Consolidation Potential of Rural Residential Areas Based on the Village Classification

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Abstract

From the perspective of village classification, a set of methods for accurately measuring the potential of rural settlement consolidation are proposed. Taking Feicheng in Shandong Province as the research area, combined with the corresponding planning, a classification and evaluation system for rural residential areas was constructed to classify rural residential areas from the four levels of natural resources, economy and society, supporting facilities and livability. The theoretical and practical potential of one type of rural settlements (relocating and merger village) is mainly calculated, and the potential scale, potential level and potential spatial distribution of different regions are analyzed. (Level and spatial distribution are analyzed. The results showed that the 621 rural settlements can be divided into five types: 148 urban-rural integration villages (URIV), 41 historical and cultural villages (HCV), 56 cluster developing villages (CDV), 155 keeping and limiting villages (KLV) and 221 relocating and merger villages (RMV). According to calculations, the theoretical potential of relocating and merger village areas was 1971.47 hm², accounting for 19.52% of the total scale of Feicheng residential areas; the comprehensive correction coefficient of each region was 0.48 - 0.70, and the revised actual potential is 1082.68 hm², accounting for the theoretical potential 54.92% of the total. There were large spatial differences in the scale of potential in different regions. In general, the theoretical and practical potential of the central and southern regions was higher than that of the northern regions.

Keywords

Rural Residential Land, Classification of Village, Consolidation Potential, Village Classification

1. Introduction

Land resources are important resources necessary for human social survival and

development. In recent years, my country's urbanization process has accelerated, and large numbers of people engaged in agriculture have moved out of rural areas, causing air-to-hearting, one-family multi-homes, restricted space, etc. [1]. These unreasonable landing phenomena cause serious land waste, and the use of agricultural modernization and ecological protection has gradually increased, so that rural areas have more contradictions in land use. Therefore, scientifically reasonably carry out rural land finishing, improving land-use efficiency, and thereby achieving land savings.

Due to the factors such as developing status, custom history and resource endowment, my country's different rural areas, the development law and evolution trend of rural residential points have shown a large difference [2]. Therefore, the type of scientific division of rural residential points is the premise of carrying out the finishing of rural residential points. In terms of rural residential classification, domestic and foreign scholars have focused on suitable aspects of suitability evaluation, spatial evolution characteristics and spatial layout optimization [3]-[10]. Generally based on geographic information system technology, combined with geographical statistical analysis methods, weighted voronoi diagrams, landscape index and minimum cumulative resistance model (MCR), etc., comprehensive considering natural, humanities and ecology, etc., for rural residents Spatial layout optimization and classification [11]-[16]. In terms of rural residential point, many scholars have also conducted the following research, 1) Theoretical potential measurement: mainly, some of the construction standards [17], household construction land standard method [18], idle rate method [19], volume ratio [20] and urban system planning methods [21]. According to the current area of rural settlements and the corresponding national standards, the area difference is a theoretical potential. 2) Realistic potential measurement: In order to make more practical operability, scholars generally choose factors such as natural, economic, social, ecological, and planning orientation, and build multi-level step-by-step correction model, and conversion to partial potential value The limit factors are quantified [22]-[29]. Different comprehensive evaluation systems are closely related to the local characteristics and general. In addition, some researchers introduce farmers' wishes [30] into the correction model, suitable for small and medium-size regions. There are also scholars to use GIS to build land to organize the database to master the potential of rural residential points [31]. However, in the actual development of rural residential points, there is a big gap between the potential and the actual situation of the measurement. It is mainly due to different types of rural residents, and its organizational potential is different. Such as agglomeration development and characteristic protection rural residential points are subjects of key development and protection, and the potential released after the finishing is extremely limited, and sometimes it is necessary to meet the development needs, and even need further expand the land. Relocating and merger village is a type of short board in partial levels such as production and development, or a type of demolition and demolition, which requires overall

relocation and demolition, can be based on national standards, scientific layout and planning new residential points. Construction to achieve the purpose of saving the land, release the potential. Most of the previous researches did not consider the effects of different types of rural residential points on the potential. Because, the calculated potential errors were large and the actual needs cannot be met, there is an urgent need to carry out the consolidation of rural residential areas to efficiently and intensively use land

In order to eliminate the impact of different types of rural residential points on the potential of the calculation, this paper put forward a set of accurately calculating the ranking of rural residential points, namely the corresponding plan, first construct a rural residential classification evaluation system, for rural residents Classification, re-use the real potential comprehensive evaluation model, focus on the reality of relocating and merger village, with a view to accurately calculate the potential of regional rural residential points, and provide data support for the preparation of county rural planning and actual development of rural residential points.

