Optimization of Rural Public Service Facilities Allocation Under the Rural Withdrawal and Integration —A Case Study of Dalong Town, Guang ‘an District

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Abstract. In the process of accelerating rural revitalization and urbanization construction, it is imperative to abolish and merge the village. For this reason, this paper takes the case of the rural withdrawal and integration in Dalong Town, Guang’an District as an example, by analyzing the rural public service facilities in the population eccentric before and after the removal, environmental conditions, and the characteristics of the layout of the residential situation and subsequent influence, and with centricity evaluation method, put forward different centricity village after removal in the public service facilities configuration optimization strategy, to integrate resources of the development of rural area, to enhance the service supply capacity of public service facilities in rural areas after the disestablishment and consolidation.

Keywords: consolidation · public service facilities · layout optimization

1 Introduction

As the basic unit of national governance, rural areas are the “cornerstone” for integrated urban-rural development and the “main battlefield” for rural revitalization. At present, China has 500 million rural people, and the urbanization rate of permanent residents has reached 64.72 percent. With the continuous acceleration of urbanization, on the one hand, there are many problems in rural areas, such as large numbers, small scale, large density, and weak strength. Unreasonable administrative divisions cannot meet the requirements of urbanization and governance modernization [1]. On the other hand, the population and spatial sustainability of rural areas are rapidly decreasing, which gradually leads to some problems such as scattered rural layout, insufficient development potential, and unreasonable resource allocation among villages, which have affected the development of rural areas to varying degrees.

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As an important carrier of rural development, public service facilities have become an important starting point for rural construction in the new era. At present, the technical guidelines and standards of village planning are mainly used as the main basis for facility allocation in rural areas in China [2], and the "one-size-fits-all" approach cannot ensure the reasonable allocation of resources. As for the research on rural public service facilities, relevant scholars have recognized the problems of facility allocation caused by factors such as urban-rural location relationship [3], industrial type [4], and village and town pattern [5]. Facing the pressure on rural resources caused by withdrawal [6], the optimization of public service facilities layout faces challenges. In addition, few scholars have given in-depth optimization ideas for the allocation of public service facilities in view of the withdrawal and integration of rural. Taking Dalong Town, Guang 'an District, Guang 'an City, as an example, this paper studies the layout characteristics of rural public service facilities after the removal of the rural and puts forward corresponding layout optimization countermeasures and suggestions, to provide practical and useful guidance for promoting the deployment of rural public service facilities and rural demolition and removal in China.

2 Regional Overview and Research Methods

2.1 Regional Overview

Dalong Town is located in the northeast of Guang'an City, in the middle reaches of the Qujiang River, about 10.5 km away from the city, covering an area of 74.7 square kilometers (Fig. 1). It is an inland subtropical humid climate zone, with abundant rainfall and mild climate. It is suitable for agriculture in all seasons. As one of the main grain-producing areas in Guang'an District, Dalong Town is one of the core towns of Guang'an modern agricultural Park. The town has Guangheng fast track, Qianzao trunk two main road intersections, convenient transportation, and highway infrastructure is perfect. After the village-level system adjustment in 2020, 36 administrative villages were merged into 16 administrative villages (excluding the Xiaoqiao community), and the number of administrative villages was reduced by 20, with a reduction of 55% (Fig. 2).

2.2 Data Sources

The basic data of the study mainly include map data, geographic information data, POI data, and other data (Table 1). All spatial data are projected in the unified coordinate system CGCS2000_3_Degree_GK_Zone_36. The geographic information data were analyzed and processed by remote sensing image processing platforms ENVI 5.3 and ArcGIS10.8.

