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Potential of land consolidation of hollowed villages under different urbanization scenarios in China

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Abstract: There exists great potential of rural land consolidation in China due to the aggravated hollowed villages against the background of rapid rural-urban transformation. The paper aims to investigate the potential of rural land consolidation within four urbanization scenarios: Complete urbanization, Semi-urbanization, Urbanization in batches and prospective urbanization in 2020. Research findings show that, (1) the potentials of rural land consolidation in complete and semi-urbanization are 809.89×10^4 hm^2 and 699.19×10^4 hm^2 respectively while rural consolidation rates are 50.70% and 43.77%. As for the urbanization in batches and urbanization in 2020, the potentials are 757.89×10^4 hm^2 and 992.16×10^4 hm^2. (2) Beside Tibet and Ningxia, rural consolidation rates in most provinces are between 40% and 60%, and the land increase rates are between 3% and 12%. Significant correlation between potential of rural land consolidation and the degree of hollowed villages is also found. (3) Evident differences of potential of rural land consolidation exist across provinces. Rural consolidation rates in the East and Central provinces are higher than that in the West provinces. Villages in the developed areas have higher consolidation rates than those in the less developed areas, and villages in the plain areas tend to have higher consolidation rates than those in the mountainous areas.

Keywords: hollowed villages; potential of land consolidation; urbanization scenarios; China

1 Introduction

Urbanization in China has entered into a stage of fast transformation (Liu and Yang, 2012). Urbanization level has reached 49.68% by 2010 according to the sixth census, and the urban-rural relationship has been changing greatly (Li, 2011). Hollowed villages have become increasingly aggravated due to the population outmigration and rural land recession (Liu *et al*., 2010; Chen *et al*., 2010; Sun *et al*., 2011). Rural transformation generates direct impact on rural land use modes (Mathera, 2006; Jonathan, 2006; Jerzy *et al*., 2010; Ying, 2012). Within current land management system, hollowed villages have induced resource and environmental problems in rural China such as the hollowed and abandoned residential land

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(Long *et al*., 2012).

Basically, urbanization development and new countryside construction have brought a strategic opportunity to rural land consolidation in China (Long *et al*., 2010; Giuseppina, 2012). On the one hand, new countryside construction calls for central planning system, of which the spatial structure consists of Central community-Central village-Township city-County level city. On the other hand, large-scale rural residential land was abandoned since large number of peasants moved out of villages and settled in cities. Thus, rural land consolidation is of great importance to improve land use efficiency and protect peasants' land profits. Besides, rural land consolidation also serves to achieve optimal land allocation in cities and countryside, and this becomes inevitable in the fast urbanization process in China (Liu *et al*., 2011).

Recently, academic sphere pays more attention to rural land consolidation and focuses on the potential of rural land consolidation, mechanism and modes of land consolidation (Liu *et al*., 2009). The estimation of potential of rural residential land consolidation is an important part of the potential calculation of rural land consolidation (Bonfanti *et al*., 1997; Castro *et al*., 2001). Basically, there are three different methods to estimate the potential of rural land consolidation, including per capita construction land method, idle rural residential land method and comprehensive evaluation method (Qiu, 2006; Chen *et al*., 2009). The potential of rural land consolidation refers to the potential which is made according to rural population structure and land policy by taking into consideration of the stage and feasibility of consolidation in hollowed villages. At present, China's agricultural population consists of rural residential population and those who are working and living in cities, but still have rural household registration. The agricultural population is 882 million, of which 721 million are rural residential population and 161 million are those living in cities. The paper aims to estimate the potential of rural land consolidation in four urbanization scenarios: Complete urbanization, Semi-urbanization, Urbanization in batches and prospective urbanization in 2020. The scenarios are set according to the differences of land demand by rural population and those who are living in cities but still own their rural residential land in their home villages.

2 Data and methods

Rural residential land refers to rural settlements and includes rural housing land, traffic land and social facilities land as well as green land. Due to the shortage of accurate data of mining and infrastructure land, we make estimation according to the rural residential land data. Generally, the potential of rural land consolidation depends on rural population and per capita residential land. Thus, the paper uses county-level data to establish models and estimate potentials in different urbanization scenarios. Rural consolidation rate indicates the ratio between increased lands after consolidation to the current residential land. Land increase rate refers to the ratio of increased land after consolidation to the current arable land. The increased land by way of village consolidation is to be preferentially used as arable land.