2. Materials and Methods

2.1. Study Area

Feicheng (Figure 1) is located in the middle of Shandong Province and borders
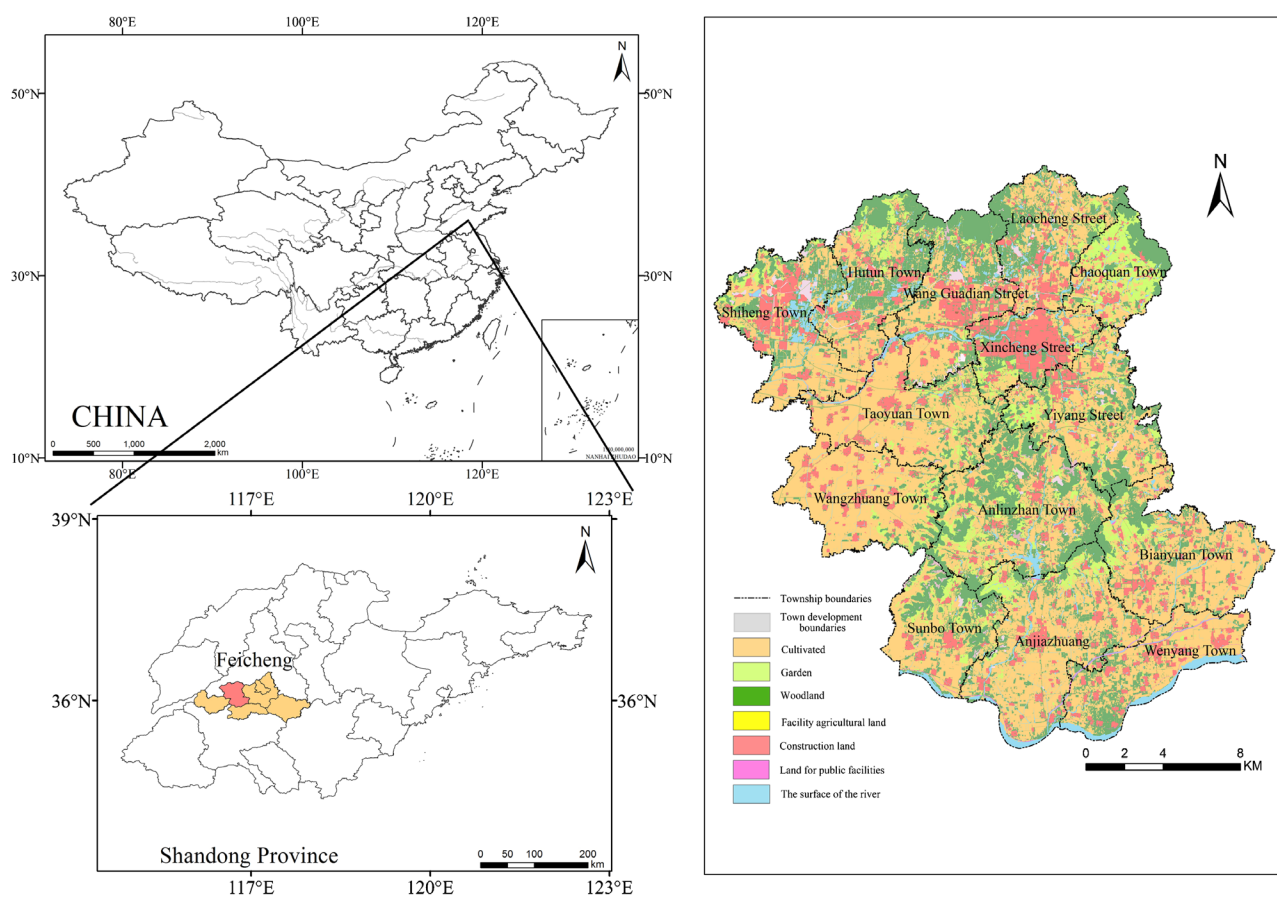
Figure 1. Map of land use in Feicheng.

Mount Tai in the east. There are 14 townships under its jurisdiction. It has a population of 502,000 in urban areas and 490,000 in rural areas, with a total area of 127,700 hm². At present, the per capita construction land area in Feicheng rural areas is 129.25 m²/person, which is 1.29 times the highest standard in Shandong Province. The lack of scientific planning and "extensive" management in the construction of rural residential areas has caused a serious waste of land resources. Therefore, there is an urgent need to carry out the consolidation of rural residential areas to efficiently and intensively use land.

The data for the research on the status, location, and land use of rural residential areas and various infrastructures are mainly derived from the third national land and resources survey database; economic conditions and social environment data are derived from the "2018 Taian Statistical Yearbook".

