



Understanding the underutilization of rural housing land in China: A multi-level modeling approach

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ABSTRACT

A rich body of literature is stressing the crucial importance of migration and market evolution on the underutilization of housing in cities. Rural housing is unique given its less mature market structure. Drawing on an empirical case of Sunan, the work reported in this paper addresses underlying mechanisms of housing land underutilization in rural China. Employing a multi-level modeling approach, results suggest that the likelihood of underutilization relates to household and village features, such as family attributes, housing/parcel characteristics, type of villages, and geographical locations. Additionally, underutilization was also closely associated with regional contexts including local economic development levels and migration patterns. Theoretically, we conceptualized rural housing land underutilization as a land use transition with villagers' awareness of policy change possibilities in the context of both rapid urbanization and rural transformation with nested hybrid results. We argue that urban-rural differences do not induce underutilization. Rather, policy-induced overbuilding of new houses and insistence on retaining uninhabited older houses combined with the tendency for villagers to view investments as a mechanism to retain ties to their rural hometowns drove underutilization.

1. Introduction

Since economic reforms of 1978, rural China has undergone transformational change in both socio-economic condition and spatial patterns of land use (Liu, 2018; Newland, 2018). It was reported that nearly 170 million peasant workers left their home villages for cities in 2016 (Liu and Li, 2017). Communities with significant rural out-migration witnessed dramatic decline (Siciliano, 2012; Li et al., 2019). To be frank, decline of rural communities due to out-migration is a global phenomenon (Kates and Parris, 2003; Lambin and Meyfroidt, 2010; Liu and Li, 2017). Rural regions in the US, UK, and Australia have also experienced rural decline (Wilson, 2001; Argent, 2002; Holmes and Argent, 2016; Cowell et al., 2020). These can be associated with adverse impacts on rural land use (Long and Woods, 2011; Liu et al., 2014). To date, a rich body of literature has addressed the inefficiency of rural land

use in general and the underutilization of housing land in particular (Ma et al., 2018; Gao et al., 2020a).

In general, studies on the underutilization of housing land can be divided into spatially explicit and non-spatially explicit studies. Regarding the former, scholars focus on detecting, identifying, and estimating the spatial layout of vacant or abandoned houses using very-high-resolution remote sensing images, demographic statistics, sample surveys, and household power consumption data (Accordino and Johnson, 2000; Molloy, 2016; Li et al., 2019; Zou and Wang, 2020). These studies have identified spatial clustering of vacant houses by highlighting the influence of neighborhood and suggest the region-specific configuration features of residential land use (Foo et al., 2013; Deng and Ma, 2015; Newman et al., 2016; Zou and Wang, 2020). Morphologically, researchers also report that vacant parcels tend to be small, odd shaped, mis-located, and disconnected, making them difficult

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to rehabilitate (Bowman and Pagano, 2000; Newman et al., 2016; Kim et al., 2018).

The latter strand is devoting to exploring the impetus and influencing mechanisms of underutilization mostly from perspectives of institutions, governance, and actor-networks (Accordino and Johnson, 2000; Bowman and Pagano, 2000; Zhu, 2017; Huang et al., 2018; Chen et al., 2019). Employing both statistical and qualitative approaches, researchers have argued that disinvestment, depopulation, overbuilding and the rise of second homes in exurban areas were primary causes of vacancy (Bowman and Pagano, 2000; Sargeson, 2002; Norris and Winston, 2009; Couch and Cocks, 2013; Newman et al., 2016). In rural China, research has identified the dualistic nature of urban-rural socioeconomic development, the lack of social security for rural dwellers, ambiguous property rights with respect to collectively-owned land, and the restrictive system of rural land transfer as key factors making rural out-migrants reluctant to given up the ownership of housing after they relocate to cities (Fan and Zhang, 2019; Gao et al., 2020b).

Though these two lines of research have documented patterns of housing vacancy and abandonment, there continues to be a need to examine underlying mechanisms of housing land underutilization in rural China. Importantly, as influencing factors of land use dynamics may differ across various scales and locations due to scale-dependency and geographical non-stationarity (Parker et al., 2003; Gao and Li, 2011; Pearsall and Christman, 2012; Turner and Kaplan, 2019), a systematic understanding on the underlying impetus causing underutilization is necessary to deal with challenges driven by rapid urbanization and rural transformation facing China. Moving away from the traditional debate emphasizing land dynamics as a process involving population redistribution (Gao et al., 2017; Liu and Li, 2017), we argue that the reconfiguration of driving forces at multiple levels provide a more comprehensive framework to understand underutilization of residential land in rural China.

This said, our work aims to interpret why some housing lands in rural China were underutilized while others were not. Following this introduction, the paper is organized into five subsequent section. First, a conceptual framework for understanding the underutilization of housing land in rural China is presented followed by a discussion of data used and methods applied. We then discuss the mechanisms influencing underutilization of residential lands in southern Jiangsu (Sunan). Empirical analysis employs a multi-level modeling approach which has been widely used to separate the effects of factors at different scales in both spatial and hierarchical terms (c.f. Jiang et al., 2012; Zhang et al., 2014; Li et al., 2018). We conclude by discussing rapid rural land use transitions in China within the context of theoretical contributions, policy implications, and future research needs.

2. Research context and conceptual framework

2.1. The geography of underutilization: a global perspective

In general, both vacancy and abandonment should be recognized as underutilization (Accordino and Johnson, 2000). Residential lands in both urban and rural regions would be considered underutilized in two situations: excess supply with limited demand and intermittent use of dwellings due to out-migration. As Molloy (2016) noted, housing underutilization reflects an important sign of overbuilding. The incentive to buy new houses in the periphery rather than inhabit old ones significantly aggravates the underutilization in central cities (Monkkonen, 2019). Haase et al. (2014) and Dubeaux and Sabot (2018), on the other hand, argued that the occurrence of underutilization was one of the most visible outcomes of depopulation. In a nutshell, housing land underutilization can be attributed to the market-driven mismatch between supply and demand both spatially and temporally (Kremer et al., 2013). To be sure, physical and institutional factors also affect underutilization of rural residential lands.

A growing literature documents underutilization as a symptom of

widening urban-rural inequality particularly in the Global South (Jedwab et al., 2017; Maharjan et al., 2020). Other research highlights location-specific physical attributes. Residential land in mountainous regions tends to be more underutilized than that in flatter plains regions (Li et al., 2019; Zhou et al., 2020). From an institutional perspective, others report the importance of land use policies, village planning, and social networks (Zhu, 2017; Yang et al., 2020). Of particular interest is the dualistic system of land use in transitional China being at the core of underutilization (Huang et al., 2018). Generally, the market-based transfer of land in rural China is explicitly prohibited. Rural migrants cannot profit from land transactions. Thus, rural outmigrants tend not to give up their land use rights in their hometowns (Chen and Fan, 2016; Yep and Forrest, 2016; Fan and Zhang, 2019). This leads to underutilization of residential lands. Studies of exurbanization in the US show that residential expansion and overbuilding in rural regions was attributed to limited control over the developmental process, low levels of regulation, relatively inexpensive rural lands, net benefits for local units of government combined with speculation, and the continual demand pressures for amenity-based frontier lands (Esparza and Carruthers, 2000; Marcouiller et al., 2002). Further, lands in remote rural regions with high levels of natural amenities are increasingly being consumed for residential purposes as part of a counter-urbanization phenomenon driven by affluent urban interests (Geyer, 2018). In South Africa, this has been shown to be a significant migratory element despite its latency from a mass migration perspective causing structural demographic change in the region of in-migration (ibid). This brings into question both gentrification-driven social justice issues due to displacement of local people (Dissart et al., 2020) and the sustainability of rural development due to an oversupply of rural housing (Gkartziou and Norris, 2011). Functional transitions in land use are a consequence of the post-productivist era largely facilitated by amenity-seeking demands of affluent and footloose urbanites (Norris and Winston, 2009; Halfacree, 2012; Gallent and Tewdwr-Jones, 2018). In a nutshell, underutilization can be generally understood as a transition in rural residential land use that inevitably involves the diminution its original function as residence for locals and the emergence of a new one catering to incoming urbanites.