2.1 Urbanization scenarios

2.1.1 Complete urbanization scenario

(1) Characteristics

For agricultural population living in cities, there are policies aiming to completely change their identities from agricultural to non-agricultural in cities. Measures are taken to meet their need for housing land in cities. Then, their ownership of residential land in home villages should be transferred to other people. For agricultural population living in countryside and possessing large housing land, their land should be consolidated by scientific planning, building central communities so as to increase land use efficiency.

(2) Calculation

The potential of rural residential land consolidation in complete urbanization scenario includes land potential of agricultural population living in cities and countryside. The consolidation model of agricultural population living in the cities can be written:

$$U_i = P_{ui} \times \left(\frac{M_i}{P_i} - \frac{c_i}{\lambda_i} \right) \tag{1}$$

where U_i is the increased land by consolidating residential land which belongs to those living in cities. P_{ui} is the agricultural population living in cities. M_i is the rural residential land which belongs to P_{ui}. P_i is the total agricultural population. C_i and λ_i indicate per capita housing area and average urban housing plot ratio.

Due to the data shortage of agricultural population in each city and county, the paper firstly computes the ratio of rural non-agricultural population at county level to the total non-agricultural population at provincial level. Then, the ratio is multiplied by the total agricultural population in urban areas at provincial level. Thus, the formula is:

$$P_{ui} = N_{ui} \Big/ \sum_{i=1}^{k} N_{ui} \times (P_{Kn} - P_{Kr}) \tag{2}$$

where N_{ui} is the population of non-agriculture employment in i county. k is the number of county in K province. P_{Kn} is the population of agricultural residence registration in K province. P_{Kr} is the rural residents in K province.

The model of the potential of rural land consolidation of rural agricultural population can be written:

$$V_i = P_{ri} \times \left(\frac{M_i}{P_i} - l_i \right) \tag{3}$$

where V_i is the increased land by consolidating residential land which belongs to rural agricultural population. P_{ri} indicates rural residential population. M_i and P_i are the same as those in formula (1). The final computation consists of these two formulas.

2.1.2 The semi-urban urbanization scenario

(1) Characteristics

For the agricultural population who are living in cities, they still rely on agriculture and rural economy in their home villages. They need affordable apartment or cheap renting houses in cities. Their land (beside their rural houses) in villages could be consolidated by the same innovative mechanism. For the residential population in villages, scientific planning and consolidation will be carried out to improve land use intensive degree.

(2) Calculation

The potential of land consolidation in the semi-urbanization scenario also includes the consolidation of residential population in villages and agricultural population in cities. The

calculation of consolidation potential of residential population in villages is the same as formula (3). The calculation of consolidation potential of agricultural population in cities is as follows:

$$U_i = P_{ui} \times \left(\frac{M_i}{P_i} - \frac{c_i'}{\lambda_i'} - \frac{c_i}{\lambda_i} \right) \tag{4}$$

where c_i' and λ_i' are the per capita housing area and the average housing plot ratio in the urban area. The meanings of other variables here are the same as those of formula (1).

2.1.3 The urbanization in batches scenario

(1) Characteristics

Part of the agricultural population in cities has permanent jobs and their own houses. However, part of the agricultural population has low income and instable jobs. Thus, these people cannot settle in cities completely. In this sense, the settlement of agricultural population in cities should be promoted step by step. Land consolidation of agricultural population of better economic conditions could follow the way in the complete urbanization. Then, land consolidation of agricultural population of instable conditions could be carried out by building central residential communities so as to improve land use intensive degree.

(2) Calculation

The calculation of potential of land consolidation in this scenario combines with the above two scenarios. Let represents the ratio of agricultural population who are suitable for complete urbanization. Thus, potential of land consolidation of agricultural population in cities could be computed in formula (5).

$$U_i = r \times P_{ui} \times \left(\frac{M_i}{P_i} - \frac{c_i}{\lambda_i} \right) + (1-r) \times P_{ui} \times \left(\frac{M_i}{P_i} - l_i \right) \tag{5}$$

The meanings of variables are the same as formulas (1) and (3). The model of the consolidation potential of rural residential population is the same as other two methods.

2.1.4 Prospective urbanization scenario in 2020

(1) Characteristics

By reforming household registration system, settlement of rural population in cities is carried out step by step. They work in cities and have the same benefits as those urban residents. The new urban residents would gradually lose their dependency on agriculture and rural land in their home villages. In the meantime, the vacant rural land could be utilized by building houses within villages and central residential communities.