2.2. Combining Planning to Classify the Types of Rural Residential Areas

The rural residential areas in the suburbs of cities and towns and county towns and towns have gradually turned to urbanization or have the conditions for transformation to urbanization. The evolution direction is defined as the integration of urban and rural areas; Fei cities have features, historical and cultural landscapes, and special protection values. Rural residential areas are retained and listed as characteristic protected rural residential areas.

2.2.1. Classification and Evaluation Index System of Rural Residential Areas

In this study, 12 factors were selected from the four levels of resource endowment, social economy, supporting facilities and livability, as the evaluation indicators of the general rural settlement classification evaluation system, as shown in Table 1.

2.2.2. Index Weight Calculation and Classification

The coefficient of variation method is a widely used objective weighting method in the evaluation of relevant land [32].

1) Calculate the coefficient of variation V_i:

$$V_i = \frac{\sigma_i}{\overline{x}_i}\left(i = 1, 2, \cdots, n\right) \tag{1}$$

2) Calculate the weight of each indicator W_i:

$$W_i = \frac{V_i}{\sum_{i=1}^{n} V_i}\left(i = 1, 2, \cdots, n\right) \tag{2}$$

3) Range standardization treatment:

$$\text{Positive index}: X_{ni} = \frac{X_{ij} - X_{i\min}}{X_{i\max} - X_{ij}} \tag{3}$$

$$\text{Negative index}: X_{ni} = \frac{X_{i\max} - X_{ij}}{X_{ij} - X_{i\min}} \tag{4}$$

Table 1. Classification and evaluation index system of rural residential areas.

Criterion level	Indicator level	Index description	Indicator attributes	Weight	Coefficient of Variation
Natural resources	Residential area size	Rural settlement scale/km²	+	0.1105	0.7395
	Cultivated land ratio	Cultivated land area of residential area/area of residential area	+	0.0696	0.4654
	Proportion of agricultural facilities	Area of agricultural facilities in residential area/area of residential area	+	0.0840	0.5618
Economy and society	Revenue	Fiscal revenue of local township governments	+	0.1387	0.9281
	Intensity of settlements	Rural settlement area/number of patches	+	0.0948	0.6342
	traffic condition	The average time from each road node to other nodes /min	−	0.0666	0.4453
Supporting facilities	Commercial Service Facilities	The shortest Euclidean distance between residential areas and commercial service facilities/m	−	0.0891	0.5964
	Medical education facilities	The shortest Euclidean distance between the residential area and the medical education facility/m	−	0.1012	0.6771
	public facility	The shortest Euclidean distance between residential areas and public service facilities/m	−	0.0872	0.5831
Livability	Geological disaster	According to the impact of coal mining subsidence, it is divided into 1 - 4 levels	+	0.0666	0.4453
	Ecological vulnerability	The potential risks of water resources protection areas are divided into 1 - 4 levels	+	0.0500	0.3342
	Construction	There is a fixed value of 1 for the construction area of major projects, and the rest are 0	−	0.0418	0.2799

Note: The impact levels of coal mining subsidence are serious, serious, minor, and no impact, respectively; the potential risks to water resources protection areas are high-risk areas, medium-risk areas, low-risk areas, and no impacts.

Among them, X_{ni} is the standardized value of each evaluation index; $X_{i\max}$ is the maximum value in the evaluation index; $X_{i\min}$ is the minimum value in the evaluation index; X_{ij} is the value of each evaluation index before standardization.

4) Calculate the score of the indicator of each rural residential area:

$$S_i = X_{ni}W_i \left(i = 1, 2, \cdots, n \right) \tag{5}$$

First, formulas (1) and (2) were used to determine the weight of each indicator, combined with the opinions of experts in the direction of agricultural land consolidation, to fine-tune the weights obtained, and then obtain the weights of each evaluation indicator (Table 1). Then, formulas (3) and (4) were used to calculate the scores of each evaluation index.

5) Classification of rural settlements

The clustering method of inter-group linkage system is a widely used classification method [33]. Using this classification method, rural settlements with similar evaluation index values can be classified into one category to ensure that rural settlements of the same type have similar attribute values.

2.3. Calculation of Potential of Rural Residential Area Consolidation

2.3.1. Theoretical Potential Calculation of Rural Residential Area Consolidation

The per capita construction land standard method was adopted to determine the per capita standard construction land area as 80 m²/person. The theoretical potential area (ΔS) is:

$$\Delta S = S_{cur} - B_t \cdot Q_t \tag{6}$$

Among them, S_{cur} is the current area of rural residential areas; B_t is the population size; Q_t is the standard construction land area per capita.