2.3 Study Methodology

(1) GIS spatial analysis method

Based on the terrain and remote sensing data, GIS spatial analysis and band calculation tools are used to extract the geographic information elements. At the same time, GIS

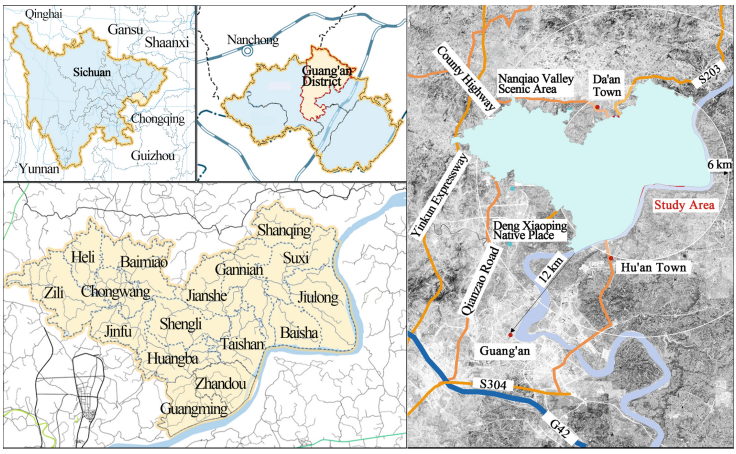

Fig. 1. Geographical location

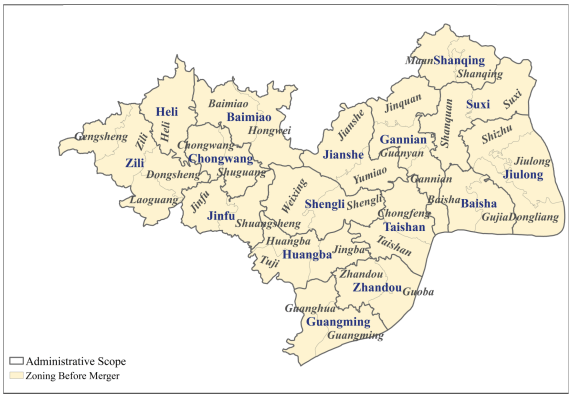

Fig. 2. Zoning adjustment

was used to analyze the correlation between POI data, residential patches, and spatial data network.

①Kernel density analysis is to grid point features and reflect their distribution characteristics according to the kernel density values in the grid [7]. In the trial, k_j is the spatial weight of element j, D_{ij} is the distance between spatial point i and research object j, and R is the search radius.

$$p_i = \frac{1}{n\pi R^2} \times \sum_{j=1}^{n} k_j \left(1 - \frac{D_{ij}^2}{R^2}\right)^2 \tag{1}$$

②The hot spot analysis statistical model is based on the statistical principle of Getis Ord Gi *, which is used to reflect the hot and cold spots of variables in space. For positive z scores with significant statistical significance, the higher the z score, the closer

Table 1. Data source and purpose

Type	The name of the data	Point in time	The data source	The main purpose
Map data	The administrative area	2020	Natural Resources Bureau of Guang 'an District	Obtain all levels of administrative boundaries
Geographic Information	Landsat 8 OLI-TRIS (30m)	2022.5	GS Cloud	Extract water systems, road networks
	ASTER GDEM 30M data	2020	GS Cloud	Get basic terrain conditions
POI data	Public service facility point location data	2022	Autonavi Data Open Platform	Public service facilities point primary
Other data	Guang'an District discloses relevant planning information	2019–2022	Visiting survey	Withdrawal and information, Rural opinion
	Borough changes	2020	Dragon town The people's government	Elements to sort out
	Drone imagery	2022	On-the-spot investigation	POI correction

the clustering of high values (hot spots).

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \overline{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \tag{2}$$

In the formula, x_j is the attribute value of element j, $w_{i,j}$ is the spatial weight between element i and j, n is the total number of elements, and G_i^* is the score of z.

③The life circle model is based on the centroid of all residential areas in the study area and the walking speed of normal adults as the standard to analyze the accessibility coverage of multiple facility dimensions near residential areas [8] (Fig. 3).