2.2. Conceptualizing the underutilization in rural China: a multi-level perspective

Economic literatures identifies several factors that contribute to an explanation of the underutilization of rural housing land in China. These involve migration of labor, deagrarianization, urbanization-induced lifestyle change, and incentives offered by the dualistic land use system (Sargeson, 2002; Fan and Zhang, 2019; Zhou et al., 2020). Geographers, however, argue that determinants of underutilization vary at different scales and levels (Jiang et al., 2012) and a wide range of factors like population, employment structure, and urban-rural disparities are important to the utility of local residential lands (Zhu, 2017; Long, 2020). In addition to these orthodox factors, scholars also identify the impact of governance structure and social configuration on rural housing land use at the village level (Gao et al., 2017; Yang et al., 2020). Moreover, anecdotal evidence indicates that an important cause of housing underutilization is that house owners in single families die without wills. This leaves a confusing situation for local authorities with respect to the disposal of parcels (Gao et al., 2020a). Inspired by findings at different scales, we propose in Fig. 1 a triple-level framework to comprehensively understand the utility of rural housing land in China.

At the household level, villager land disposal decisions are likely to be simultaneously influenced by both family and parcel/housing characteristics (Gao et al., 2017; Cao et al., 2019). Scholars identified the significance of livelihood and family structure in household decision criteria regarding new house building and old house disposal (Yang et al., 2020). The aging of a large nuclear family into several subsequent families certainly raises the need for new dwellings. This causes a lateral

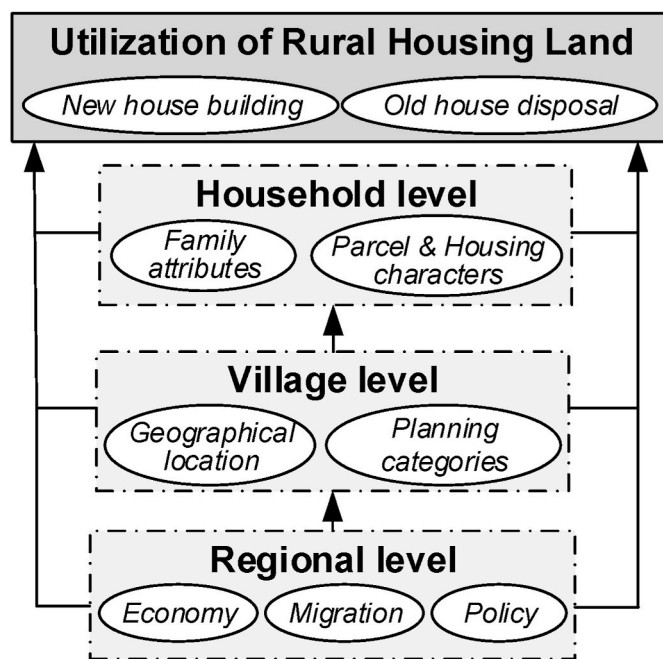


Fig. 1. Multi-level framework for analyzing the utilization of rural housing land in China.

expansion of rural residential land (Liu et al., 2010). Sargeson (2002) reported that social and demographic aspirations of families and the reconfiguration of their economic activities were major stimuli of rapid house building spurts. Kong et al. (2018) suggests that morphologies (i. e., shape and area) of land parcels were core factors affecting the utility of rural housing land. More directly, housing conditions like building age, construction type, and floor area ratio have been widely considered as factors affecting the well-being of rural dwellers, which are therefore primary consideration for villagers in making their land use decisions (Zavadskas and Antucheviciene, 2007; Gao et al., 2017).

At a broader village level, the utility of rural housing land is influenced by a set of factors that interact with each other and differ across regions (Shan and Feng, 2018; Xu et al., 2019; Xia et al., 2020). Tian et al. (2014) highlighted the significance of geographical location (i.e. distance to cropland, water bodies, main roads, and urban centers) in affecting rural housing land dynamics. Employing DEM data, Shan and Feng (2018) revealed the impact of topographical factors (i.e., slope and elevation) on the utilization of residential land in rural China. Furthermore, Morckel (2014) argued that conditions in surrounding neighborhoods tended to have a greater influence on the probability of housing abandonment than did conditions in the neighborhood itself. Socio-economic factors including per household housing area, per capita net income, per capita arable land, arable land quality in villages, as well as rural cultural/heritage attributes and local planning initiatives have also been considered in demystifying the nexus between housing land utility and rural restructuring (Tan and Li, 2013; Zhou et al., 2020).

At the county/regional level, the underutilization of rural housing land is generally characterized as a result of the interaction of socio-economic factors (Li et al., 2015; Long, 2020). For instance, some scholars have reported the importance of population and migration extent, industrial structure, and urban-rural gaps in affecting the utility of rural housing land (Scarlett Epstein and Jezeph, 2001). While some others documented significant differences in influencing factors of rural housing land use under different levels of economic development (Zhang and Han, 2018). More comprehensively, Xu et al. (2019) and Zhou et al. (2020) argued that the social environment, regional planning, and land use policies tended to have an interactive effect on the utility of housing land.

3. Data and methods applied

3.1. Study area and data processing

Situated in the Yangtze River Delta, Sunan (including the five prefectural level cities of Nanjing, Wuxi, Changzhou, Suzhou, and Zhenjiang; see Fig. 2) - is also one of the most urbanized areas in China. Sunan had a total population of 38.01 million with about 80% dwelling in urban areas in 2020. Compared with other regions, Sunan is unique not only because of its eye-catching performance in urbanization but also due to the well-known model of development driven by local state-directed township and village enterprises (TVEs) (Ma and Fan, 1994). Since the early 1990s, TVEs have been privatized with changing institutional contexts. Globalizing Sunan has become a new strategy of regional development (Wei, 2010). Sunan has witnessed dramatic changes in both socio-economic and spatial terms. The transition in rural residential lands featured by underutilization was particularly significant (Gao et al., 2020b).

The work reported in this paper is based on three sets of data: household-level data, locational and physical attributes, and survey data. The household-level data was used to portray the family/housing and parcel characteristics and was collected from a rural land survey in Jiangsu Province conducted by the provincial Department of Natural Resources in 2016. For reasons of confidentiality, we first desensitized the land use data by converting polygons to point features. With the basic information about families, housings, and parcels, a database of rural housing land was constructed to examine the pattern of underutilization. The database indicates over 3.12 million housing parcels with a total area of 63,786 ha in rural Sunan by the end of 2016, accounting for 20.42% of all construction land. The areas of vacant and abandoned parcels were 5820 ha and 892 ha, giving a total underutilization rate of 10.53%.

Given that the size of the original data, a spatial sampling method combining grouped and random approaches was used to reduce the size of the data set. Employing the inbuilt data analysis tool of sampling and the VLOOKUP function in MS Excel software, we first sampled 1% of the underutilized parcels yielding 3902 parcels (including 3680 vacancies and 222 abandonments). Considering the ratio of one to seven between the normally-used and underutilized parcels, we randomly selected 27,314 normally-used parcels. Thus, the total number of housing land parcels employed in the final models was 31,216, which well represents the population and can be handled by such commonly used statistical software packages as R.

To examine the hypothesis that the underutilization of housing land was determined jointly by household attributes and village characters, we used data on locational and geological features of villages. Employing the digital evaluation map of 30 m resolution acquired from the U.S. Geological Survey (USGS), we generated average levels of slope and elevation in sample villages. We also calculated the distance of villages to nearest towns and major roads with the help of ArcMap 10.2 software. The information about village type was derived from village planning datasets of local governments. The third data set, acquired from Jiangsu Statistical Yearbook 2017, was used to test influences of county-level socio-economic development.