2.3.2. Calculation of the Realistic Potential of Rural Residential Areas

1) Constructing a comprehensive evaluation model of realistic potential

In the actual process of rural settlement reorganization, some influencing factors limit the conversion of theoretical potential to practical potential. Synthesize the impact of six factors at three levels: natural factors, population factors, and land use status (**Table 2**), quantify the influencing factors, build an evaluation model to comprehensively modify the theoretical consolidation potential [34].

Calculation formula:

$$S' = \Delta S \cdot K_{cor}, \quad K_{fix} = \sum_{i=1}^{n} \left(X_{ni} \cdot w_i \right) \tag{8}$$

Among them, S' is the actual potential; ΔS theoretical potential; K_{cor} is the corresponding potential correction coefficient; n is the total number of indicators; X_{ni} is the standardized value of each evaluation index; w_i is the single evaluation The weight value of the indicator.

2) Index weight calculation and grading

Synthesize the importance of various restrictive factors and the size of the sample size, used the analytic hierarchy process (AHP) to obtain the weight of each evaluation index, and carried out standardization processing (formula 3, 4)

Table 2. Evaluation index of realistic potential of rural residential renovation.

Criterion level	Indicator level	Index description	Indicator attributes	Weight
Natural factors	Terrain slope	The slope is divided into 5 grades in sequence with 25˚, 15˚, 6˚, and 2˚ as the boundary	+	0.0851
	Soil thickness	Taking 30 cm, 60 cm and 100 cm as the boundary, Soil thickness, divided into four levels in turn	+	0.1007
Demographic factors	Urbanization rate	Urbanization rate of local townships	+	0.2082
	Proportion of young and middle-aged population	Proportion of population aged 18 - 50 in local townships	−	0.0843
	Proportion of employees in secondary and tertiary industries	Proportion of population engaged in secondary and tertiary industries in local townships	+	0.1083
Land use status	Intensity of settlements	Intensive degree of patches in various rural residential areas	+	0.1279
	Farm-to-civil ratio	Area of cultivated land/area of residential area	−	0.2855

and assign values. Finally, according to (Equation (8)), the correction coefficient and the actual consolidation potential of rural residential areas were calculated. Using the classification method of natural discontinuities, the consolidation potential of rural residential areas in Feicheng City was divided into 4 levels in terms of townships [35].

3. Results

3.1. Classification of Rural Settlements

The study combined the land and space planning of Feicheng and the special plan for historical and cultural protection, determined the boundaries of urban development and the scope of characteristic protected villages, and screened out 148 urban-rural integration types and 41 characteristic protection types. For rural residential areas without special requirements, 12 evaluation indicators were selected from the four aspects of resource endowment, economy and society, supporting facilities and livability, to construct a classification and evaluation system for rural residential areas, and divided them into 56 cluster developing village, 155 keeping and limiting village and 221 relocating and merger village (Table 3). A total of 621 rural settlements of various types were involved, with a total scale of 6333.22 hm^2, covering 14 towns in the city, and the proportions and spatial distribution were basically in line with the actual situation (Figure 2).

Table 3. Classification results of rural settlements.

Township	URIV	HCV	CDV	KLV	RMV	Population size	Area of village/hm^2
Xincheng Street	22	0	0	1	3	0.26	38.84
Laocheng Street	35	6	1	3	2	2.89	118.31
Shiheng Town	14	1	10	16	2	2.82	444.69
Hutun Town	6	5	4	10	21	3.69	378.71
Wang Guadian Street	21	2	2	4	5	1.88	147.85
Taoyuan Town	4	1	6	13	18	4.59	644.48
Bianyuan Town	9	6	5	39	21	6.92	783.97
Anjiazhuang Town	3	3	4	15	46	5.36	915.87
Wenyang Town	9	8	3	21	13	5.39	621.94
Chaoquan Town	2	0	3	5	1	1.03	272.61
Wangzhuang Town	4	3	9	10	27	4.14	745.13
Anlinzhan Town	5	2	4	7	30	4.5	549.44
Sunbo Town	2	1	4	3	7	1.98	319.86
Yiyang Street	12	3	1	8	25	3.57	351.54
Total	148	41	56	155	221	49.02	6333.22

