due to the upgrading of farmers' livelihood and their demand for a good living environment. Airing land use intensity fell by 70% and productive storage land intensity fell by 62.5%. This was mainly due to the change from single farming to diversification. In addition, it was due to the squeeze caused by the increase in the number and area of housing, while the transformation of the mode of production caused the reduction of the proportion of agricultural production activities. The productive storage of farmers mainly consists of farm tools and grain storage, and the change of economically developed plain area is more severe than that of economically-backward mountainous area. The intensity of the land used for leasing increased by 15 times, while the intensity of the land used for industry and commerce increased more than 8 times. This is mainly due to the rapid development of the suburban economy, which attracts the employment of the migrant population, resulting in frequent rental activities, the development of tourism in some villages in the mountainous areas, and the increase in rural entertainment.

4.2 Influencing factors and change mechanism of rural housing land production function

4.2.1 Influencing factors of rural housing land production function

Many factors affect land use structure, such as village location, village environment, and peasant household characteristics. As the actual users of rural housing land, farmers play a direct role in the use and function change of rural housing land (Yang et al., 2019; Kong et al., 2021). Therefore, this section focuses on the impact of household behavior characteristics on the production function of rural housing land. To quantitatively analyze the relationship between them, this chapter constructs a SEM based on TPB.

(1) Model test

Reliability refers to the dependability, stability, and consistency of scale test results. The internal consistency coefficient Cronbach's α was used for the reliability test.

$$\alpha = \frac{k}{k-1}\left[1 - \frac{\sum_{i=1}^{k} s_i^2}{s_x^2}\right], \tag{6}$$

where K is the total number of questions tested, s_x is the variance of the total number of tests, and s_i is the variance of the value of question i. SPSS19.0 software was used to analyze the reliability of observable variables of behavioral attitude, subjective norms, and perceived behavioral control. The results showed that Cronbach's α value was between 0.765 and 0.886, and the overall α value of the questionnaire was 0.914. Therefore, the data used in this study have good internal consistency.

Validity refers to the accuracy and reliability of the questionnaire, which can generally be analyzed from two aspects: convergence validity and discriminant validity. The KMO value of the analyzed data was 0.742, and the Bartlett sphericity test value was less than 0.001, which indicates that the sample data had the condition of factor analysis. In this study, principal component analysis (PCA) was used to perform exploratory factor analysis on the data. The convergence validity and discriminant validity of the observed variables were judged by the load value. The results show that the standard factor load of each observation variable is above 0.5, which indicates that the structure validity of each potential variable is good.

(2) Identifying the influencing factors

According to the analytical framework of TPB in the final model figure, path coefficients of behavioral attitude, subjective norms and perceived behavior control, and load coefficients of observation variables were obtained (Figure 6).

1) Behavior and attitude. Figure 6 shows that behavioral attitude has a positive impact on farmers' willingness, with a direct effect of 0.15. This indicates that the more positive the behavioral attitude of farmers is, the more significant their willingness to increase the production land will be. Among the three observed variables, the load coefficient of BA2 is 0.76, which is significantly greater than the other two variables, while BA3 is not significant. This indicates that in their behavior and attitude, farmers pay more attention to the improvement of living quality than the efficiency of rural housing land use and village planning. Behavior attitude has no significant effect on the land use suitability index. The analysis shows that the behavior and attitude may only affect the willingness of farmers, and there is no direct effect on whether or not to increase the production function of land.

2) Subjective norms. The social group pressure that farmers feel when deciding whether to increase the productive land still plays a certain role. As can be seen from Figure 6, the load coefficient of subjective norms' impact on farmers' willingness is 0.09, while the impact on the intensity of rural housing land production land is 0.41. This shows that social groups have little influence on the farmers' will but have more influence on their behavior. According to the specific analysis, the load coefficients of SN1 and SN3 are higher than 0.8, while the influence of SN2 is not significant. This reflects that family members play a greater role in the model norms, while relatives and friends have no significant influence. The prescriptive norms brought by the village collective have a great influence on farmers. This reflects the farmers' obedience to the government's advocacy behavior, and also indicates that the government's role of the village collective, as the owner of the rural housing land, plays a leading role in the change of the intensity of production land in the rural housing land.

