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ANALYSIS OF RURAL HOUSING LAND CONSOLIDATION POTENTIAL IN THE LOESS HILLY REGION: A CASE STUDY OF BAIMATAN VILLAGE IN HUANGLONG COUNTY

CUI Xiao-lin, FU Li-meng, WEI Xiao-qing, WANG Qian, CHENG Yun and LEI Yu-tong
College of Geo-matics, Xi'an University of Science and Technology, Xi'an, China
Email: xiaolin_cui@xust.edu.cn

Abstract: *The purpose of this paper is to determine the potential for rural housing land consolidation quantitatively and objectively in the loess hilly region and to provide the local government with scientific reference, which could be used to deal with rural housing land consolidation work. Data was obtained by onsite investigation, and 10 factors were selected to divide the consolidation potential into three categories, with the application of factor analysis method. The characteristic of consolidation potential area of rural housing land was analyzed statistically by overlapping slope gradients and calculating actual potential area for consolidation. The results show that: the degree of housing land consolidation is low in this region, marked by severely over-standard residential area and lower density of housing land. As is shown in this case, an average rural household tends to own an over-standard number of residential sites which exist in different forms and use rate of housing land is generally low. It is found in this case that the potential area for consolidation could reach 34064.78m2, and it falls into three categories: Over-standard area (two villages), multi-housing area (3 villages), and lower-use-rate area (two villages).*

Key words: Rural Housing Land, Potential Consolidation, Slope, Factor Analysis

Introduction

As an important carrier of rural life and production, rural housing land is the core of the relationship between performance of rural people and land. With the continuous progress of urbanization, rural housing land consolidation has become an effective way to promote rational allocation of resources and intensive land use and to speed up the pace of rural modernization. Many scholars have conducted in-depth discussion and study on it. Zhan *et al.* (2007) discussed and analyzed rural residential land consolidation of Henan Province, Wang *et al.* (2001) analyzed and explored the process and mode of village relocation in the process of consolidation in Sunqiao Town, Pudong District, Shanghai; Fang *et al.* (2007) analyzed and forecasted trends of rural residential land consolidation in Zhejiang, Beijing and other three regions.

Currently, the research of rural land consolidation involves method of models (Liu and Zhang, 1999; Han and Chen, 2000; Yang and Zhang, 2003), the strategy of implementation (Han and Zheng, 2002), benefit evaluation (Gong, 2003), "hollow village" consolidation (Xue, 2001), rural villages planning (Zhou, 2006), spatial distribution arrangement (Si and Hu, 2006; Tian *et al*, 2002), consolidation focus and difficulty (Zhou *et al*, 2002), etc. However, little attention has been paid to research on the influence of natural factors on housing land consolidation, among which topography is one strong influencing factor on the distribution of

the housing land. And this paper took topography into consideration when studying this issue. Baimatan located in the hilly-gully region of Loess Plateau was selected to analyze the actual use of rural land and to calculate the realistic consolidation potential of housing land according to slope conditions. Finally, factor analysis method was used to classify the land consolidation potential and to give suggestions suitable for the rural housing land consolidation in loess hilly areas.

Study Area

Baimatan village located in the southeast of Huanglong county which located in (35°24′09″-36°02′01″N, 109°38′49″-110°16′49″E) the southeast of Yan'an in the northern Shaanxi province, is a hilly-gully area of Loess Plateau. This study area average elevation is 1100m. It belongs to the warm-temperate-zone with an annual mean precipitation of 602mm. The study area includes 7 natural villages: Zhangfeng village, Yangmian village, Dongshan village, Qixingping village, Baidong village, Baixi village and Sunjiapo village. Usable land resources include productive land and non-agricultural construction land. Woodland, farmland and orchard all belong to productive land; rural land for public welfare and public facilities and farmers' residential land belong to non-agricultural construction land.