Note: "Others" refers to the management scope of the state-owned forest farm and Tai'an Water Resources Bureau, which are not covered in this study area.
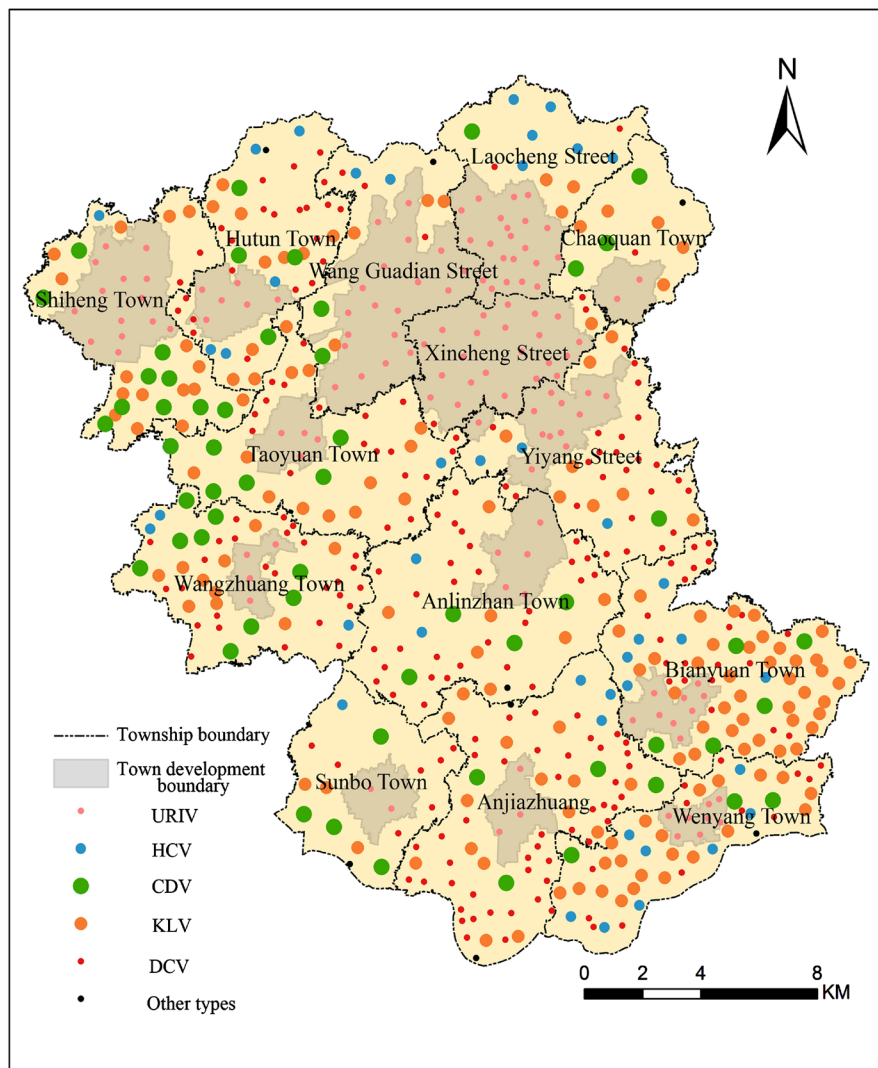
Figure 2. Classification spatial distribution map of rural residential areas in Feicheng.

Urban-rural integration village (URIV): This type of rural settlements was mainly covered by the main urban areas of counties and cities, towns and suburbs, with a total of 148 rural settlements, accounting for 23.83% of the total. The rural settlements within the coverage of the urban development boundary were mainly distributed around cities and towns. As a whole, the coverage of the northern region was wider than that of the southern region, and the urban development boundary of the four sub-districts in the northeastern region was connected together, which was the largest Area.

Historical and cultural village (HCV): mainly villages with special protection value, a total of 41 villages, accounting for 6.6%. The direction of its reorganization was to coordinate the relationship between protection, utilization and development, combine characteristic resources with cultural tourism and leisure industries, and drive local development.

Cluster developing village (CDV): This type of rural settlement was characterized by superior resource endowment conditions, large and concentrated settle-

ments, and relatively completes agricultural production and living facilities. A total of 56 rural settlements, accounting for 9.02%, were rural revitalization. In terms of spatial distribution, there were more rural settlements of this type in the northern region than in the southern region. The reason was that the financial situation of the northern townships was better than that of the southern region, and can support the retention and development of more rural settlements under the same conditions. At the junction of Wangzhuang Town, Taoyuan Town and Shiheng Town, the density of agglomerated and developed rural settlements was relatively high. The main urban agglomeration in the east could be used to develop industrial clusters in rural areas and form a new pattern of coordinated development of urban and rural areas.

Keeping and limiting village (KLV): Compared with agglomeration development type rural settlements, the development conditions of this type of rural settlements were outstanding. A total of 155 rural residential areas accounts for 24.96%. The future development direction was to maintain the status quo of residential areas, improved the production and living environment, and improved the quality of life of the people. In terms of spatial distribution, the remaining rural residential areas were mainly distributed in the areas surrounding the development boundaries of towns and towns. Among them, the southern part of Feicheng City, especially Bianyuan Town and Wenyang Town, were more concentrated, mainly because this area was a traditional agricultural production area. This feature could be combined to vigorously develop modern agriculture and improve the vitality of residential development.