3.2. Multi-level model specification

Research on land system and land change science over the past decades concludes that land utilization is an outcome of biophysical and socioeconomic determinants that occur across multiple spatial and temporal scales (Jiang et al., 2012). Similarly, housing land use is spatially autocorrelated and more similar within groups (villages/counties) than across different groups, due to the influence of environment within same groups (Siciliano, 2012; Zhang et al., 2014). The utility of rural housing land represents similar trends within households with similar attributes, and much greater differences among those

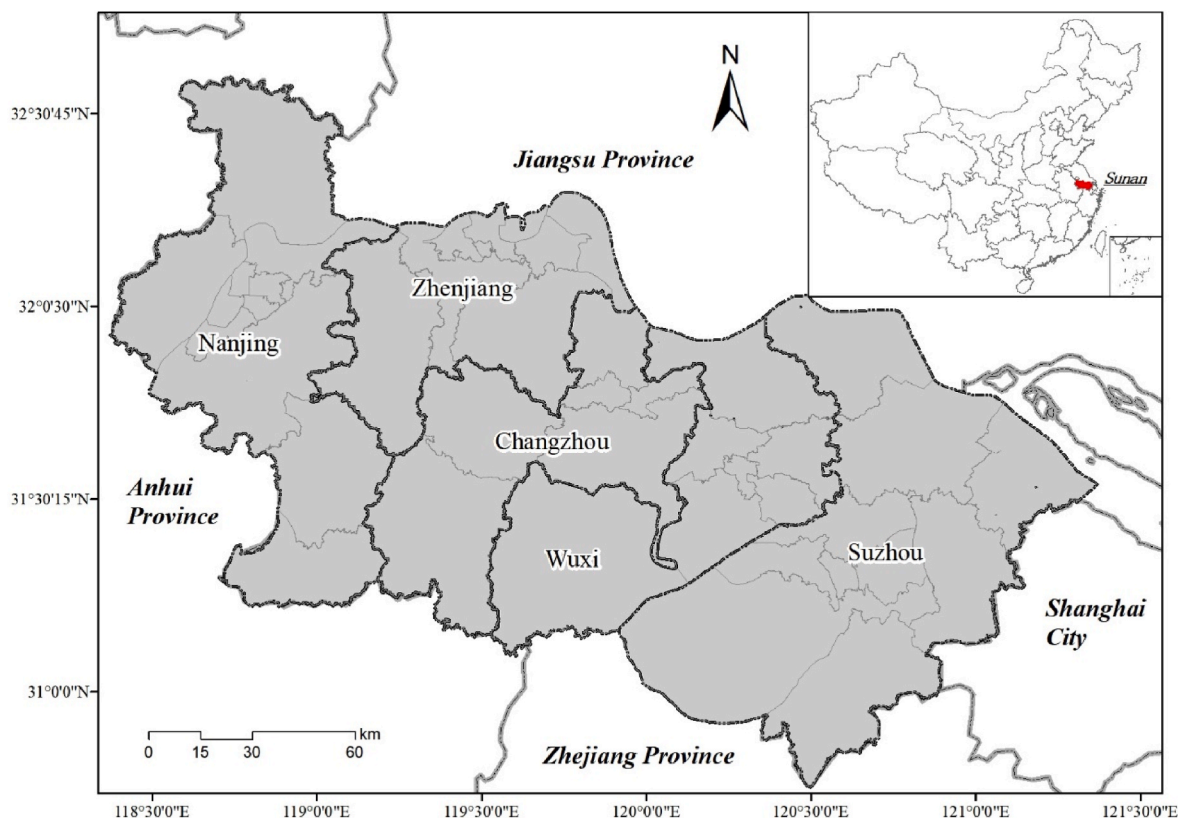


Fig. 2. Location and spatial organization of study area.

without similarity. In a nutshell, the underutilization of rural housing land is a result of nested structure activity. It is the result of processes that act at different levels.

Given that conventional regression models cannot resolve such nested relationships, the multi-level modeling approach was employed in this work to separate the effects of factors at household-, village-, and county-levels. Being designed to simultaneously integrate variation that originates from multiple levels to evaluate the relative impact of factors across administrative and spatial scales, the multi-level model seems to hold great promise in helping to understand the nested structure of activity that underlies the underutilization of rural housing land. Specific to this work, the one-level model is a pooled regression using household-level data including family attributes, housing conditions, and parcel features, while the two-level model adds village-level factors ($n = 4869$). Moreover, considering that the county-specific effects are uncorrelated with the underutilization at each household/village, we further controlled for random effects across the 36 county groups in the three-level model. Inspired by the work of Zhang et al. (2014) on cropland abandonment as a binary response variable, we structured a multi-level logistic model in the following equations:

$$Y = \log\left(\frac{P_{ijk}}{1 - P_{ijk}}\right) \tag{1}$$

$$Y = \beta_0 + \beta_1 x_{ijk} + \beta_2 v_{jk} + \beta_3 c_k + r_{ijk} + u_{jk} + e_k \tag{2}$$

where Y denotes the dependent variable representing the log of the odds of ‘success’. P is the probability of the occurrence of a “rural housing land underutilization” event. The subscripts i, j and k represent the three levels of household, village, and county, respectively. x_{ijk} , v_{jk} , and c_k are the explanatory variables in the three levels. $\beta_0, \beta_1, \beta_2, \beta_3$ are regression coefficients. r_{ijk} , u_{jk} , and e_k are the random errors.

3.3. Potential explanatory variables

We introduced seven indicators to describe parcel characters and associated family and housing features at the household level: area of parcel (*AREA*), shape of parcel (*SHP*), type of household (*ToH*), household population (*HPOP*), housing age (*HA*), housing structure (*HS*), floor area ratio (*FAR*) as reported in Table 1. Scholars have demonstrated that both housing area and structures of buildings matter for the welfare of dwellers (Wu et al., 2012; Kremer et al., 2013), which can thus influence the utility of housing. The household type and population also affects use of housing land in rural China through the downsizing and out-migration of family members (Zhu, 2017; Lu, 2020). Others factors like the age and floor area ratio tend to impact the physical condition of housings, which are regarded as key to their utility (Gao et al., 2017; Gao et al., 2020a).

We employed five indicators at the second level to capture village attributes likely to influence the utility of housing land. The type of village (*ToV*), as a meso background of rural land use, denotes the impact of governmental planning on rural land use (Yang et al., 2020; Zhou et al., 2020). While distances to towns (*D2T*) and roads (*D2R*) are used as indicators of urbanizing potential and market access, which have reflect main drivers for land use transition in rural China (Gao et al., 2020b; Long, 2020). As Xia et al. (2020) demonstrated, the village’s physical attributes including average slope (*SL*) and elevation (*EL*) were closely associated with vacancy and abandonment of housing land in rural China.

At the county level, we used seven indicators of socio-economic development: per capita GDP (*PGDP*), fiscal concentration (*FC*), permanent population (*PPOP*), ratio of migration (*RoM*), rural income (*RI*), ratio of rural household expenditure to income (*RE2I*), and urban-rural gap (*URG*). We expected *PGDP*, *FC*, and *PPOP* to have negative impacts on housing land underutilization because those developed and populated counties tended to be physically and socially attractive (Li et al.,

Table 1
Definitions and statistical descriptions of variables used in the multi-level model.