(2) Centrality analysis method

As a method of social network analysis, centrality reflects the centrality degree of the overall structure of the network. In this paper, each element of the administrative village is regarded as the structural unit of the network, and the connectivity, correlation, and activity degree of the village in the relationship network is studied [9]. The range standardization of the data was carried out to eliminate the index dimension, and the

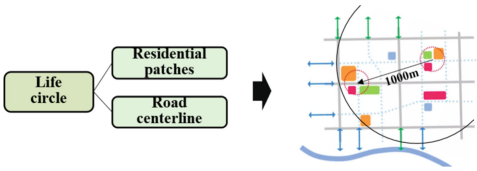

Fig. 3. Schematic diagram of life circle model

formula was as follows:

$$X = \begin{cases} \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})} Positive\ indicators \\ \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})} Negative\ indicators \end{cases} \tag{3}$$

AHP was used to determine the weight w_i of each index. The calculation formula for the village centrality evaluation value is as follows:

$$F = \sum x_{ij} \cdot w_i \tag{4}$$

(3) Field survey method

Through field observation and semi-structured interviews, the POI data were modified, and the realistic demand of villagers for public service facilities and the time they were willing to spend on going to rural public service facilities were understood.

3 Analysis of the Current Characteristics and Impacts of Public Service Facilities

3.1 Optimization Situation Under Population Bias

In terms of population flow, the permanent population of Dalong Town is in a one-way outflow state, with a large number of migrant workers and a small number of external populations. In terms of age composition, the outflow of young and middle-aged people is dominant, and middle-aged and elderly people aged 45–65 years account for more than 50%, indicating an obvious aging phenomenon. In addition, students studying in town schools and young children left by their parents' migrant work also account for a certain proportion of the permanent resident population, and they are highly dependent on public service facilities such as social welfare and security facilities, education, and medical facilities.

The population of Dalong Township, Suxi Township, and Chongwang Township is larger, which is manifested in the areas around Zili Village, Suxi Village, and Shengli Village before the consolidation, and the overall population of the central and western regions is higher than that of the eastern regions. In terms of the consolidation of rural, the consolidated form was affected by rural populations before the consolidation to a certain extent, showing the characteristics of small-scale villages "Be annexed" and large-scale villages "Increase scale", or villages with population gathering around core

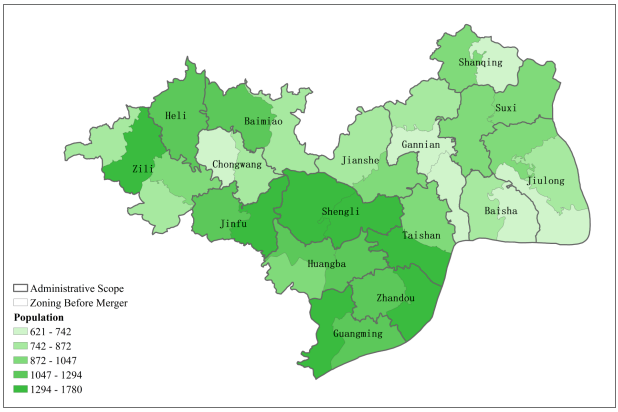

Fig. 4. Schematic diagram of population consolidation

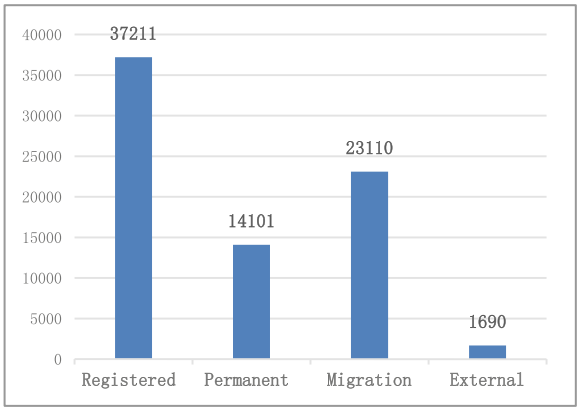

Fig. 5. Population status

industries dominated the "Consolidate other villages" (Fig. 4). At the time of population consolidation, Zili Village, Shengli Village, and Huangba Village after the consolidation had public service facilities based on the population before the consolidation, compared to Jiulong Village and Gannian Village after the consolidation faced more pressure due to insufficient public service facilities (Fig. 5).