3) Perceptual behavioral control. When farmers perceive that they have insufficient capacity and resources to implement the behavior of increasing production function land for rural housing land, their behavior will be hindered. The load coefficient of perceived behavioral control on farmers' willingness was 0.86, and the load coefficient of perceived behavioral control on farmers' behavior was 0.79. This shows that perceived behavioral control not only has an impact on intention but also has a direct effect on behavior. It can be seen from Figure 6 that PBC1, PBC2, PBC3, and PBC6 show significant effects, in which the load coefficient of PBC3 reaches 0.81, which is larger than other observed variables. PBC4 and PBC5 had no significant effect. This indicates that the household size, economic conditions, income structure, and other factors have a significant impact on the changed behavior of rural housing land production function intensity, while the characteristics of household owners have no significant effect.

4) It can also be seen from Figure 6 that behavioral attitude, subjective norms, and perceived behavioral control interact. Among them, the interaction force between behavioral attitude and perceptual behavioral control was larger, and the load coefficient was 0.71. This indicates that farmers with a positive attitude toward the increase of functional land for rural housing land are generally more willing to create more conditions for it, and thus have relatively high perceptual and behavioral control in the process of internal function change. In contrast, farmers with higher perceptual behavioral control have a stronger pursuit of a comfortable living environment and have a stronger behavioral attitude toward the increase of productive land on rural housing land. Meanwhile, the load coefficients between subjective norms and behavioral attitude and perceived behavioral control are 0.43 and 0.41, respectively, which shows that there is a certain mutual influence.

4.2.2 The change mechanism of rural housing land production function

Access to adequate housing is a basic human right and the provision of facilities essential for safety, comfort, health, and nutrition is considered to be central to human welfare. With the integrated development of urban and rural areas, the production function of rural housing land also changes to varying degrees. Relevant policies, village positioning, family conditions, and other factors affect the farmers' land use behavior. As micro-independent decision-making individuals, farmers have the characteristics of rational economic people. The occurrence of their idea-decision-behavior is a complex process, which plays a core role in the change of land use structure inside rural housing land.

1) The rationalization of the farmers' behavior decisions is the direct influencing factor of the internal land use change of rural housing land. Farmers have certain characteristics of "rational smallholder farmers," and their rational behavioral decisions can constantly adjust the use of rural housing land, driving its change in the direction of maximum land use efficiency, and efficient and reasonable land use structure. At the same time, affected by individual cognitive ability, family capital, and their selfishness and narrowness, the decision-making behavior of farmers is not completely rational. Unreasonable behavior may cause the inefficient

phenomenon, such as large courtyards and disorderly parking. To effectively guide and correct farmers' irrational behavior, we should further exert the prescriptive and normative role of the village collective.

2) Peasant household differentiation fundamentally affects the formation and change of rural housing land production function. With the rapid development of urbanization, the flow of urban and rural populations is more frequent. Depending on the difference in the family size, education level and other resource endowments of farmers, the livelihood mode of farmers has changed to different degrees, which further increases the existing differences among farmers. The differentiation of peasant households leads to the diversified characteristics of their understanding, demand, and choice of rural housing land, thus forming the diversified use of rural housing land with different functions and characteristics.
3) The macroeconomic, social, and institutional environment often takes farmers as the carrier and indirectly affects the internal land use change process of rural housing land. Regional land policy, village environment, and location characteristics are the external factors for the change in rural housing land use. The rapid development of society and economy makes the types of farmers increasingly abundant and the differentiation of farmers more complex, which also leads to the strengthening of the diversity and difference in rural housing land use. At present, the coordinated development of urban and rural areas continues to be promoted, various factors flow to rural areas, exchanges between urban and rural areas are frequent, institutional and policy barriers to rural development are gradually broken, and farmers' various land use behaviors show a diversified trend. However, the land use structure of residential land should urgently be reconstructed under the requirements of the rural revitalization strategy.