Variables	Definitions	Exp. sign	Mean	SD	Min	Max
Dependent variable						
Status of utilization (<i>SoU</i>)	Dummy variable equals 1 if a land parcel is vacant or abandoned; otherwise, the value is 0.		0.12	0.33	0.00	1.00
Explanatory variables						
<i>Household level (n = 31,216)</i>						
Area of land parcel (<i>AREA</i>)	Total area of a land parcel (square meter).	–	199.34	221.40	3.50	10,251.31
Shape of land parcel (<i>SHP</i>)	The perimeter of a land parcel divided by the perimeter for a square patch of the same size.	+	0.40	0.19	0.04	3.66
Type of household (<i>ToH</i>)	Farming = 1, part-time farming = 2, non-farming = 3.	–	1.53	0.64	0.00	3.00
Household population (<i>HPOP</i>)	Number of family members registered locally in the housing land.	–	3.19	2.05	0.00	186.00
Housing age (<i>HA</i>)	Age of buildings on the parcel (years).	+	30.90	10.04	5.00	50.00
Housing structure (<i>HS</i>)	Steel & concrete = 1, brick & concrete = 2, brick & wood = 3, others = 4.	+	2.42	0.73	1.00	6.00
Floor area ratio (<i>FAR</i>)	Ratio of the building area to the area of land parcel.	–	0.78	0.21	0.00	10.89
<i>Village level (n = 4869)</i>						
Type of village (<i>ToV</i>)	Planned to be consolidated = 1, to be preserved = 2, to be expanded = 3.	–	1.95	0.30	1.00	3.00
Dis2Towns (<i>D2T</i>)	Distance to the nearest urban area (meter).	+	3589.65	1742.20	34.63	11264.58
Dis2Roads (<i>D2R</i>)	Distance to the nearest major road (meter).	+	226.48	257.76	0.03	4558.87
Slope (<i>SL</i>)	Average slope of the village (degree).	+	2.75	2.66	0.00	37.36
Elevation (<i>EL</i>)	Average elevation of the village (meter).	+	13.12	19.32	0.00	309.00
<i>County level (n = 36)</i>						
Per capita GDP (<i>PGDP</i>)	Gross domestic product of a county divided by its population (10,000 yuan).	–	145,000	39,889.74	78,862	284,000
Fiscal concentration (<i>FC</i>)	General budgetary revenues of a county divided by its GDP.	–	0.09	0.02	0.04	0.16
Permanent population (<i>PPOP</i>)	Number of people dwelled in a county for at least 6 months in a year (10,000 person).	–	40.10	16.67	0.51	70.07
Ratio of emigration (<i>RoM</i>)	Number of rural migrants divided by the size of registered population in a county.	+	12.97	16.46	–21.43	46.38
Rural income (<i>RI</i>)	Average annual income of rural households (yuan).	–	23,928	3085	18,893	28,181
Ratio of expenditure to income (<i>RE2I</i>)	Annual expenditure of rural household divided by rural income.	+	63.04	27.39	0.00	86.77
Urban-rural gap (<i>URG</i>)	Ratio of urban income to rural income in a county.	+	2.00	0.12	1.758	2.24

2019; Xu et al., 2019; Tang et al., 2020). On the contrary, *RoM*, *RE2I*, and *URG* were expected to aggravate the underutilization because of the consequence of push and pull interactions from rural to urban areas (Gao et al., 2017; Ma et al., 2018; Fan and Zhang, 2019).

4. Results

4.1. General trends of rural housing land underutilization

In association with theoretical and contextual issues, we first analyzed the overall utilization preference of rural housing land with different attributes at the household, village, and county levels. The result is reported in Table 2 and discussed as follows.

First, with the primary source of rural household income changing from farming to part-time farming and non-farming sectors, the underutilization rate increased from 6.03% to 14.93% and then to 22.63%. This reflects the aggravating effect of deagrarianization on the underutilization of housing land on the one hand (Zhou et al., 2020) and of the potential of functional transition of housing land on the other (Ma et al., 2018). Coincidentally, households with smaller numbers of occupants tended to make similar housing land use decisions with

lower-farming-dependent households, whereas households with more registered family members were inclined to keep their housing land efficiently used. Once again, these reflect the significance of family attributes in shaping the geography of housing land use in rural Sunan (Fig. 1).

Compared with land parcels of larger area and more regular shapes, counterparts with a relatively small area and complex shapes were more inclined to be underutilized. This is consistent with the arguments of Qu et al. (2019). Moving to attributes of the housing itself, the survey reported that the underutilization rate was much lower for houses built with strong materials (i.e., steel & concrete or brick & concrete) and high floor area ratio than for those built with simple materials (i.e., brick & wood) and low floor area ratio, suggesting the significance of construction cost. From another perspective of housing age, underutilized houses had an average age of 34.55 years, which was 4 years older than the normally-used counterparts, indicating the importance of housing conditions.

Consistent with common sense, villages to be consolidated had the highest rate of underutilization due to upcoming community remediation projects. However, the underutilization rate in resettlement communities was ironically 4.59% higher than that in preserved villages,

Table 2
Utilization preferences of rural housing land parcels with different attributes.

Status	<i>ToH</i> = 1*	<i>ToH</i> = 2*	<i>ToH</i> = 3*	<i>HPOP</i>	<i>AREA</i>	<i>SHP</i>	<i>HS</i> ≤ 2*	<i>HS</i> ≥ 3*
Underutilized	6.03	14.93	22.63	1.46	145.43	1.12	7.33	17.58
Normally-used	93.97	85.07	77.37	3.45	204.50	1.10	92.67	82.42
Status	<i>HA</i>	<i>FAR</i>	<i>ToV</i> = 1*	<i>ToV</i> = 2*	<i>ToV</i> = 3*	<i>D2T</i>	<i>D2R</i>	<i>SL</i>
Underutilized	34.55	0.78	27.42	9.51	14.10	3450.48	273.18	2.69
Normally-used	30.53	0.80	72.58	90.49	85.90	3597.71	221.89	2.79
Status	<i>EL</i>	<i>PGDP</i>	<i>FC</i>	<i>PPOP</i>	<i>RoM</i>	<i>RI</i>	<i>RE2I</i>	<i>URG</i>
Underutilized	11.15	143,821	0.08	40.77	19.99	23,621	66.61	1.97
Normally-used	13.11	145,081	0.09	40.20	12.07	24,022	62.35	2.00

Note: * denotes the proportion of land parcels; other variables use the average value of observations.

verifying the argument by Norris and Winston (2009) and Holmes and Argent (2016) that rural renewal schemes together with demographic flux played a significant role in driving growth in vacant dwellings numbers. Moreover, underutilized land parcels tended to be located in villages distant to major roads but closer to the urban areas, reflecting the significance of traffic accessibility and urbanization potential within China’s dualistically organized regime (Hao and Tang, 2015; Gao et al., 2020b). Contrary to conventional wisdom (Li et al., 2015), villages with slight slope and low elevation had more housing land being underutilized than their counterparts with steep slope and high elevation.

Regarding regional characteristics, lagging counties with smaller GDP per capita and lower fiscal ability witnessed more issues of underutilization. Populated counties and particularly those with more out-migration were facing a similar dilemma. As expected, increasing household income could substantially enhance farmers’ ability of improving their living conditions and thus facilitated the utility of their housing land. Higher ratio of daily expenditure to income, however, limited their ability and consequently raised the underutilization rate. Analogously, narrow urban-rural gaps led to relatively lower cost for rural dwellers to relocate in towns and indirectly resulted in the underutilization of housing land and even village hollowing (Tang et al., 2020).

4.2. Determinants of rural housing land underutilization: a multi-level logistic approach

To shed further light on the underlying impetus of housing land underutilization, we employed a multi-level modeling approach to investigate the determinants with the consideration of heterogeneities of household attributes, village features, and county characteristics. Prior to the construction of models, we tested the variance inflation factor (VIF) of each independent variable and found that all VIFs were smaller than 10 with the mean of 2.67, implying an acceptable levels of multicollinearity in these models. Tables S1 & S2 represent the result of the test and correlation analysis. To further indicate the proportion of variance that is explained by a given group, intra-class correlation coefficients (ICCs) were calculated by structuring the null model (i.e., an intercept-only model). The result shows the ICCs for village and county levels were 0.547 and 0.238, justifying the application of the multilevel logistic models. We also introduced the Akaike’s information criterion (AIC) and Bayesian information criterion (BIC) as goodness-of-fit indices, which compare the fitness improvement over the one-level model by adding the context characteristics of two-level and three-level. Smaller values on AIC and BIC suggest better models in terms of fit and parsimony. The estimation results of multi-level models are presented in Table 3 as odds ratios with 95% confidence intervals and a 5% significance level with random intercept models.