3.2 Configuration Conditions Under Environmental Conditions

According to the classification of public service facilities, there are eight categories: education, medical and health, culture and entertainment, social welfare and security, financial services, commercial services, postal and telecommunications, administration, and community services (Table 2). Through POI crawling and survey data correction analysis, the existing types of public service facilities in Dalong Town are relatively complete, but the number is relatively small. There are differences in the allocation of

public service facilities between villages, and the gap is more obvious after the removal and consolidation of the system, which is in urgent need of optimization and supplementation. According to the analysis of the topographic conditions of Dalong Town, 75% of the area under the jurisdiction of Dalong Town is located in hilly terrain with moderate slope, and there are many low hills and rough ground surface, which is reflected in the existing public service facilities built on flat land, and the high terrain and poor topographic conditions areas should be avoided as far as possible (Fig. 6).

In general, except for the basic living facilities such as administrative management, community services, and education, the other facilities are relatively inadequate in configuration level, relatively scattered in layout, and poor in quality and service capacity (Fig. 7). In terms of administrative villages, Chongwang Village, Huangba Village, and Suxi Village had relatively good facilities, while most villages had insufficient facilities. In addition to the elderly activity center, there is a serious lack of public service facilities in many villages, such as Baimiao Village, Shengli Village, Zhandou Village, and Jiulong Village, and there is a gap in commercial service facilities like shops and cultural facilities for villagers' leisure and entertainment.

Table 2. Statistics of various public service facilities in Dalong Town

Facilities type	Education			Medical and health		Cultural and entertainment		Social welfare and security	
Specific classification	Middle school		Primary school	Institutes of health	Health posts	Leisure entertainment	Tourism	Nursing home	The elderly Activity center
Number	2		3	3	1	6	6	1	20
Facilities type	Financial Services		Business service		Postal and Telecommunications			Administration and community services	
Specific classification	Bank	Village financial Service	Company and factory	Agriculture, forestry, husbandry	E-commerce service point	Postal Service Points	Telecommunications business hall	Village committee (Removed)	The people's government
Number	6	2	7	5	6	4	2	20	16

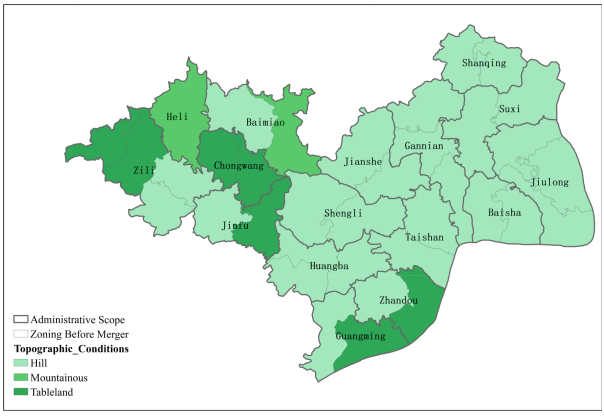

Fig. 6. Distribution of topographic conditions

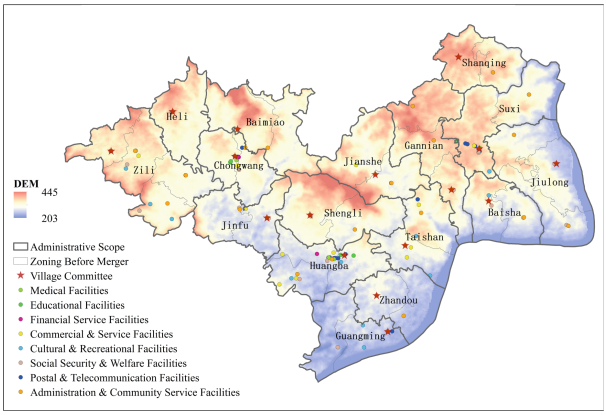

Fig. 7. Distribution of public service facilities

3.3 Configuration Influence Under Settlements Layout

In the rural settlements space layout and on the basis of the existing road, based on the rural life circle concept analysis existing [10], the applicable scope of the public service facilities in 10 min considering the general health of the elderly fatigue limit build walk on foot, maximum distance is set to 1000 m (Fig. 8), it can be seen that most of the public service facilities within 10 min walk. In addition to the serious shortage of the number of public service facilities, they have good adaptability to existing villagers, which is obvious in Huangba Village and Chongwang Village, but still cannot meet the daily needs of permanent villagers in the walking circle area.