4.2.3 Explanation of production function changes of rural housing land from the perspective of bid rent and the theory of rent dissipation

Based on location theory, Wilhelm Alonso put forward a theoretical model of bid rent. The difference in land use in rural housing land comes from the difference in regional land prices and the difference in land rent payment ability of different economic activities. Restricted by property rights arrangement, rural housing land cannot be freely transferred and traded, so it is difficult to form a specific price. However, with the change in village economy and location, the asset property of rural housing land becomes increasingly obvious. It is quite common for farmers to use their rural housing land for industrial and commercial activities. Rural housing land occupies a large proportion of rural collective construction land, and the function change of rural housing land has an important impact on the overall land use form of rural areas (Zhu and Zhang, 2016).

Rural residents apply for rural housing land as collective members and allocate it for free. The initial allocation is based on welfare and security purposes. Theoretically, this is a completely planned allocation and is not affected by the market. However, as the spillover of urban residential function to the suburbs and urban property prices soar, the study area of house-sites in the countryside, and industrial and commercial activities and rent phenomenon is widespread, the market is increasingly obvious, and the influence of land asset attributes gradually appear. This can be seen in the following ways: the houses inside the rural housing land other than self-occupancy are rented out or engaged in industrial and commercial operations by themselves. Among them, rental for residential use, and mixed commercial and residential income along the street have little impact on the farmers' quality of life and are the main regional manifestation. However, the residential sites rented as industrial factories or warehouses significantly affect the farmers' quality of life, accounting for a small proportion, generally occurring in "one family with multiple houses" or in the idle residential sites of farmers living in cities. It can be seen that the expression form of rural housing land asset attribute is affected by village, location of rural housing land, and rural housing land ownership rate.

The theory of bid rent studies the distribution of land resources in different locations from the demand perspective of economic activities for land resources. Its premise is that land is homogeneous and can be bought and sold freely, and (actually) the property rights of rural housing land are separated; that is, collective ownership belongs to the village, and the use right for farmers, affected by the property rights system has the effect of rent dissipation, in entering the market and inevitable problems in the circulation. Its layout and construction are restricted by many factors. Therefore, the study of functional spatial differentiation of rural housing must take into account the role of property rights and institutions in the allocation of rural housing land.

According to Zhang Wuchang's two propositions about the dissipation of rent value, the difference between rural housing land and urban land property right arrangement leads to the restriction of the use and transaction of the rural housing land, and the value of rural housing land will inevitably decline. As the actual users of rural housing land, the farmers will not helplessly look at land rent dissipation, see their economic interests damaged and indifferent, but will take appropriate action to minimize the degree of dissipation. The function transformation of rural housing land from security to an asset is the result of the actions that farmers can take to reduce the dissipation of rural housing land rent under the constraints of the existing system. House rental, small family workshops, and farmhouse management are all typical methods of intensive use of rural housing land and reduce the rent dissipation of rural housing

land. At the same time, under the same institutional arrangement, the opportunity cost of farmers in villages with different location conditions to maintain the original residential security function of rural housing land is different, which will cause regional heterogeneity in the dissipation degree of rural housing land rent.

5 Discussion

5.1.1 Rural housing land production function

During the study period, the decrease in agricultural production activities resulted in a decrease of land space for productive storage, breeding, and airing, while the land for planting was preserved and strengthened because of its agricultural culture and ecological value. At the same time, the change of livelihood mode makes the amount of leased and commercial land rise. The rapid economic development of some areas in the suburbs (such as Pinggu Town) has attracted the employment of migrants, resulting in frequent rental activities. Part of the mid-level area has convenient transportation and beautiful scenery, which promotes the development of village tourism and family entertainment.