The one-level model with household-level variables reveals that the underutilization of rural housing land is closely associated with both family features and parcel/housing characters. The negative influences of AREA and HPOP on the underutilization of rural housing land were statistically significant. Smaller household size in terms of both land area and family member were more likely to underutilize housing land reflecting the influence of family size on farmer housing decisions in China (Zhu, 2017). The type of household (TOH) and housing features (HA and HS) were positively associated with underutilization, implying that rural housing land underutilization was likely to be associated with non-farming households and poor housing conditions. These socio-economic stratification factors reflected the housing disposal preference of rural households. This is thought to reflect the idea that lower farming-dependent households tended to live in urban areas with better living environments and employment opportunities (Long et al., 2010; Xu et al., 2019). Houses left behind by those migrant households were consequently vacant or abandoned (Liu and Li, 2017). The floor area ratio (FAR) however had significant negative influence on underutilization, which suggests evidence supporting the hypothesis that

Table 3 Estimations of multi-level regression.

Variables		One-level	Two-level	Three-level
Cons	Constant	-2.940***	-3.859***	-3.790***
<i>Household level</i>				
AREA	Area of land parcel	-0.305***	-0.366***	-0.209***
	(log)			
SHP	Shape of land parcel	0.072	0.124**	0.219***
ToH	Type of household	0.351***	0.448***	0.404***
HPOP	Household population	-1.830***	-2.092***	-2.101***
HA	Housing age	0.102***	0.150***	0.140***
HS	Housing structure	0.242***	0.326***	0.132***
FAR	Floor area ratio	-0.116***	-0.126***	-0.050
<i>Village level</i>				
ToV	Type of village		-0.364***	-0.372***
D2T (log)	Dis2Towns		-0.046*	0.022
D2R (log)	Dis2Roads		0.192***	0.124***
SL (log)	Slope		-0.030	-0.065
EL (log)	Elevation		-0.082	-0.077
<i>County level</i>				
PGDP	Per capita GDP			0.587***
	(log)			
FC	Fiscal concentration			-0.061
PPOP	Permanent population			-0.036
RoM	Ratio of emigration			0.737***
RI (log)	Rural income			-0.468
RE2I	Ratio of expenditure to income			-0.095
URG	Urban-rural gap			-0.320
var (cons[county])				0.612***
var (cons[county>village])				2.090***
var (cons[village])			2.894***	
Observations		31,216	31,216	31,216
AIC		16,141.65	13,829.47	13,423.61
BIC		16,208.33	13,945.99	13,606.71

Note: Log is the natural logarithm; ***, **, * denote significant at 0.01, 0.05, and 0.1 levels.

larger floor area had more potential in satisfying the upgraded housing needs of farmers and therefore decreased the probability of being underutilized (Gao et al., 2017; Xia et al., 2020).

To understand the effect of village features, we added a group of variables at the village level into the two-level model and unsurprisingly found that the type of village (TOV) was negatively related to the underutilization; namely, the underutilization issue was policy-sensitive and far more serious in those to-be-consolidated villages than the regenerating counterparts. Distance to towns (D2T) was also negatively correlated; in other words, the closer a village was to county towns, the more housing land was likely to be underutilized. This was in line with our previous argument about the relationship between rural land use and the urbanization potential (Ma et al., 2018). Inconsistent with the negative impact of traffic accessibility in poverty regions (Xia et al., 2020), the proximity of a road offered farmers better market access and thus alleviated the issues of out-migration and underutilization in developed Sunan. In addition, we also found that influences of household-level variables had been strengthened with the values of AIC and BIC declining after adding village-level variables, indicating that controlling the random effect from village groups improved the model, and the spatial heterogeneity of village features did have an influence on the influences of household attributes. In particular, the variable SHP became statistically significant in the two-level model, suggesting that the shape of land parcel mattered across villages and complex-shaped parcels were more inclined to be underutilized.

Taking the county characteristics into further consideration, results of the three-level model suggest that the influence of household-level variables excluding SHP and HPOP declined but were still significant. The coefficient of FAR had become insignificant. Similar trends could also be found in village-level variables with the type of village (TOV) as an exception. This might be because of the similarity of household/

village attributes within a same county. Conversely, the influence of TOV increased after considering the socioeconomic conditions of counties, reconfirming the argument that planning at the village level mattered and underutilization was, to a large extent, policy-driven. As for the influences of county level variables, we found significant positive relationships between *PGDP/RoM* and underutilization. That is, the underutilization of rural housing land was more likely to occur in counties with a higher level of economic development or more rural migrants. This can be further understood as that higher level of economic development would trigger an increase of rural-to-urban migration, which naturally aggravated the issue of underutilization in the countryside and resulted in further exoduses of those left behind.

5. Discussion

5.1. Institutionally driven underutilization within the post-productivist transition

In China, the underutilization of rural housing land is simultaneously determined by factors at multiple levels (Long, 2020). Households, as the primary stakeholder, played an important role in making housing land use decisions. Controlling for random effects of village level variables, the model significantly improved with the influences of increasing household variables (Table 3). That is, the heterogeneity of village features did have an influence on and somehow covered up the impact of household attributes on housing land use. Taking county characteristics into further consideration, we found that the impacts of both household and village factors were, to some extent, overestimated. In other words, the influences of household and village factors on underutilization could be partially attributed to the difference in socio-economic conditions of counties.

Specifically, household land use decisions were largely affected by state policies at all levels. Given the nature of collective ownership, housing land in rural China cannot be traded in formal land markets (Gao et al., 2020a). This makes it impossible to understand underutilization from a supply-demand perspective. This is unlike that in urban areas. Rather, rural housing land use transitions accompany the transition of agricultural mechanisms from productivism to post-productivism (Long et al., 2010). As Wilson (2001) notes, productivism can be conceptualized as a commitment to an intensive, industrially driven and expansionist agriculture with state support based primarily on increased productivity. It was thus argued that rural housing land acted as the very space of residence in the productivist era (Holmes and Argent, 2016). The underutilization of which should mostly be attributed to the dynamics of dwellers. The advancement of agricultural industrialization would generate an increasing number of surplus rural labors, the majority of whom migrate to cities and leave the houses in their home villages underutilized. Even settled down in cities, some migrants preferred not to demolish their houses given the urban-rural dualism of household registration and associated social welfares. This had been reflected by the positive associations of underutilization with the type of household and ratio of migration (Table 3). What's worse, in our field visit to case villages, we found that some young generations built new houses in their long-lost home villages just for vanity, which made the issue of underutilization more serious.

Propelled by the emergence of amenity-driven land use and changing societal values (Holmes, 2002), rural Sunan had undergone a post-productivist transformation since the turn of the new millennium (Long et al., 2009). The impact of village features on underutilization increased and sometimes even covered up that of household influence. Particularly, the policy of building new countryside, as a practice of post-productivism, significantly promoted the multifunctional transition of housing land (Long et al., 2010; Jiang et al., 2016). Rural housing land was no longer just a space of residence but also of amenity-based recreational consumption (Esparza and Carruthers, 2000; Woods, 2011). In 2017, China's central state issued the strategy of rural revitalization,

after which an increasing number of urban developers and land speculators flooded into the countryside (Zhang and Wu, 2017; Zhao, 2019). Villages with high accessibility to the urban market and higher levels of natural amenities were more likely to experience an influx of urban consumers and thereby witnessed more shifts of rural houses into commercial properties. Consequently, there could be serious issues of underutilization exacerbating disparities between the "haves" and the "have-nots", which has been discussed from a developed, and post-productivist economic perspective (Marcouiller et al., 2011; Argent et al., 2014).