Relocating and merger village (RMV): This type of rural residential area had shortcomings in its own resource endowment conditions, and the production and living conditions cannot meet the needs of local rural residents. Due to the fragmented patches of rural residential areas and the limited scale of funds and technical support, the benefits of infrastructure construction and industrial upgrading in such villages were not significant. Therefore, it was a more rational choice to rationally invest limited resources in areas with high development potential. There were a total of 221 such rural settlements, accounting for 35.59% of the total, which was the largest number among the five types. In terms of spatial distribution characteristics, the relocation and merged rural settlements of various towns and villages were mainly distributed in the fringe areas of towns and towns, far away from the urban area, and it was difficult to cover infrastructure and public services. In the northern part of Feicheng, some relocating and merger village areas are located in the coal mining subsidence area, and the risk of geological disasters was higher; the central area was within the scope of the water resources protection zone and the ecological environment was fragile; on the whole, Feicheng There were more Relocating and merger in the southern part of the city than in the northern part, of which 46were involved in An Jiazhuang Town.

## 3.2. Analysis of the Potential Scale of Relocating and Merger Village

Different types of rural settlements had different development directions. Rural

settlements had completed the entire process of relocation, construction and demolition. Only the rural settlements that had been scientifically planned and constructed could truly release their consolidation potential, and different rural settlements of the same type were due to natural conditions, demographic factors, and land. There were differences in conditions such as utilization status, and the actual potential of its used value will also be different. In order to make the research results have practical application value, this research focused on calculating the theoretical and practical potentials of relocation and merger-type rural settlements relocating and merger village with higher reorganization potential (Table 4 and Figure 3).

Due to the influence of the size of their own settlements, population and other factors, the theoretical potential, practical potential and comprehensive correction coefficients of rural settlements of various towns and villages showed large differences. The total theoretical potential scale of Feicheng relocating and merger village was 1971.47 hm^2, accounting for 19.52% of the total scale of Feicheng rural settlements. Among them, Anjiazhuang Town involves the most rural residential areas and has the highest theoretical potential. It was the only first-level potential area, reaching 544.09 hm^2. The total scale of the actual potential for relocating and merger village was 1082.68 hm^2, accounting for 54.92% of the theoretical potential. Due to the large theoretical potential base of Anjiazhuang Town, even though it was restricted by factors such as the level of urbanization

Table 4. The theoretical and realistic potential of rural settlement readjustment in Feicheng.