The production function of rural housing land tends to be imbalanced. It fosters the spatial evolution from multi-use to single-use land, and the dominant development from balanced to single-use land type. With the continuous improvement the economy and social development, when the traditional profit land such as planting and breeding is no longer a necessary type of rural housing land, the area standard of rural housing land can be moderately reduced to strengthen the intensive use of rural housing land. Previously, scholars believed that farmers in economically developed areas have higher income, and the production function of rural housing land is weak, so the area of land use should be less (Song, 2012). However, this study found that the agricultural production function (e.g., the subclass function of planting, breeding, and airing) in economically developed areas is weakening, while the production function strengthens thanks to the appearance and enhancement of non-agricultural production function (e.g., the subclass function of industrial, commercial, and rental use).

5.1.2 The embodiment of land use in the production function socialization of rural housing land

From the historical change and the trend of the farmers' independent choice, the production function can be separated from rural housing land and socialized within the village through rural land planning. The function of space separation and socialization of rural housing land is an important basis for the commercialization of rural spaces and provides the source of land use (Figure 8). The commodification of rural space is a process of re-resourcing in rural areas, which emphasizes the role of modern rural space as material production is declining, while the role of consumption space as non-material products is gradually increasing. The commercialization of rural space is one of the most important factors to promote rural change and prevent rural economic decline (Wang, 2013). It emphasizes the role of capital and power in rural change, which is the theoretical advantage of an international Frontier perspective of rural geography.

The commercialization of rural space pays more attention to the non-material goods that are attached to concrete resources. Immaterial "goods" created by material entities can be consumed repeatedly and consumers pay for and gain access to immaterial goods, rather than ownership. According to studies on the commodification of rural space, one of the paths to realizing the commercialization of rural space is the consumption of rural space by urban residents brought by reverse urbanization. In particular, rural tourism can attract people's imaginations (Wang, 2013).

5.1.3 The production function socialization within village of rural housing land is an important prerequisite to realizing the commercialization of rural space

Rural environment, population, rural housing land, and its ownership status are the foundation of rural land development and planning (Tusting et al., 2019). In 2019, the CPC Central Committee and The State Council issued "Several Opinions on Establishing and Supervising the Implementation of the Territorial Space Planning System," which required the formulation of practical village planning integrating multiple plans. Beijing Municipal Commission of Planning and Natural Resources promulgated the "Revised Guidelines for Village Planning in Beijing." In the same year, the General Office of Land and Resources issued the "Notice of the General Office of Natural Resources on Strengthening Village Planning and Promoting Rural Revitalization," stipulating that by the end of 2020, village layout at the county level should be complete under the national spatial planning. The implementation of these plans has significantly and gradually affected the state of rural land use in the region (Ma et al., 2022; Yao et al., 2022).

According to the data of the third national land survey, the area of rural housing land in Pinggu District is 4,682.17 hm^2, which is mainly distributed in the central and southwest mid-level mountains and plains. In the village, the agricultural land for facilities is 587.80 hm^2, and the pit and pond for breeding are 550.18 hm^2, which reflects the centralized function of agricultural land in the village. There are 1,335.85 hm^2 of industrial land, 1,043.37 hm^2 of facility land for commercial service, and 720.78 hm^2 of logistics and storage land in the village. This indicates that the industrial and commercial service land functions in the village have appeared to agglomerate. From a relatively regular distribution pattern, a certain unified layout and arrangement of land use have been made. In the village, the