Moving to a broader regional or country scale, scholars document that the possession of rural residential lands is desirable in and of itself. Few rural migrants solely choose to settle down in cities by obtaining an urban hukou, which contradicts the common perception that rural migrants desire the urban identity (Hao and Tang, 2015). Results of the three-level model reported here suggest that the more economically developed a county was, the higher rate of rural housing land underutilization it had (Table 3). That is, the urban-rural gap was no longer the primary driving force of underutilization in rural Sunan. Rather, the potential of rural development and peasant awareness of the possibility of policy changes now were central (Ma and Fan, 1994). This should be conceptualized as land speculation by villagers (Kan and Chen, 2021). In socialist China, the revitalization of countryside is not only an issue of economic development but also a performance assessment and political task for local governments (Zou and Zhao, 2018; Harrison and Gu, 2021). Therefore, the developed counties were willing and able to invest more to their rural areas, which consequently attracted more land speculators and would in turn raise the likelihood of underutilization. The high underutilization rate in those resettled communities (Table 2) and in the subgroup of houses built after 2010 (Gao et al., 2020a) could partially confirm this argument.

5.2. Strategies for coping with the underutilization and land use transition

Given the nature of hybridity, the revitalization of countryside is a huge project that blends multiple forces (Woods, 2007). Rural housing land use is similarly affected by factors at multiple levels. As discussed above, new house building in rural Sunan may be a profit-seeking choice of villagers rather than based on inelastic demands of households. Particularly, for the small-sized and non-farming households, new house building is more like an investment for the future and emotional attachments. So does their insistence on those uninhabited old houses. In summary, rural-to-urban migration would not necessarily lead to a decrease in rural housing land. On the contrary, it increases the likelihood of underutilization. In view of this dilemma and to further cope with rapid land use transitions in rural China, we propose two policy suggestions from the perspective of benefit-sharing and urban-rural integration.

First, the construction of a unified system of social welfare for both urban and rural residents might be a valid instrument to address the concern of "migrating to cities without withdrawal from rural homesteads". In general, rural housing land provides housing security for farmers as long-term welfare improvement under the dualistic system in China (Cao et al., 2019). The rural *hukou* tends to limit rural migrant access to urban social benefits like subsidized housing, health care and education of higher quality (Hao and Tang, 2015). Rather than rural housing land being a space of residence, it becomes an identity of rural residents and a refuge for urban wanderers to reconnect with their agrarian roots (Gao et al., 2020b). In this regard, rural migrant access to public services of high quality would be largely improved by loosening the ties to the dualistic system. This, in turn, could promote the transition of peasant workers in cities to "footloose" entrepreneurs in regions. This could facilitate the consolidation of underutilized housing land in their home villages.

Second, we call for an integrated land market in both urban and rural areas. Within the context of post-productivist transitions, rural housing

land is no longer just a space of residence for rural natives but also of consumption for outsiders (Woods, 2009; Holmes and Argent, 2016). The countryside, with the promise of a rural idyll, could thus witness an influx of capital (Darling, 2005). However, there is the possibility of mavericks (mostly migrants dwelling in cities) who prefer not to cooperate with external capitalists given the unfair profit sharing in the informal transfer of property rights (Kong et al., 2018). Following the logic of “maximization of profit”, original cooperators would also institute rent increases with land values surging, which may trigger dispute and finally result in the failure of rural land regeneration (Zhao, 2019). In this sense, the integration of urban-rural land market is an essential approach to fulfil the “highest and best” use of housing land by providing avenues for formal transfer of rural land.

6. Conclusions

In this research, we examine the underutilization of rural housing land within the twofold context of unprecedented urbanization and rural transformation in contemporary China. Employing a multi-level modeling approach, we explored the determinants of underutilization and found that the likelihood of underutilization in rural Sunan was not only sensitive to household and village features (family attributes, housing/parcel characteristics, type of villages, and geographical locations) but was also closely associated with regional contexts (county economic development levels and migration patterns). Results also suggest the nested impacts of factors at different levels on underutilization of rural housing. Specifically, regional characteristics magnified the impact of localities, whilst village features would somehow cover up the influence of household attributes. In addition, results of our analysis suggest that institutional contexts of transitions in rural Chinese residential land use were caused by the overbuilding of new houses and the insistence on retention of uninhabited old houses; these were largely policy-induced. Arguably, the dualistically organized regime was the primary driver of underutilization, particularly with the transition of rural space from productivism to post-productivism.

Against the backdrop of post-productivism, an increased emphasis on the provision of environmental services coupled with a reduced focus on material production is exhibited in rural Chinese land use transitions (Mather et al., 2006; Roche and Argent, 2015). The productivist idea of the countryside as a space of production and dwelling for rural villagers nowadays mirrors the similarly powerful idea of “rural” as a place of consumption for “urban escapes” in the post-productivist era. This post-productivist turn of rural space largely facilitated the transition of rural housing land spatially and functionally. Particularly, the amenity-rich and economically advanced regions have witnessed a marked growth in the number of commercialized rural homes, indirectly leading to an increase in underutilized dwellings. Theoretically, this paper adds to a growing literature on land use transitions by integrating the contested concept of post-productivism in the Western discourse into the institutional analysis with Chinese characteristics to further explore mechanisms underlying underutilization of rural residential land use.

Finally, our work could be further improved by more fully taking into account diverse types of underutilization. For instance, recent research investigates differential inducers of short-term and long-term vacant properties in urban areas (Molloy, 2016; Newman et al., 2016; Zou and Wang, 2020). Given analogous difference in determinants of vacant and abandoned rural housing land (Gao et al., 2020a), considering the specific type of underutilization may have potential in improving our understanding and provide inspiration to proposing coping strategies that are more effective and equitable. Moreover, both patterns and motivations behind land use transition are variegated and locally sensitive to specific political-economic circumstances (Holmes, 2002; Woods, 2007; Lambin and Meyfroidt, 2010). To further test the linkage between underutilization of housing land and rural land use transitions, greater effort should be made to collect and integrate anecdotal evidence that adequately represents the processes of rural transformation.

Author statement

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Appendix A. Supplementary data