The decentralized spatial layout of rural residential areas has gradually limited the development of marginal villages far away from areas with high facility allocation. Therefore, in the process of relocation, consolidation, reduction, and contraction of rural settlements, people's willingness to move to areas with more perfect facilities has become the development trend. Through the hot spot analysis of the GIS spatial analysis module, the possible distribution characteristics of the village and village residential patches in the town were studied in the future. Then, the residential patches in Dalong town showed agglomeration distribution, and Zili Village, Chongwang Village, Shanqing Village, and Suxi village had high hot spots, forming a layout area with high possibility. It provides a reference basis for the layout of rural public service facilities in Dalong town (Fig. 9).

4 Evaluation and Optimization Strategy of Public Service Facility Allocation

4.1 Index Composition

According to the analysis of population distribution, environmental conditions, and settlements situation above, the rural centrality index system is constructed by three criterion layers and nine factor layers: population "emphasis", environment condition "emphasis" and settlements "emphasis" (Table 3).

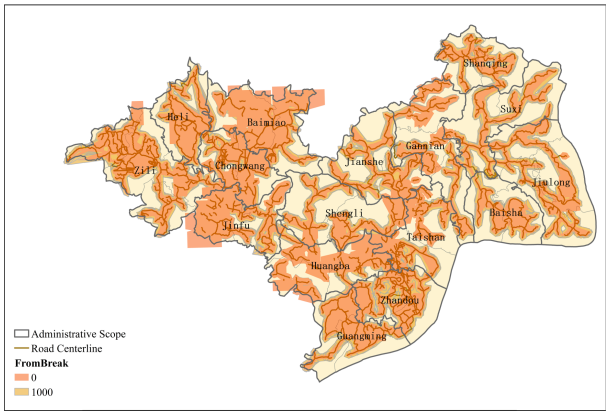

Fig. 8. Construction of pedestrian circle network

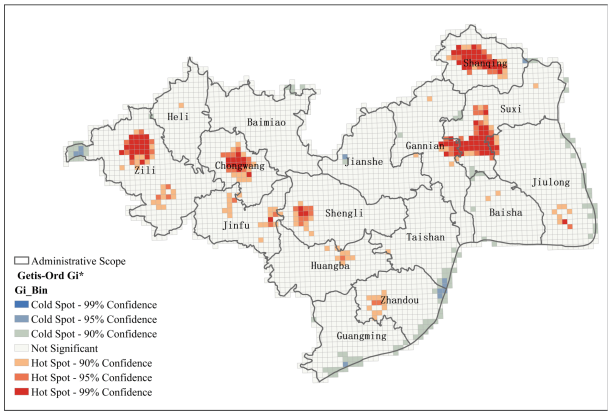

Fig. 9. Hot spot distribution of settlements

4.2 Analysis and Evaluation

The visualization results of rural centrality were obtained by standard quantification and evaluation of index evaluation data through GIS.

The darker the color, the greater the potential of the village as a central village, and the lighter the color, the vice versa. It can be clearly seen that the areas with high centrality are concentrated in the central and western areas of Dalong town, and the number of villages with high, medium, and low centrality types are 7, 4, and 5, respectively (Fig. 10). High centrality villages have a greater possibility to serve as public service centers. In addition, it also affects the balance of distribution of surrounding villages and other facilities.