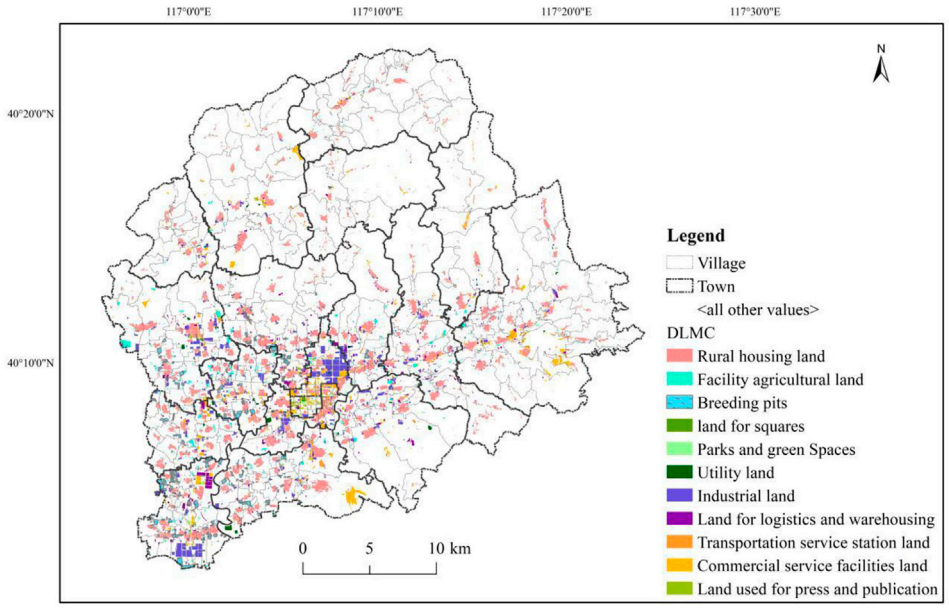

FIGURE 7
Present rural land use in the third national land survey in Pinggu District.

land for public facilities is 182.53 hm^2, the land for the traffic service station is 114.10 hm^2, and the land for the square is 25.52 hm^2. To some extent, this kind of land for public service has emerged and become an essential part of the village (Figure 7).

The analysis shows that the land for industry, commercial services, and some public facilities in villages of Pinggu District has gradually separated from the rural housing land, and has become centralized and socialized in villages. The layout of village land is changing toward zoning, classification, and is moving in a more reasonable direction. The development of village collective industries should conform to the functions and industrial development direction of the capital; highlight the industrial characteristics; rely on the resources of rural green mountains, rural scenery, and local culture; and promote the integrated development of primary, secondary, and tertiary industries under the principle of suitability. Based on sorting out the current situation of the collective industry and investigating the development intention of villagers, the types, goals, and paths of collective industry development should be proposed in combination with the requirements of superior planning (Serra et al., 2014; Qu et al., 2022).

On the premise of ecological protection and according to different location conditions and resource endowments, the characteristic industries of "suitable for agriculture and suitable for a green" should be developed in the villages with enhanced features and improved regulation located in the exurb plain and mountainous areas. In addition, leisure agriculture and rural tourism should be guided to develop. Based on sorting out the current situation of the collective industry and investigating the development intention of villagers, the development path of the collective industry before urbanization or relocation should be clarified in combination with the relevant arrangements for future development and construction of superior planning.

The distribution of land for collective industrial use in villages should meet the requirements of "two lines and three zones," and should encourage appropriate concentration by industrial characteristics through the overall planning and rational distribution of townships. Priority should be given to the use of existing industrial land for construction, and diversified forms of appropriate scale operation should be developed to achieve an organic link between the development of small farmers and modern industries. This will not only regulate the land but also meet the function demands of farmers and save land space. In the future, institutional innovation in rural housing land should be implemented based on region and type (Zhang et al., 2019). Rural housing land with strong production capacity in the plain can expand use rights, enter the market subject to rural land planning and land use control, and have the same right as state-owned residential land, allowing rent, sale, and mortgage and thus internalizing external profit (Ghosh, 2021).

5.1.4 Policy implications for rural land planning

General Secretary Xi Jinping pointed out in his report to the 19th National Congress of the Communist Party of China that we will implement the rural revitalization strategy and deepen reform of the rural land system. Land is the core element of

urban and rural development, and the diversification and compounding of land use functions is an important way to implement the rural revitalization strategy. Diversified use of rural housing land and effective activation of "sleeping" land assets are new driving forces for accelerating agricultural and rural modernization, and promoting integrated development of urban and rural areas. As the largest proportion of collective construction land, the system reform of rural housing land involves a huge number of farmers and is also an important link to rural revitalization.