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References

- Accordino, J., Johnson, G.T., 2000. Addressing the vacant and abandoned property problem. *J. Urban Aff.* 22 (3), 301–315.
- Argent, N., 2002. From Pillar to Post? In search of the post-productivist countryside in Australia. *Aust. Geogr.* 33 (1), 97–114.
- Argent, N., Tonts, M., Jones, R., Holmes, J., 2014. The amenity principle, internal migration, and rural development in Australia. *Ann. Assoc. Am. Geogr.* 104 (2), 305–318.
- Bowman, A.O.M., Pagano, M.A., 2000. Transforming America's cities: policies and conditions of vacant land. *Urban Aff. Rev.* 35 (4), 559–581.
- Cao, Q., Sarker, M.N.I., Sun, J., 2019. Model of the influencing factors of the withdrawal from rural homesteads in China: application of grounded theory method. *Land Use Pol.* 85, 285–289.
- Chen, C., Fan, C.C., 2016. China's hukou puzzle: why don't rural migrants want urban hukou? *China Rev.* 16 (3), 9–39.
- Chen, C., Gao, J., Chen, J., 2019. Behavioral logics of local actors enrolled in the restructuring of rural China: a case study of Haoqiao Village in northern Jiangsu. *J. Rural Stud.* <https://doi.org/10.1016/j.jrurstud.2019.01.021>.
- Couch, C., Cocks, M., 2013. Housing vacancy and the shrinking city: trends and policies in the UK and the city of Liverpool. *Hous. Stud.* 28 (3), 499–519.
- Cowell, M., Eckerd, A., Smart, H., 2020. The rural identity and the encroaching city: governance, policy and development in Northern Virginia's Wine Country. *Growth Change* 51 (1), 79–101.
- Darling, E., 2005. The city in the country: wilderness gentrification and the rent gap. *Environ. Plann.: Econ. Space* 37 (6), 1015–1032.
- Deng, C., Ma, J., 2015. Viewing urban decay from the sky: a multi-scale analysis of residential vacancy in a shrinking U.S. city. *Landsc. Urban Plann.* 141, 88–99.
- Dissart, Jean-Christophe, Marcouiller W, David, Schaeffer, Yves, 2020. Natural amenities and social justice. In: Dissart, Jean Christophe, Seigneuret, Natalie (Eds.), *Local Resources, Territorial Development and Well-being*. Edward Elgar Publishing, New York, pp. 227–250.
- Dubeaux, S., Sabot, E.C., 2018. Maximizing the potential of vacant spaces within shrinking cities, a German approach. *Cities* 75, 6–11.
- Esparza, A.X., Carruthers, J.I., 2000. Land use planning and exurbanization in the rural Mountain West: evidence from Arizona. *J. Plann. Educ. Res.* 20 (1), 23–36.
- Fan, W., Zhang, L., 2019. Does cognition matter? Applying the push-pull-mooring model to Chinese farmers' willingness to withdraw from rural homesteads. *Pap. Reg. Sci.* 98 (6), 2355–2369.
- Foo, K., Martin, D., Wool, C., Polsky, C., 2013. The production of urban vacant land: relational placemaking in Boston, MA neighborhoods. *Cities* 35, 156–163.
- Gallent, N., Tewdwr-Jones, M., 2018. *Rural Second Homes in Europe: Examining Housing Supply and Planning Control*. Routledge, London and New York.
- Gao, J., Li, S., 2011. Detecting spatially non-stationary and scale-dependent relationships between urban landscape fragmentation and related factors using geographically weighted regression. *Appl. Geogr.* 31, 292–302.
- Gao, J., Liu, Y., Chen, J., 2020a. China's initiatives towards rural land system reform. *Land Use Pol.* 94, 104567.
- Gao, J., Wu, Z., Chen, J., Chen, W., 2020b. Beyond the bid-rent: two tales of land use transition in contemporary China. *Growth Change* 51 (3), 1336–1356.
- Gao, X., Xu, A., Liu, L., Deng, O., Zeng, M., Ling, J., Wei, Y., 2017. Understanding rural housing abandonment in China's rapid urbanization. *Habitat Int.* 67, 13–21.
- Geyer, Nicholas, 2018. Counterurbanization in South Africa: Measuring migration significance. *Reg. Sci. Pol. Pract.* 10 (1), 3–14. <https://doi.org/10.1111/rsp3.12105>.