Data and Analysis of Rural Housing Land

Rural land ownership and land use status data are collected from field investigation, and rural housing land area and graphic data from field survey. The data includes owners of the housing land, its living family members and its situation, the status of housing land right source, the four boundaries of every parcel land, the surrounding terrain factors, boundary point coordinate, the housing land area, building area and building structure, etc. The investigation obtained 565 cases.

The Situation Analysis of Rural Housing Land

According to the allotment policy, an average household is allotted a maximum area of 266.68 m^2 as one rural household unit. The index was selected according to this standard. There are two types of index selection: a) regarding a whole village as a unit, covering total area, the total number of parcels and the total number of households (Tab.1); b) taking an individual peasants household as a unit, covering the housing land area of every household, the number of parcels owned by each household, the multiple housing area and average household area. And as the date shows, there are 565 parcels and 436 households, the total area being 165 959.54 m^2. Among them, 128 households are the type of "one household owing multiple housing lands"; 352 parcels have exceeded the allotted size; and the multiple occupancy area is 34205.27m^2.

1) Villages like Yangmian, Dongshan, Qixingping, Baixi and Baidong are between 10% and 20%. Those of the other two villages Sunjiapo and Zhangfeng are even greater than 20%, with the latter having the highest percentage of multi occupancy area 32.18%. The research also shows the number of households falling into the bracket of "one household owing multiple housing lands," which is 128, accounting for 29.30% of the total village households, among which those of Yangmian and Qixingping are between 10% and 20% and those of Baidong, Baixi, Sunjiapo, Dongshan and Zhangfeng are greater than 20%. The highest percentage is shown in Sunjiapo village, 29.33%.

Table 1: Index of Rural Housing Land

Village	Total area(m^2)	Total number of household	Total number of parcel
Baimatan	165959.54	436	565
Zhangfeng	41725.46	111	144
Yangmian	22369.9	56	63
Dongshan	4753.30	13	17
Qixingping	7995.47	23	28
Baidong	30580.77	85	117
Baixi	27878.56	73	94
Sunjiapo	30656.08	75	102

2) Low homestead density. The homestead density is the ratio of homestead area to residential area. The average density of homestead is 14.29%. Among the seven villages, the ratios of Dongshan and Qixingping are less than 10%. And those of Yangmian, Baidong and Baixi are between 10% and 20%. Zhangfeng has got the highest, 25.41%. The number of occupied parcels per household is 1.3. More specifically, those of Yangmian, Zhangfeng, Qixing and Baixi are between 1.13 and 1.29. Those of Dongshan, Baidong and Senjiapo are greater than 1.3 and Baidong village has the highest, 1.38 parcel/household.

3) Homestead area being severely above the standard. The homestead area exceeds the local average homestead area standard, which is 266.68 m^2 per household to the maximum. The over standard rate is 62.3%. Among the seven villages, those of Dongshan, Qixingping, Zhangfeng, Baidong and Sunjiapo are between 50% and 70%. Those of Yangmian and Baixi are more than 70%. The highest over standard rate is shown in Yangmian village, 82.54%.

Low Homestead Use Intensity

Homestead use intensity is the degree of land development and utilization measured in one unit of land area. Considering the actual situation, the research build rural land use intensity evaluation standard in the study area, based on factors like building density, building volume ratio and average building layers (Tab. 2).

Table 2: Index of Evaluate Rural Housing Land Intensity

Village	Occupied area(m^2)	Building area(m^2)	Building volume ratio	Building density	Average building Layers
Baimatan	59189.79	48058.44	0.36	0.29	1
Zhangfeng	14071.1	14506.77	0.34	0.35	1
Yangmian	7029.78	5155.16	0.32	0.23	1
Dongshan	1334.93	1706.92	0.28	0.35	1
Qixingping	2571.98	2572.2	0.32	0.32	1
Baidong	20568.3	12065.93	0.67	0.39	1.1
Baixi	6446.65	5174.35	0.23	0.19	1
Sujiapo	7167.05	6877.11	0.23	0.22	1

Selecting Factor Paired Comparison Method was used to determine the weight of each factor. For index characteristics, the research calculated the weight of factors according the 0-1 ratio scale method (Tab. 3). The formula is shown as follows:

$$W_j = \frac{\sum a_{ij}}{\sum_{j=1}^{n}\sum_{i=1}^{n} a_{ij}} \quad (1)$$

Where, a_i and a_j denote comparison factors. 0 denotes that a_i is less important than a_j; 0.5 denotes that a_i is as important as a_j; and 1 denotes that a_i is more important than a_j (Buhyoff and Leuschnerw, 1978 and 1980).