Since 2003, the "No. 1 Document" for 19 consecutive years has focused on "agriculture, rural areas, and farmers." In 2018, the "No. 1 Central Document" laid out the reform idea of "separation of the three rights of rural housing land" in principle within the strategic framework of rural revitalization, which indicates the important significance of rural housing land system reform for rural revitalization. The first document of the CPC Central Committee in 2022 stressed the importance of steadily and prudently advancing the pilot reform of the rural housing land system and supporting the development of country inn and agritainment that are directly or jointly operated by farmers. In the process of urbanization in China, the functional transformation of rural housing land is not smooth, the value is not balanced, and the withdrawal mechanism is missing. This forms the paradox of the decrease in the rural population and the increase of rural housing land, and it is behind the conflict between the rural housing land system and the functional change of rural housing land, creating the dilemma between the government and farmers (Lv et al., 2021).

Under the guidance of industrial parks and urban industrial development, the degree of public service facilities in villages should be improved, attention should be given to maintaining and repairing the rural ecological environment, renovation of the living environment should be carried out, and the quality of life should be improved. At the same time, the disorderly expansion of rural housing land should be controlled, the social security function of rural housing land should be strengthened, and better basic conditions for the development of the production function should be created. Among them, for some villages who are close to urban areas and have a strong desire for urbanization, farmers can be settled by building centralized living communities with relatively complete basic conditions (Guo et al., 2020). The original rural housing land or house yard can be reclaimed for farming, planting vegetables or trees, or developing secondary and tertiary industries. Some of the rural housing land with protection value or utilization value can be retained. At the same time, as the production function of this area is relatively strengthened, the residential sites that were previously close to roads or concurrently used for industry and commerce can be directly demarcated as industrial development land and not demolished. The land will be centrally planned along the streets. In this way, the functional demand can be guaranteed, the farmer's quality of life can be improved, and the intensive use of rural housing land can be realized (Figure 8).

New city fringe areas and the center towns surrounding mid-levels district can lead to the construction of the new urbanization, put the village and town planning and construction together, take advantage of the town's population, improve industrial land utilization rate, reduce the proportion of idle land, and it can also relieve some farmers employment and avoid the contradiction of phase separation. The state should also accelerate the construction of the rural housing land system, especially the withdrawal mechanism, strengthen the social security system of rural villagers, and promote the stable withdrawal of farmers' rural housing land. Efforts to improve the living environment in villages should be made on an equal footing with those in cities and towns. The unused rural housing land can be reclaimed as farmland or built into public facilities, such as park green spaces, elderly houses, and parking lots, according to their different locations in the village.

In remote mountainous areas far away from new towns and central towns, the focus of rural land planning should be to optimize the living conditions of the farmers and improve the housing security function of rural housing land through renovation policies of dilapidated houses. It is necessary to strengthen the construction of auxiliary land for agricultural production in villages and guide the withdrawal of some functional structures in rural housing land according to the actual livelihood mode of rural households, promote the separation of agricultural production and living space, adjust and optimize the pattern of villages and rural housing land use, and improve functional specialization and rationalization of utility structure.

Typical rural villages with non-agricultural industry development should speed up rural land planning and construction and establish a unified village brand, such as the regional characteristics of the farmhouse management model. Furthermore, the regional landscape and cultural differences are fully reflected to make the production function of rural housing land sustainable. Because most of these villages are located in mountainous and mid-level areas, traffic conditions and local infrastructure conditions play an important role in attracting tourists and benefiting rural housing land. Therefore, a sound system of public service facilities should be established, including transportation, supermarkets, express delivery points, medical clinics, and other facilities. In addition, the rural social security system should be improved, such as providing an old-age pension and assistance, refine the policy of "mortgage of two rights," and guide the transformation of rural housing land into a profit function.