- Gkartzios, M., Norris, M., 2011. 'If you build it, they will come': governing property-led rural regeneration in Ireland. *Land Use Pol.* 28 (3), 486–494.
- Haase, A., Rink, D., Grossmann, K., Bernt, M., Mykhnenko, V., 2014. Conceptualizing urban shrinkage. *Environ. Plann.* 46 (7), 1519–1534.
- Halfacree, K., 2012. Heterolocal identities? Counter-urbanisation, second homes, and rural consumption in the era of mobilities. *Popul. Space Place* 18 (2), 209–224.
- Hao, P., Tang, S., 2015. Floating or settling down: the effect of rural landholdings on the settlement intention of rural migrants in urban China. *Environ. Plann.* 47 (9), 1979–1999.
- Harrison, J., Gu, H., 2021. Planning megaregional futures: spatial imaginaries and megaregion formation in China. *Reg. Stud.* 55 (1), 77–89.
- Holmes, J., 2002. Diversity and change in Australia's rangelands: a post-productivist transition with a difference? *Trans. Inst. Br. Geogr.* 27 (3), 362–384.
- Holmes, J., Argent, N., 2016. Rural transitions in the Nambucca Valley: socio-demographic change in a disadvantaged rural locale. *J. Rural Stud.* 48, 129–142.
- Huang, P., Li, H., Zhang, X., Zhang, X., 2018. Land use policy as an instrument of rural resilience – the case of land withdrawal mechanism for rural homesteads in China. *Ecol. Indic.* 87, 47–55.
- Jedwab, R., Christiaensen, L., Gindelsky, M., 2017. Demography, urbanization and development: rural push, urban pull and...urban push? *J. Urban Econ.* 98, 6–16.
- Jiang, G., He, X., Qu, Y., Zhang, R., Meng, Y., 2016. Functional evolution of rural housing land: a comparative analysis across four typical areas representing different stages of industrialization in China. *Land Use Pol.* 57, 645–654.
- Jiang, L., Deng, X., Seto, K.C., 2012. Multi-level modeling of urban expansion and cultivated land conversion for urban hotspot counties in China. *Landsc. Urban Plann.* 108 (2), 131–139.
- Kan, K., Chen, X., 2021. Land speculation by villagers: territorialities of accumulation and exclusion in peri-urban China. *Cities* 119, 103394.
- Kates, R.W., Parris, T.M., 2003. Long-term trends and a sustainability transition. *Proc. Natl. Acad. Sci. Unit. States Am.* 100 (14), 8062.
- Kim, G., Miller, P.A., Nowak, D.J., 2018. Urban vacant land typology: a tool for managing urban vacant land. *Sustain. Cities Soc.* 36, 144–156.
- Kong, X., Liu, Y., Jiang, P., Tian, Y., Zou, Y., 2018. A novel framework for rural homestead land transfer under collective ownership in China. *Land Use Pol.* 78, 138–146.
- Kremer, P., Hamstead, Z.A., McPhears, T., 2013. A social-ecological assessment of vacant lots in New York City. *Landsc. Urban Plann.* 120, 218–233.
- Lambin, E.F., Meyfroidt, P., 2010. Land use transitions: socio-ecological feedback versus socio-economic change. *Land Use Pol.* 27 (2), 108–118.
- Li, H., Wei, Y.D., Korinek, K., 2018. Modelling urban expansion in the transitional greater mekong region. *Urban Stud.* 55 (8), 1729–1748.
- Li, J., Guo, M., Lo, K., 2019. Estimating housing vacancy rates in rural China using power consumption data. *Sustainability* 11 (20), 5722.
- Li, T., Long, H., Liu, Y., Tu, S., 2015. Multi-scale analysis of rural housing land transition under China's rapid urbanization: the case of Bohai Rim. *Habitat Int.* 48, 227–238.
- Li, Y., Westlund, H., Liu, Y., 2019. Why some rural areas decline while some others not: an overview of rural evolution in the world. *J. Rural Stud.* 68, 135–143.
- Liu, Y., 2018. Introduction to land use and rural sustainability in China. *Land Use Pol.* 74, 1–4.
- Liu, Y., Fang, F., Li, Y., 2014. Key issues of land use in China and implications for policy making. *Land Use Pol.* 40, 6–12.
- Liu, Y., Li, Y., 2017. Revitalize the world's countryside. *Nature* 548 (7667), 275–277.
- Liu, Y., Liu, Y., Chen, Y., Long, H., 2010. The process and driving forces of rural hollowing in China under rapid urbanization. *J. Geogr. Sci.* 20 (6), 876–888.
- Long, H., 2020. *Land Use Transitions and Rural Restructuring in China*. Springer, Singapore.
- Long, H., Liu, Y., Li, X., Chen, Y., 2010. Building new countryside in China: a geographical perspective. *Land Use Pol.* 27 (2), 457–470.
- Long, H., Liu, Y., Wu, X., Dong, G., 2009. Spatio-temporal dynamic patterns of farmland and rural settlements in Su-Xi-Chang region: implications for building a new countryside in coastal China. *Land Use Pol.* 26 (2), 322–333.
- Long, H., Woods, M., 2011. Rural restructuring under globalization in eastern coastal China: what can be learned from Wales? *J. Rural Commun. Dev.* 6 (1), 70–94.
- Lu, C., 2020. Does household laborer migration promote farmland abandonment in China? *Growth Change* 51 (4), 1804–1836.
- Ma, L.J.C., Fan, M., 1994. Urbanisation from below: the growth of towns in Jiangsu, China. *Urban Stud.* 31 (10), 1625–1645.
- Ma, W., Jiang, G., Li, W., Zhou, T., 2018. How do population decline, urban sprawl and industrial transformation impact land use change in rural residential areas? A comparative regional analysis at the peri-urban interface. *J. Clean. Prod.* 205, 76–85.
- Maharjan, A., Kochhar, I., Chitale, V.S., Hussain, A., Gioli, G., 2020. Understanding rural outmigration and agricultural land use change in the Gandaki Basin, Nepal. *Appl. Geogr.* 124, 102278.
- Marcouiller, D.W., Clendenning, J.G., Kedzior, R., 2002. Natural amenity-led development and rural planning. *J. Plann. Lit.* 16 (4), 515–542.
- Marcouiller, D.W., Lapping, M.L., Furuse, O., 2011. *Rural Housing, Exurbanization, and Amenity-Driven Development: Contrasting the "haves" and the "have Nots*. Ashgate Publishing, Surrey, UK.
- Mather, A.S., Hill, G., Nijnik, M., 2006. Post-productivism and rural land use: cul de sac or challenge for theorization? *J. Rural Stud.* 22 (4), 441–455.
- Molloy, R., 2016. Long-term vacant housing in the United States. *Reg. Sci. Urban Econ.* 59, 118–129.
- Monkkonen, P., 2019. Empty houses across North America: housing finance and Mexico's vacancy crisis. *Urban Stud.* 56 (10), 2075–2091.
- Morckel, V.C., 2014. Spatial characteristics of housing abandonment. *Appl. Geogr.* 48, 8–16.
- Newland, S.A., 2018. Innovators and implementers: the multilevel politics of civil society governance in rural China. *China Q.* 233, 22–42.
- Newman, G.D., Bowman, A.O.M., Jung Lee, R., Kim, B., 2016. A current inventory of vacant urban land in America. *J. Urban Des.* 21 (3), 302–319.
- Norris, M., Winston, N., 2009. Rising second home numbers in rural Ireland: distribution, drivers and implications. *Eur. Plann. Stud.* 17 (9), 1303–1322.
- Parker, D.C., Manson, S.M., Janssen, M.A., Hoffmann, M.J., Deadman, P., 2003. Multi-agent systems for the simulation of land-use and land-cover change: a review. *Ann. Assoc. Am. Geogr.* 93 (2), 314–337.
- Pearsall, H., Christman, Z., 2012. Tree-lined lanes or vacant lots? Evaluating non-stationarity between urban greenness and socio-economic conditions in Philadelphia, Pennsylvania, USA at multiple scales. *Appl. Geogr.* 35 (1), 257–264.
- Qu, Y., Jiang, G., Tian, Y., Ran, S., Wei, S., Li, Y., 2019. Urban-rural construction land transition (URCLT) in Shandong Province of China: features measurement and mechanism exploration. *Habitat Int.* 86, 101–115.
- Roche, M., Argent, N., 2015. The fall and rise of agricultural productivism? An Antipodean viewpoint. *Prog. Hum. Geogr.* 39 (5), 621–635.
- Sargeson, S., 2002. Subduing "the rural house-building craze": attitudes towards housing construction and land-use controls in four Zhejiang villages. *China Q.* 172, 927–955.
- Scarlett Epstein, T., Jezeph, D., 2001. Development—there is another way: a rural-urban partnership development paradigm. *World Dev.* 29 (8), 1443–1454.
- Shan, Z., Feng, C., 2018. The redundancy of residential land in rural China: the evolution process, current status and policy implications. *Land Use Pol.* 74, 179–186.
- Siciliano, G., 2012. Urbanization strategies, rural development and land use changes in China: a multiple-level integrated assessment. *Land Use Pol.* 29 (1), 165–178.
- Tan, M., Li, X., 2013. The changing settlements in rural areas under urban pressure in China: patterns, driving forces and policy implications. *Landsc. Urban Plann.* 120, 170–177.
- Tang, P., Chen, J., Gao, J., Li, M., Wang, J., 2020. What role(s) do village committees play in the withdrawal from rural homesteads? Evidence from Sichuan Province in western China. *Land* 9 (12), 477.
- Tian, G., Qiao, Z., Gao, X., 2014. Rural settlement land dynamic modes and policy implications in Beijing metropolitan region, China. *Habitat Int.* 44, 237–246.
- Turner, V.K., Kaplan, D.H., 2019. Geographic perspectives on urban sustainability: past, current, and future research trajectories. *Urban Geogr.* 40 (3), 267–278.
- Wei, Y.D., 2010. Beyond new regionalism, beyond global production networks: remaking the Sunan model. *China Environ. Plan. C* 28 (1), 72.
- Wilson, G.A., 2001. From productivism to post-productivism ... and back again? Exploring the (un)changed natural and mental landscapes of European agriculture. *Trans. Inst. Br. Geogr.* 26 (1), 77–102.
- Woods, M., 2007. Engaging the global countryside: globalization, hybridity and the reconstitution of rural place. *Prog. Hum. Geogr.* 31 (4), 485–507.
- Woods, M., 2009. Rural geography: blurring boundaries and making connections. *Prog. Hum. Geogr.* 33 (6), 849–858.
- Woods, M., 2011. *Rural*. Routledge, London and New York.
- Wu, J., Gyourko, J., Deng, Y., 2012. Evaluating conditions in major Chinese housing markets. *Reg. Sci. Urban Econ.* 42 (3), 531–543.
- Xia, K., Liu, L., Wang, W., 2020. Spatial distribution of rural housing abandonment and influencing factors at the village level: a case study of the Loess Plateau of China. *Geojournal*. <https://doi.org/10.1007/s10708-020-10193-5>.
- Xu, F., Ho, H.C., Chi, G., Wang, Z., 2019. Abandoned rural residential land: using machine learning techniques to identify rural residential land vulnerable to be abandoned in mountainous areas. *Habitat Int.* 84, 43–56.
- Yang, F., Chi, G., Wang, G., Tang, S., Li, Y., Ju, C., 2020. Untangle the complex stakeholder relationships in rural settlement consolidation in China: a social network approach. *Land* 9, 210.
- Yep, R., Forrest, R., 2016. Elevating the peasants into high-rise apartments: the land bill system in Chongqing as a solution for land conflicts in China? *J. Rural Stud.* 47, 474–484.
- Zavadskas, E.K., Antucheviciene, J., 2007. Multiple criteria evaluation of rural building's regeneration alternatives. *Build. Environ.* 42 (1), 436–451.
- Zhang, Q.F., Wu, J., 2017. Political dynamics in land commodification: commodifying rural land development rights in Chengdu, China. *Geoforum* 78, 98–109.
- Zhang, X., Han, L., 2018. Which factors affect farmers' willingness for rural community remediation? A tale of three rural villages in China. *Land Use Pol.* 74, 195–203.
- Zhang, Y., Li, X., Song, W., 2014. Determinants of cropland abandonment at the parcel, household and village levels in mountain areas of China: a multi-level analysis. *Land Use Pol.* 41, 186–192.
- Zhao, Y., 2019. When guest house meets home: the time-space of rural gentrification in southwest China. *Geoforum* 100, 60–67.
- Zhou, T., Jiang, G., Li, G., Zhou, D., Qu, Y., 2020. Neglected idle rural residential land (IRRL) in metropolitan suburbs: spatial differentiation and influencing factors. *J. Rural Stud.* 78, 163–175.
- Zhu, X., 2017. Impact of the household registration system on farmers' rural housing land use decisions in China. *Land* 6 (4), 75.
- Zou, S., Wang, L., 2020. Individual vacant house detection in very-high-resolution remote sensing images. *Ann. Assoc. Am. Geogr.* 110 (2), 449–461.
- Zou, Y., Zhao, W., 2018. Searching for a new dynamic of industrialization and urbanization: anatomy of China's characteristic town program. *Urban Geogr.* 39 (7), 1060–1069.