Table 3. Central evaluation index system

Rule layer	Index layer	describe	The weight	attribute
Demographic "emphasis" (0.4429)	Permanent population (person)	The current permanent population of each administrative village	0.1672	+
	Attrition rate (%)	1- Permanent population/registered population	0.1348	-
	Aging rate (%)	Number of permanent residents aged over 60/number of permanent residents	0.0874	+
Habitat "emphasis" (0.3873)	Public service facility density (per $\cdot km^{-2}$)	The higher the density of facility distribution, the higher the value	0.1932	+
	Number of core industry projects (per unit)	Number of core industries where Dalong Town administrative village is located	0.1292	+
	Landscape Diversity Index	$H = -\sum_{i=1}^{m}(P_k)log_2(P_k)$, m is the number of landscape types, P_k is the area proportion of patches of type k in the landscape	0.0120	+
Settlements "emphasis" (0.1698)	Degree of settlement aggregation	Settlement patch right confirmation data	0.1668	+
	Village road accessibility	Road length/total area of the village	0.0530	+
	Tillage closest distance	Distance from the centroid of the arable patch to the centroid of the nearest settlement	0.0564	+

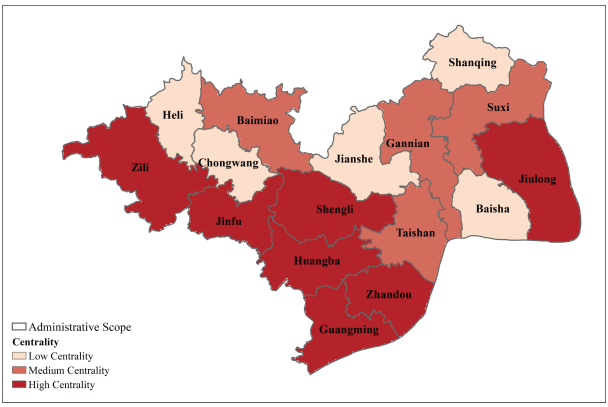

Fig. 10. Evaluation of rural centrality

5 Conclusion

With the promotion of the rural revitalization strategy, governments at all levels continue to increase investment in rural construction. The withdrawal and integration in rural areas are conducive to integrating rural regional development resources, expanding and optimizing development space, and enhancing the ability to supply public services. However, the unequal distribution of population, different environmental conditions, and the inefficient allocation of residential areas become obstacles to the allocation of public service facilities. Therefore, through the construction of rural construction centrality evaluation, the optimization strategy of public service facility allocation is proposed for the villages with high centrality, moderate centrality, and low centrality.

(1) High centrality villages: improve quality and efficiency, and focus on development

On the one hand, these villages have high potential construction efficiency, and the allocation of public service facilities is larger than in other villages. On the other hand, in terms of configuration types, most of them are difficult to meet the survival and even development needs of villagers. Therefore, when configuring public service facilities, the facilities with weak demand and poor spatial quality of villagers should be scientifically withdrawn and guided by land allocation, to realize the transformation from quantity to quality, and further promote the advantages and efficient construction of rural public service facilities. Give full play to the radiating driving function of villages, combine the development advantages, drive the development of surrounding villages, improve the convenience of villagers' life, and promote the orderly layout of public service facilities.

(2) Moderate central villages: adapt measures to local conditions and allocate according to needs

The development and construction efficiency of such villages in general, the residential areas are scattered and distributed, and the regional development is uneven. Therefore, differentiated supply strategies should be implemented for villages with different levels of development. For villages with poor terrain conditions and remote regions, the needs of villagers should be regarded as the focus of facility configuration, and the characteristic layout of "point-to-point" should be carried out according to different levels

of demand. According to the development situation and population characteristics of the village group, the space utilization of the remaining village committees after the removal and consolidation was considered, and the spatial characteristics were tamped basis on reasonable measurement. The connectivity between settlements was improved based on the guidance of the life circle and the needs of villagers. To improve the allocation conditions of rural public service facilities, the illegal construction in villages and the destruction of village differences are remediated, and the disadvantages that hinder village development are gradually weakened.

(3) Low centrality villages: gradually orderly and actively guided

These kinds of rural residential areas are few and scattered, and there are many residential areas where the elderly live or are directly abandoned. Under the dual principles of village development law and respecting villagers' will, villagers should be guided to relocate to the dominant village group areas in a reasonable, moderate and gradual manner. On the one hand, new construction and expansion activities in rural areas are strictly restricted, and public service facilities are no longer invested in them. On the other hand, the village group to be relocated should be actively guided to relocate to the village in the resettlement area, and the investment of public service facilities should be guided to move closer to the resettlement area, so as to achieve reduced development.

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