| Township	Theoretical potential/hm^2	Potential grading	Realistic potential/hm^2	Potential grading	Comprehensive correction factor
Xincheng Street	42.11	Level 4	39.30	Level 4	0.6705
Laocheng Street	29.44	Level 4	17.36	Level 4	0.5895
Shiheng Town	17.11	Level 4	12.06	Level 4	0.7048
Hutun Town	102.49	Level 3	63.06	Level 3	0.6153
Wang Guadian Street	42.17	Level 4	29.83	Level 4	0.7074
Taoyuan Town	149.56	Level 2	73.87	Level 3	0.4939
Bianyuan Town	141.37	Level 2	69.35	Level 3	0.4906
Anjiazhuang Town	544.09	Level 1	318.10	Level 1	0.5846
Wenyang Town	174.82	Level 2	93.57	Level 2	0.5352
Chaoquan Town	32.45	Level 4	20.43	Level 4	0.6294
Wangzhuang Town	241.66	Level 2	121.13	Level 2	0.5012
Anlinzhan Town	182.73	Level 2	96.75	Level 2	0.5295
Sunbo Town	69.90	Level 3	42.92	Level 3	0.6140
Yiyang Street	201.57	Level 2	96.02	Level 2	0.4764
Total	1971.47		1082.68		
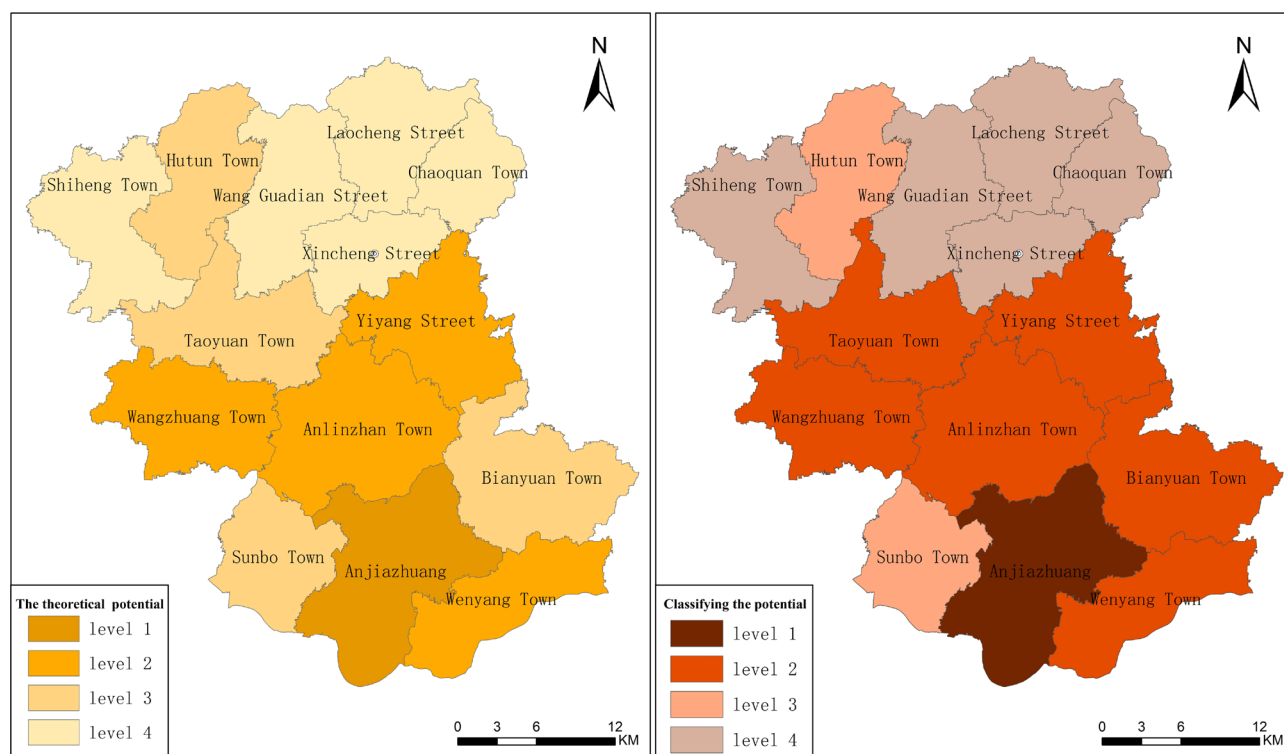
Figure 3. Classifying the potential value of rural settlement readjustment in Feicheng.

and human-land contradictions, the comprehensive correction coefficient of the town is only 0.5846, and its actual potential scale was also the largest. This area had low cost, high efficiency, and quick results. It could be used as a key area for reorganization. However, Shiheng Town and Wangguadian Streets were less restrictive to potential transformation, so the comprehensive correction coefficients are 0.7048 and 0.7074 respectively, which were at a relatively high level. The urbanization rate of Yiyang Street was only 0.21, and the contradiction between people and land wasmore prominent, so the comprehensive correction coefficient was the lowest, and the potential conversion efficiency was low.

3.3. Analysis of Spatial Distribution and Change of Sorting Potential

In terms of spatial distribution, both theoretical and actual potentials showed that the northern region was significantly lower than the central and southern regions. The main reasonwas that the northern region's own resource endowment and economic and social development were generally better than the central and southern regions, and the relocating and merger village involved The number of sites was small, and the scale of reorganization is relatively small. Moreover, the central and southern regions were traditional agricultural agricultural areas with dense populations and large-scale rural settlements, so the efficiency of rural settlement reorganization was relatively high. With Anlinzhan Town as the center, high-potential areas were concentrated, forming a key consolidation area in the south. In the northern region, around the main urban area of Feicheng, a
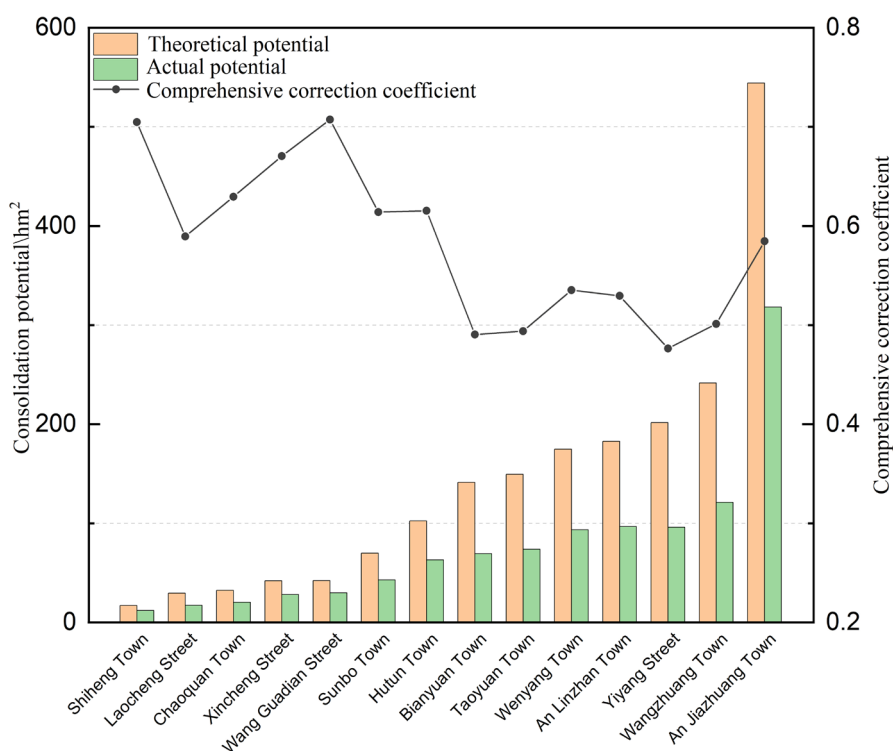
Figure 4. Changes in the potential for remediation of rural residential areas.