The rural housing land management system should be improved and its prescriptive norms of the village collective should be optimized. The management system of rural housing land should be placed based on guaranteeing farmers' rights, fairness, and social stability to realize the reasonable and effective use of resources. To improve the system of rural housing land, we must introduce the concept of public participation, allow farmers to appeal for their interests, and let farmers themselves become the best

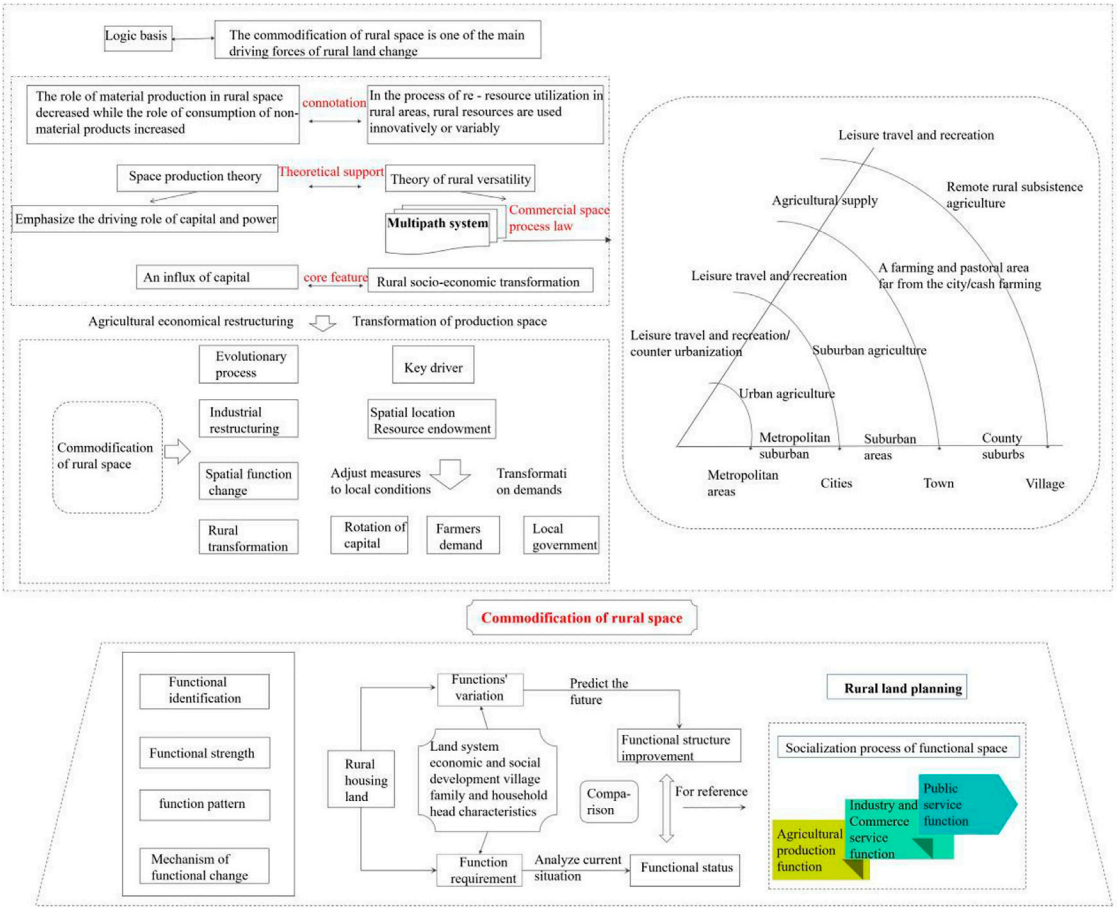

FIGURE 8
The relationship between the production function socialization of rural housing land and rural space commercialization under the background of village planning.

judge of their interests—who are no longer dominated only by the government, not pushing force by mandatory command, and cannot kidnap a few farmers with the will of the many farmers. Government, village collective, and policy researchers and makers need to strengthen two-way communication with farmers, understand the real demand to make sure the farmer rural housing land management system more scientific and democratic. It should make the management accord more with the actual situation and embody the interests of the public demand. In addition, the prescriptive code system for rural housing land management should be improved (Yang et al., 2021).