(2) Calculation

The potential of residential land consolidation in hollowed villages depends on total population, rural residential population and housing standards in rural and urban areas in forthcoming years. The urbanization rate would reach 60% and the total population would be 1.45 billion in 2020 according to population development plan in the 11th Five-Year Plan.

The population growth and urbanization development are different in every county and city due to different economy, topographical features and arable land resources etc. This paper assumes that the total population change and rural residential population change in every county and city from 2008 to 2020 will maintain the annual population changes in the period 2000–2008. The total population and rural residential population are predicted in every

county and city as formulas (6)–(7).

$$P_{ti}=P_{0i}+t\times\Delta p \tag{6}$$

$$P_{tri}=P_{0ri}+t\times\Delta p_r \tag{7}$$

where P_{ti} is the total population in 2020. P_{tri} is the rural resident population in 2020. P_{0i} is the total population in 2008. P_{0ri} is the rural resident population in 2008. Δp is the annual change of total population from 2000 to 2008 in every county and city. Δp_r is the annual change of the rural resident population from 2000 to 2008 in every county and city. t is 12. The statistical analysis showed that the distribution of the population growth rate was a significant spike right-skewed (Skewness = 15.874, Kurtosis = 352.537) from 2000 to 2008. It is that the scale of the population growth rate is in a narrow range for 2251 counties and cities. So, it is assumed that it is abnormal sample when the increase rate is greater than 50%, or the reducing speed is more than 30%.The models of the total population, rural resident population and residential land consolidation potential of village are formulas (8)–(9) in every county and city in 2020.

$$P_{ti}^{/}=14.5\times P_{ti}\Big/\sum_i P_{ti} \tag{8}$$

$$P_{tri}^{/}=14.5\times(1-60\%)\times P_{tri}\Big/\sum_i P_{tri} \tag{9}$$

$$U_{ti}=M_{0i}-P_{tri}\times l_{0i}-(P_{0ri}-P_{tri})\times\frac{c_{ti}}{\lambda_{ti}} \tag{10}$$

where U_{ti} is residential land consolidation potential of village for i county or city in 2020. i is 1 to 2251. M_{0i} is the area of rural residential land for i county or city in 2008. P_{0ri} is the rural resident population for i county or city in 2008. P_{tri} is the rural resident population for i county or city in 2020. l_{0i} is the rural residential land use standard for i county or city. C_{ti} and λ_{ti} are the per capita housing area and the housing average plot ratio respectively in urban areas in 2020.

2.2 Data

Rural population data refers to the China Statistical Yearbook, Statistical Yearbook of every province and Statistical Yearbook of Chinese counties (cities) in the same calendar years (2001 and 2009). Rural residential land data is from the land survey database in 2000 and 2008. The urban population and urban residential land are from China Urban Construction Statistics Yearbook (2009). The standards of rural housing land use have been set by the Land Management Law in China and land management regulations e.g. rural housing land management regulations in every province.

The research includes 2251 counties or county-level cities. For the small number of cities and counties which lack socio-economic data are removed from the research. The paper does not include Taiwan, Hong Kong and Macau.

3 Potential of residential land consolidation in hollowed villages

(1) Complete urbanization scenario

By using formals (1)–(3), the consolidation potential is calculated according to the resi-

dential population in villages and agricultural population in cities. According to the village and town plan, the residential land ratio is 55%, which is the minimum ratio of residential land in the central villages or upper limit in general town (Song *et al*., 2008). Thus, the standard of per capita rural residential land can be obtained by the standard of per capita rural housing land that is divided by 55%.

The potential of residential land consolidation in complete urbanization is 809.89×10^4 hm^2, the rural consolidation rate and land increase rate are 50.70% and 6.85% respectively. Upon the spatial distribution, evident differences of rural land consolidation exist across provinces. In the Inner Mongolia Plateau Region which is of high hollowed village degree and stable economic development, and in Mountains Regions in Southeast China which are of moderate hollowed village degree and stable economic development, the rural consolidation rates are more than 50%. In Qinghai-Tibet Plateau Region which is of low hollowed village degree and backward economy, and in Xinjiang Region which is of low hollowed village degree and stable economic development, the rural consolidation rates are below 40%.