Homestead use intensity was calculated with the formula:

$$F = 100\left(\sum A_j \times W_j\right) \quad (2)$$

Where, F denotes the score of homestead use intensity; A_j denotes the evaluation index value of the *j* item; and W_j denotes the weight value of the j item.

Table 3: The weight of Evaluation Index for Rural Resident Use Intensity

Evaluation index	Average building layers	Building volume ratio	Building density	Weight
Average building layers	0.5	0	0	0.11
Building volume ratio	1	0.5	0.5	0.44
Building density	1	0.5	0.5	0.44

According to the research, the score of Baixi is less than 30; the scores of Qixiping, Dongshan, Yangmian, Sunjiapo and Zhangfeng are between 30 and 50; the score of Baidong is the highest, 58.5. The analysis of building volume ratio and building density shows that the average maximum construction layer is 1.1, most of them being 1 layer. The building volume ratio in Baidong village is the highest, 0.67, those of others being less than 0.4. The basic type of building is bungalow and the occupied area is very large. On the whole, the overall homestead use intensity is low.

THE CONSOLIDATION POTENTIAL FOR RURAL HOUSING LAND

The Theoretical Consolidation Potential for Housing Land

Based on the actual land use for homestead construction per household and the local standard in the study region, the theoretical consolidation potential for housing land was :

$$\Delta P_i = P_{i0} - B_0 \times A \quad (3)$$

Where ΔP_i denoted the theoretical consolidation potential of homestead in i region (m^2), P_{i0} denoted the status of use homestead area in i region, B_0 denoted the number of household in i region and A denotes per household planning standards (m^2/household). Potential coefficient (%) denotes the ratio of the potential for rural homestead to the total area of a homestead. The results show that: the consolidation potential area of homestead is 49687.06 m^2 and the potential coefficient is 29.94 %. Among the seven villages, the potential

coefficient of Zhangfeng, Dongshan, Qixingping and Baidong are between 20% and 30%. Those of Yangmian, Baixi and Sunjiapo are more than 30%, Sunjiapo's being the highest, 34.76%, and the consolidation potential area is 10655.08 m^2.

Consolidation Potential Regarding Different Slopes

The values shown above are merely theoretical values. Other factors also exert their influence like customs, production requirements and farmers intentions, and the topography of the local region also needs considering. As a loess hilly region, its terrain condition has a greater influence on the housing construction. To analyze this restriction condition, the study area was divided into 5 levels, namely, 0°- 2°,2°- 6°,6°- 15°,15°- 25°and > 25°, with the application of the space analysis is function of ArcGIS. Then the slop and distribution of homestead map were overlaid and thus came the spatial distribution map of homestead regarding different slopes. The slop critical values divided the levels of homestead consolidation and identified realistic consolidation potentiality regarding different slopes (Fig.1). According to the finding of an existing mountain rural housing security investigation, villagers' homes are safe, which are built on the gentle slope, average slope < 20° (Wang, 2008).