The income level of farmers and the employment structure should be improved, and the perceived difficulty of the farmers should be weakened. When adjusting the internal land use of rural housing land, the higher the household income, the higher the proportion of non-agricultural land; and the stronger the degree of non-agricultural employment mode, the lower the perceived difficulty of implementation (i.e., the lower the resistance of the change of internal land use of rural housing land). Therefore, we should promote the improvement of rural housing land use, reduce the hindrance of village collective to promote the reform of rural housing land use, and facilitate the advancement of village planning.

5.1.5 Research limitations and prospects

The sample size of this study is limited. Therefore, we recommend that more differentiated data should be collected in the next step. Due to the subjectivity of the survey object, the driving factor index system needs to be further improved. In the new background of urbanization and the request for the integration of urban and rural development, the production function of the rural housing land is taken as the breakthrough point. The index system and quantitative methods should be perfected. In addition, the production functions and space differences of rural housing land should be further studied according to the different kinds of function and farmers' demand to realize the rural housing land standard redesign. Based on this, different scenarios were set up to predict

the evolution law of rural housing land function. The potential of rural housing land renovation and the path of function improvement should be urgently studied. Finally, a scientific basis for the reform of rural housing land system and rural land planning should be provided.

6 Conclusion

In this study, Pinggu District and the important channels for the coordinated development of the Beijing-Tianjin-Hebei Urban Agglomeration are taken as an example. Based on the sample data of rural housing land, the theory of planned behavior, and the SEM, the micro-mechanism of rural housing land production function differentiation is analyzed from the perspective of internal land use and its socialization trend is discussed. The main conclusions are as follows:

(1) This study found that the production function of rural housing land in Pinggu District was differentiated and showed significant spatial differentiation. The high-value areas were mainly concentrated in the suburban plain and mid-level mountains. The production function of rural housing land withdrew and socialized in the village, following the rule of socialization of agricultural function—socialization of industrial and commercial service function, and socialization of public service function.
(2) Behavioral attitude, subjective norms, and perceived behavioral control have a significant influence on each other. Among them, the interaction force between behavioral attitude and perceived behavioral control is prominent (the coefficient is 0.71), which was above two and significantly affected the farmers' intentions. The subjective norms and perceived behavioral control significantly affected the production function of rural housing land, reaching 0.41 and 0.79, respectively. The demonstrative norms of family and the commanding norms of the village collective have significant effects on subjective norms (0.93 and 0.83, respectively), while relatives and friends had no significant effects. The perceived behavior control was significantly affected by income scale and structure, family size, and employment type (0.81, 0.71, 0.6, and 0.61, respectively), while the age and educational level of the household head have no significant affected.
(3) To further promote management of rural housing land, it is necessary to improve the institutional reform of rural housing land and optimize its mandatory norms, improve the income level of farmers and the employment structure, and weaken the perceived difficulty of the farmers. The production function socialization of rural housing land is an important prerequisite to realizing the commercialization of rural space. In rural land planning, it is advisable to optimize the layout of land use by zoning and classification according to the different location characteristics and function socialization stages of rural housing land (The Department of Economic and Social Affairs of the United Nations Secretariat, 2018; Zhao et al., 2019).

Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Ethics Statement

Ethics review and approval/written informed consent was not required as per the local legislation and institutional requirements.

Author Contributions

QZ: conceptualization, investigation, original draft preparation. GJ: writing-reviewing, editing, funding acquisition, project administration. WM: writing-review, editing, methodology. YY: writing-editing, language polishing. TZ: investigation, editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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