Hollowed villages are divided into ten big regions according to the hollowed village degree. They are (I) Xinjiang Region which is of low hollowed village degree and stable economic development, (II) Qinghai-Tibet Plateau Region which is of low hollowed village degree and backward economy, (III) Mountainous Regions in Southwest China which are of low hollowed village degree and backward economy, (IV) Loess Plateau Region which is of moderate hollowed village degree and backward economy, (V) Inner Mongolia Plateau Region which is of high hollowed village degree and stable economic development, (VI) Northeast China Plain Region which is of moderate hollowed village degree and stable economic development, (VII) Huang-Huai-Hai Plain Region which is of moderate hollowed village degree and stable economic development, (VIII) Lower Yangtze River Region which is of high hollowed village degree and developed economic development, (IX) Mountains Regions in Southeast China which are of the moderate hollowed village degree and stable economic development, and (X) Middle Yangtze River Region which is of moderate hollowed village degree and stable economic development (Liu *et al*., 2011). Generally, rural consolidation rates in the East and Central provinces are higher than that in the West provinces. Villages in developed areas tend to have higher consolidation rates than those in the less developed areas. Then, villages in plain areas tend to have higher consolidation rates than those in the mountains and hilly areas (Figure 1a).

(2) Semi-urban urbanization scenario

For the agricultural population living in cities, the demand for housing land is the same as the per capita living area in each province or city. In rural areas, the per capita housing area is larger than that in the urban areas, but rural housing area is of lower usage efficiency than urban counterpart. The standard of housing area is calculated by per capita housing construction area (30 m^2) and the plot ratio of 0.5 in rural areas. The consolidation potential of the agricultural population living in cities is calculated in formula (4). The consolidation potential of the agricultural population living in rural areas is the same as that in complete urbanization. In the Semi-urban urbanization scenario, the consolidation potential of hollowed villages is 699.19×10^4 hm^2, the rural consolidation rate and land increase rate are 43.77% and 5.92% respectively. The rural consolidation rates in most provinces beside

Table 1 Potential of residential land consolidation in hollowed villages within different urbanization scenarios in China

Situations	Features of the situation	Potential of consolidation	Assessment of the situation
Complete urbanization	(1) Guarantee the reasonable demand for housing land of agricultural population living in urban areas, and vacate their rural home stead through appropriate compensation mechanism; (2) Regulate and control the non-rational land-use situation of the resident population of the rural areas through land intensification and the center communalization.	With the potential of 809.89×10^4 hm^2, the rate of rural consolidation and land increase rate are 50.70% and 6.85% respectively.	(1) Assume that the urban public services can meet the needs of the newly increased population in city, and the agricultural population living in cities, all have stable jobs and strong housing affordability. (2) Have not yet reached the stage of economic development, if blindly forward; it is easy to trigger the trap of urbanization.
Semi-urbanization	(1) Adopt economically affordable housing, low-rent housing and other forms to guarantee the basic living needs of agricultural population living in urban areas, and vacate other types of land except for the rural housing demand through the appropriate compensation mechanism; (2) Regulate and control the non-rational land-use situation of the resident population of the rural areas through land intensification and the center communalization.	With the potential of 699.19×10^4 hm^2, or about 105 million mu, the rate of rural consolidation and land increase rate are 43.77% and 5.92% respectively.	(1) Assume that migrant workers are not qualified to become urban residents at all, which needs to retain a certain amount of living space both in the rural areas and urban areas; (2) It does not reflect the internal differentiation of agricultural population living in urban areas, hollowing and waste rural land will become more significant with further urbanization.
Urbanization in batches	(1) There is also a differentiation in the agricultural population living in urban areas at the same time, which needs to adopt the complete urbanization situation consolidation program for part of the agricultural population living in the city; the rest population who are not suitable for being completely transferred to the town needs to be regulated and controlled to the reasonable scope of the land-use specified by different provinces step by step; (2) Regulate and control the irrational land-use situation of the resident population of the rural areas through land intensification and the center communalization.	With the potential of 757.89×10^4 hm^2, or about 114 million mu, the rate of rural consolidation and land increase rate are 47.45% and 6.41% respectively.	With these two situations considered comprehensively, the program is recommended. The program further conforms to the basic national conditions of unbalanced regional development and big differences between urbanization and rural development level, puts more emphasis on local conditions, classification guidance, the benefit of the people's livelihood, and advocates the adoption of integrated models of regional differentiation, target diversification, consolidation diversification.

Heilongjiang and Tibet have decreased by 1.81%–17.37% comparing with that in the complete urbanization scenario. Due to the large output of agricultural labor force, the land increase rate surpasses 8% in some provinces, including Anhui, Jiangxi, Henan, Hunan, Guangxi, Chongqing, Guizhou, Sichuan and Henan (Figure 1b).