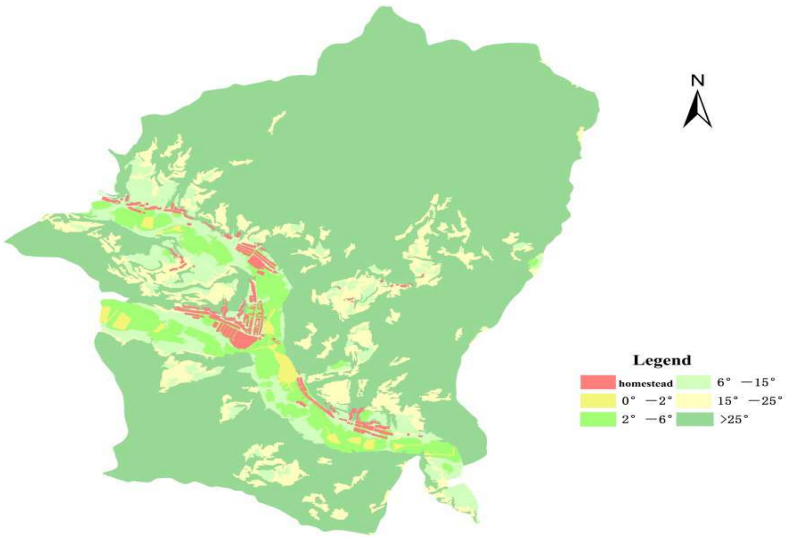

Fig.1 Homestead Distribution Overlaid With Slope Classification

Based on the field survey, in combination with the geological condition of the region which is covered by loess in the surface, 15° is taken as the safe consolidation critical value. If the slope is above 15°, the security rate of the homestead is desirable (Tab. 4). 147 parcels over 15° with the over occupied area being 34064.78 m^2, namely, the realistic consolidation potentiality value.

Table 4: Slope classification of over occupied area

Slop level	Parcel number (parcel)	Total area (m^2)	Over occupied area(m^2)
0° ~ 2°	0	0	0
2° ~ 6°	175	43551	3183.46
6° ~ 15°	243	77544.64	12438.82
15° ~ 25°	65	19561.4	13690.41
>25°	82	25302.5	20374.37

Classification of Housing Land Consolidation Potentiality

The factor analysis was conducted by using a small number of comprehensive factor indexes to describe the multiple initial factor indexes. The main factors were obtained in linear combination with comprehensive factors (Wang, 2007). Because the consolidation potentiality for housing land may take a variety of forms in the research region, it is difficult to judge the dominate form simply from the collected data and therefore, factor analysis method was needed to classify each of the existing potential form in the study region. Based on the characteristics of housing land use in the study area in combination with field investigation and measurement data, 10 factors which are quantifiable and observable were selected to build the factor index system of consolidation potentiality based on land classification. With the aid of SPSS software and the application of the factor analysis method, 10 factors were classified, namely, X_1 which denotes per household parcel, X_2, the household percentage of " one housing lands" , X_3, the area percentage of " one household owing multiple housing lands", X_4, per household area, X_5, the area percentage of over occupied housing land, X_6, average building layers, X_7, average volume ratio, X_8, average building volume ratio, X_9, the over standard parcel percentage, X_{10}, housing land density. And finally, the dominant type of consolidation potentiality was dug out.

Normalization of Data

Since the factor indexes have different attributes and the scopes of the units are different, the averaged method was adopted to select indicators for standardization processing by the formula :

$$X_i' = \frac{X_i}{X} \qquad (4)$$

Where X_i' denotes standardized value; X_i denotes each variable's value; and X denotes average value of the variable. The averaged method removes the effects of the order of magnitude and dimension, and meanwhile, ensures the existing difference degree of each factor index in its original value. Factor indexes affect the comprehensive analysis along with the degree of difference proportional to the change (Han, 2008). Reverse index indicates if the factor index is smaller, it is the better for earned value and if it's bigger, the more unfavorable. Of all factor indexes, there are three factors which are reverse indexes, namely, average building layers, average building volume ratio and housing land density. In order to achieve the same comparability, it is necessary to transform their reverse attributes into positive ones. Here comes the formula:

$$X_i' = \frac{X_{max} - X_i}{X_{max} - X_{min}} \qquad (5)$$

Where X_i' and X_i are same as formula (4), X_{max} denotes the maximum value of the evaluation factor index, whereas X_{min} denotes the minimum value.