low-potential reorganization area in the northern region was formed, which involved fewer rural settlements and relatively little resistance to reorganization. In terms of potential changes (**Figure 3** and **Figure 4**), the five towns of Shiheng Town, Laocheng Street, Chaoquan Town, Xincheng Street and Wangguadian Street were restricted by their own remediation scales, and their comprehensive correction coefficients were relatively high. Therefore, their potential changes were relatively small; the other 9 towns had more obvious changes in their potential values, especially Anjiazhuang Township's potential value changes by 225.9hm^2. The potential levels of most towns and villages did not change significantly before and after the revision. Only the potential levels of Taoyuan Town and Bianyuan Township were reduced from Level 2 to Level 3, indicating that their potential conversion efficiency was low.

4. Discussion

At present, agricultural and rural modernization is progressing steadily, and land consolidation in rural areas has gradually become one of the hot topics of discussion and research. Rural settlement consolidation is an indispensable link in land consolidation. It is in the promotion of people-oriented new urbanization and in-depth promotion of rural revitalization strategies. There is an important meaning in this respect. According to the scientific classification of rural residential areas according to the law of development and evolution, and quantitatively describe the potential of rural residential areas consolidation, land consolidation planning can be formulated in accordance with regional characteristics

and inject new impetus into local development. This study uses the above research methods to divide Feicheng's rural residential areas into five types. The proportion and spatial distribution of each type of rural residential areas are relatively uniform and basically consistent with the actual situation. In the process of calculating the realistic potential of the selected relocating and merger village, the multi-factor comprehensive correction method is adopted, and representative factors can be selected to truly reflect the basic conditions of different rural settlements, and the final calculated theory, realistic potential and the comprehensive correction coefficient is in line with the actual situation as a whole. The main purpose of carrying out rural settlement reorganization is to promote rural revitalization, and the economic and social benefits it produces are indispensable resources for the development of agriculture, rural areas, and farmers [36]. Therefore, in the process of classifying rural settlements and calculating the potential for consolidation, the starting point is to protect the interests of farmers and increase their land income. How to comprehensively consider the "human" factors of relevant farmer groups and include them in the evaluation system requires further research.

5. Conclusions

1) Combining the corresponding planning, this study established a classification and evaluation system for rural residential areas and divided the 621 rural residential areas in Feicheng into 148 urban-rural integration villages, 41 historical and cultural villages, 56 cluster developing villages, 155 keeping and limiting villages and 221 relocating and merger villages (RMV). The proportions of various types of rural residential areas were coordinated, and the spatial layout is more reasonable. It not only implemented the relevant requirements of land and space planning and characteristic protection but also reflected the differences of different types of rural residential areas, so as to better identify relocating and merger village.

2) The relocating and merger village were the key areas for rural settlement consolidation. By using the per capita construction land standard method, the theoretical potential of rural settlement consolidation within the research area was calculated to be 1971.47 hm^2, accounting for the total scale of urban settlements. 19.52%; A comprehensive evaluation model of realistic potential was constructed, and the comprehensive correction coefficient of each area was calculated to be 0.48 - 0.70. The practical potential of rural residential settlements was 1082.68 hm^2, accounting for 54.92% of the theoretical potential. There were big differences in the scale and space of consolidation potential in different regions. In general, the theoretical and practical potential of the central and southern regions was higher than that of the northern regions.

Using the method of first classifying and then calculating and reorganizing potential, it can reasonably screen out the relocating and merger village, quantify the impact of restrictive factors on potential transformation, accurately calcu-

lated the actual potential, and prepared corresponding plans and carried out differentiated rural residential area reorganization.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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