(3) Urbanization in batches scenario

With the order principle, the inner characteristics of agricultural population living in cities have been analyzed. Assume that 50% of the agricultural population living in cities has been suitable for the complete urbanization scenario, so the scientific planning and consolidation will be carried out in rural areas through land intensification and the center communalization, to improve the intensive degree of land use.

In this scenario, the consolidation potential of hollowed villages is 757.89×10^4 hm^2, and the rural consolidation rate and land increase rate are 47.45% and 6.41% respectively (Figure 1c and Table 1).

(4) The perspective urbanization scenario in 2020

The consolidation potential in the fourth scenario is calculated in formulas (6)–(10). The standard of rural residential land (l_{oi}) is the same as that in the complete urbanization scenario. The standard of per capita housing construction area (C_{ti}) is 30 m^2 with the plot ratio (λ_{ti}) of 1.2, which is the level for well-off society in urban areas.

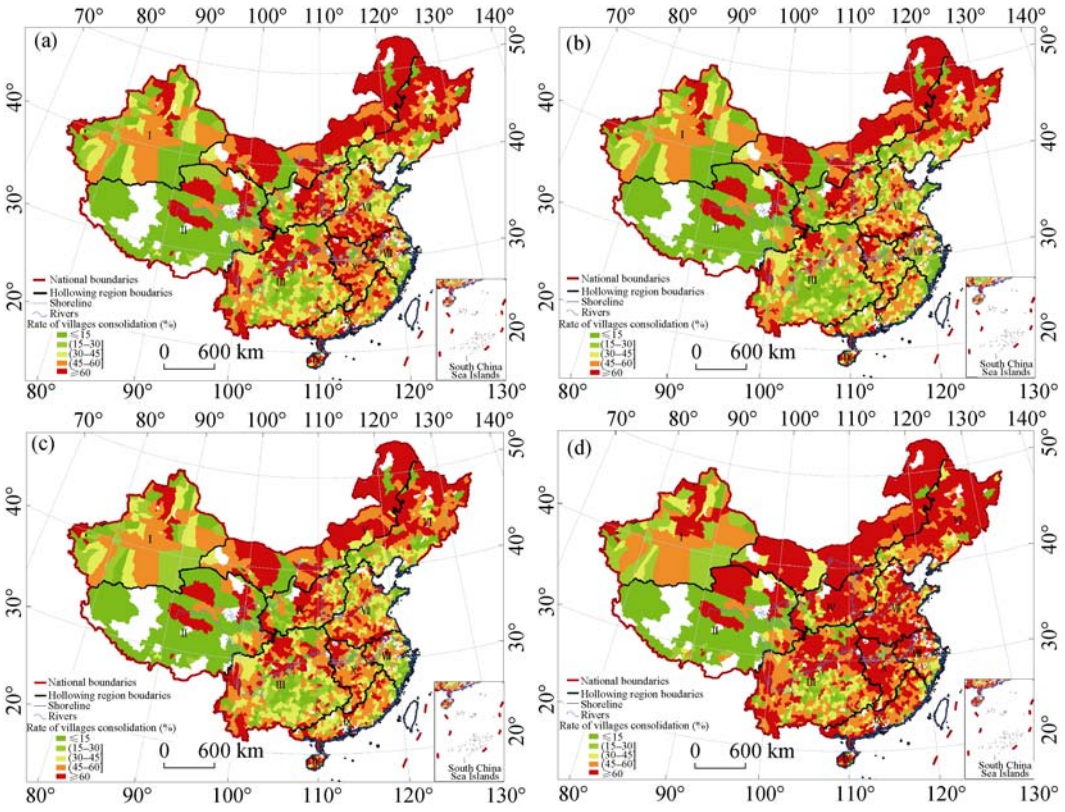

Figure 1 The rate of villages consolidation with complete urbanization, semi-urbanization scenario, urbanization in batches scenario and urbanization scenarios of China in 2020

Table 2 The consolidation potentials of hollowed villages in different urbanization scenarios in various hollowed villages