Relativity detection

In order to distinguish whether each factor index was suitable for factor analysis, it was necessary to detect the relativity among each factor index. There are commonly two tests

used to measure whether the factor analysis model is valid statistical indicator: Bartlett test and KMO test (Li, 2001). Thus, this study also used them to detect the relativity among each factor index. And test results show that the detection value of KMO is 0.647, p (Sig. = 0.000) <0.05, proving that the model is valid, and the Chi-square statistics of Bartlett spherical detection is 259.998, thus rejecting the null hypothesis, the correlation matrix not being a unit matrix. The test results proved that the institute selected appropriate factor indexes for factor analysis.

Main Factor Determination and Consolidation Classification

According to the extraction principle characteristic value should be greater than 1, three factor indexes were found to comply with the principle, and the cumulative contribution rate shows that it can effectively represent the initial factor index information. Because the extraction factor index is abstract, it is necessary to extract the three dominant factor indexes represented by the figurative meaning using variance biggest orthogonal rotation method.

In the Tab.5, the main factor1 denotes the main content of X_1, X_2, and X_3, which mainly describes the type represented by the factor of “one household owning multiple housing lands”. The score of factor1 directly reflects the consolidation potential magnitude of “one household owning multiple housing lands” type. The main factor2 denotes the main content of X_4, X_5, and X_9, which mainly describes the type represented by the factor of over occupied area. The score of factor2 directly reflects the consolidation potential magnitude of over standard type. The main factor3 denotes the main content of X_6, X_7, X_8, and X_{10}, which mainly describes the type represented by the factor of low housing land use intensity. The score of factor3 directly reflects the consolidation potential magnitude of low housing land use intensity type. The score is higher; the corresponding consolidation potential is greater.

Table 5: Rotated Component Matrixes

Index	Factor1	Factor2	Factor3
X_3	0.897	0.148	0.074
X_2	0.879	-0.147	-0.160
X_1	0.811	-0.388	-0.184
X_{10}	-0.688	-0.343	0.371
X_5	0.021	0.922	0.250
X_9	-0.421	0.885	-0.019
X_4	0.197	0.800	0.186
X_6	-0.104	0.394	0.874
X_7	0.026	0.473	0.855
X_8	-0.380	-0.228	0.706

Table 6: The Name of Principal Factors

Variable	Factor1	Factor2	Factor3
high load index	X_3、X_2、X_1	X_5、X_9、X_4	X_6、X_7、X_8、X_{10}
naming type	“one household, multiple housing lands” type	over area standard type	low housing land use intensity type

Table 7: The Factor Score of Villages

Village name	Factor1	Factor2	Factor3
Zhangfeng	1.01617	-0.38459	0.40335
YAngmian	-1.52297	1.21038	-.16835
Dongshan	-0.40285	-1.32637	1.33973
Qixingping	-0.97347	-.42261	0.10528
Baidong	0.23544	-0.89367	-1.98280
Baixi	0.57370	0.90435	0.17427
Sunjiapo	1.07399	0.81252	0.22853

According to Tab.6 and Tab.7, there exist three types of consolidation potentiality in all of the natural villages, the type of “one household owning multiple housing lands”, the type of over standard area and the type of low homestead use intensity. Among the seven villages, Zhangfeng, Sunjiapo and Baidong belong to the type of “one household owning multiple housing lands”; Yangmian and Baixi belongs to that of over area standard type; and Dongshan and Qixingping belong to low homestead use intensity type.

Conclusions and Suggestion

After analyzing the present rural land use of the loess hilly region and calculating the realistic consolidation potential for housing land regarding slope conditions, and finally, using the factor analysis method to classify the types of land consolidation potentiality, it is highly recommended that the work of housing land consolidation should be arranged in accordance with the local natural conditions and considering the different consolidation types as are shown in Baimatan village. Meanwhile, for rural hilly regions where consolidation fund is inadequate and land management technology is relatively backward, it is necessary to broaden the financing channels, including the aid from the second and third industry of the local region, and to gain technical support to improve existing land management system and to speed up the informationalization of the rural residential area management.

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