Hollowing zones	Complete urbanization scenario			Semi-urbanization scenario			Urbanization in batches scenario			Urbanization scenario in 2020		
	ILA (hm^2)	RRC (%)	LIR (%)	IA (hm^2)	RRC (%)	LIR (%)	IA (hm^2)	RRC (%)	LIR (%)	IA (hm^2)	RRC (%)	LIR (%)
I	176309	37.14	4.34	182605	38.47	4.49	190979	40.23	4.7	219186	46.18	5.39
II	6546	6.65	0.63	3008	3.06	0.29	2038	2.07	0.2	26608	27.05	2.58
III	1474162	50.14	5.93	1121920	38.16	4.51	1348246	45.85	5.42	1699278	57.79	6.83
IV	632190	46.57	5.37	565782	41.68	4.81	577675	42.56	4.91	828841	61.06	7.04
V	313252	55.45	5.25	302028	53.47	5.06	295424	52.3	4.95	409551	72.5	6.87
VI	1303601	53.2	5.33	1235820	50.44	5.06	1218177	49.72	4.98	1672129	68.24	6.84
VII	2263846	51.83	8.79	1979727	45.32	7.69	2143322	49.07	8.32	2751451	62.99	10.69
VIII	580812	45.6	9.14	455852	35.79	7.18	523900	41.13	8.25	769952	60.45	12.12
IX	665025	53.45	9.96	558183	44.87	8.36	635454	51.08	9.51	752512	60.49	11.27
X	683111	56.86	9.43	586967	48.85	8.1	643722	53.58	8.89	792135	65.93	10.93
Total	8098854	50.7	6.85	6991892	43.77	5.92	7578937	47.45	6.41	9921642	62.11	8.4

ILA is the increase land area, RRC is the rate of rural consolidation, LIR is the rate of land increase.

Around 1.4 million agricultural populations completely converted to non-agricultural population from 2008 to 2020. The consolidation potential of hollowed villages is

992.16×10^4 hm^2 (Table 2). The ten provinces of top rural consolidation rates include Jilin, Inner Mongolia, Tianjin, Heilongjiang, Chongqing, Hainan, Anhui, Hubei, Sichuan and Henan, while the last 10 provinces and cities include Tibet, Qinghai, Guizhou, Shanghai, Xinjiang, Zhejiang, Yunnan, Hebei, Fujian and Gansu. The land increase rates are higher in the Inner Mongolia Plateau Region which has high hollowed village degree with stable economic development, and in the Northeast China Plain Region which is of moderate hollowed village degree with stable economic development. However, it is lower in the Qinghai-Tibet Plateau Region which is of low hollowed village degree with backward economy, and in Xinjiang Region which is of low hollowed village degree with stable economic development (Figure 1d and Table 2).

4 Conclusions and discussion

The paper calculates the consolidation potentials of hollowed villages in China according to the different residential land demand of agricultural population settling in countryside and those living in cities. Calculation is made within four urbanization scenarios: complete urbanization, semi-urbanization, urbanization in batches and prospective urbanization in 2020. The potentials of rural land consolidation in complete urbanization and semi-urbanization are 809.89×10^4 hm^2 and 699.19×10^4 hm^2 respectively while the rural consolidation rates are 50.70% and 43.77%. As for the urbanization in batches and prospective urbanization in 2020, the land consolidation potentials are 757.89×10^4 hm^2 and 992.16×10^4 hm^2. Beside Tibet and Ningxia, rural consolidation rates in most provinces are between 40% and 60%, and the land increase rates are between 3% and 12%.

Moreover, there is a significant correlation between potential of rural land consolidation and the hollowed village degree. Evident differences of rural land consolidation exist across provinces. Rural consolidation rates in the East and Central provinces are higher than that in the West provinces. Villages in developed areas tend to have higher consolidation rates than those in less developed areas. Then, villages in plain areas tend to have higher consolidation rates than those in mountain areas.

The consolidation potential of hollowed villages depends on the transfer mechanisms of agricultural population and the exit and reuse mechanisms of rural housing land in China. The paper estimates the land consolidation potential in different regions of China according to the standard of per capita construction land. The estimation does not take the natural, social and economic differences among the regions into consideration. Besides, the changing urbanization modes and scenarios would impact the land consolidation potential. Thus, the real land consolidation potential should also be assessed and adjusted.

Optimal land allocation between urban and rural areas is necessary to ensure the improved land use efficiency in China. However, there still exists unclear land use rights and ownership in rural China. Peasants can use the land, which is however, collectively owned. There is also lack of stable institutions to guarantee peasants' land use rights and benefits. In this sense, these may generate limits to the exit and reuse of rural housing land. Institutional innovation should be made to better use rural land and promote optimal land allocation in rural China.

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