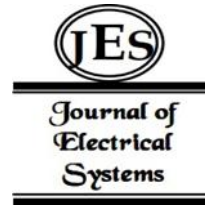


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Research on the Construction of Rural Living Circles in Hilly and Gully Areas of the Loess Plateau: A Case Study of Guanghe County



Abstract: - Ue and practical significance for achieving equitable urban and rural infrastructure within a region and promoting integrated urban-rural development. Employing landscape ecology theory and GIS spatial analysis techniques, this paper comprehensively analyzes the construction of rural living circles in Guanghe County, taking into account the convergence characteristics of residents' daily life trajectories and biological migration movements. The results indicate: (1) Within the "resistance surface" of Guanghe County, easily accessible areas and generally accessible areas account for 69.92% of the total area, while relatively difficult-to-access and hard-to-access areas constitute 30.08% of the total area, with weaker development potential in these regions. (2) Based on the results of the MCR model, a methodological pathway for identifying rural living circles is established. This includes delineating a "four-level, three-category" system for rural living circles in Guanghe County, and proposing a "mandatory allocation + selective allocation" modular customization approach to precisely allocate public service facilities. (3) Building upon the concept of travel "resistance surfaces," the study introduces transportation resistance coefficients to delineate different scales of living circles between river valley plain areas and mountainous areas. The research findings provide a basis for the construction of rural living circles in hilly and gully areas of the Loess Plateau.

Keywords: Rural Living Circles; Facility Allocation; MCR; Landscape Ecology; Loess Plateau Hilly and Gully Areas

III. INTRODUCTION

Rural areas, as focal points for achieving coordinated urban-rural development and high-quality development within the context of current land spatial planning, the elevation of public service levels holds significant practical significance for addressing issues related to agriculture, rural areas, and farmers, achieving equitable urban and rural infrastructure, and rural revitalization[1]. Rural living circles, as geographical units formed by residents' daily behavioral activities such as residence, production, employment, and communication, fundamentally represent the spatial scope formed by the interaction between residents and spatial facilities in time and space[2]. Traditional rural planning, which uses administrative divisions as planning management units and adopts a public service facility allocation model centered on service radius and population[3], neglects residents' travel capabilities and population spatial distribution characteristics, resulting in issues such as the separation of public services from administrative management and low efficiency in public services[4]. The concept of "living circles" as an effective means of precisely allocating public service facilities has been widely applied in urban areas. However, the current top-down approach to rural living circle planning is overly arbitrary in terms of circle delineation and scope, leading to issues such as disregarding residents' spatiotemporal behavioral patterns, lack of feasibility in implementation, and difficulty in practical application[5]. This situation is particularly pronounced in dispersed rural settlements, as well as in areas characterized by complex terrain factors such as the loess plateau hills and gullies.

The concept of "living circles" originated in Japan, referring to the geographical distribution of specific[6] community production and living behaviors. In the 1980s, South Korea first classified living circles into "small living circles," "medium living circles," and "large living circles." [7] Subsequently, Australia and Shanghai respectively proposed the "20-minute living circle" and the "15-minute living circle." In recent years, research on living circles in China has gradually shifted from urban[2] to rural areas[3,9-10], and definitions of rural living circles have been made, namely, that living circles refer to the spatial scope constituted by many activities that maintain residents' daily lives, reflected spatially as concentric forms, with directional overlap and other attribute features[11]. Identifying rural living circles and measuring their scope are prerequisites and technical challenges for planning[11]. In recent years, scholars have mainly used spatiotemporal behavioral data to identify living circle boundaries, such as GDP[5,11] trajectory data, and mobile signaling data[12]. Although these methods can compensate for the lack of precision in traditional living circle delineation[4-5,9], they are costly and not suitable for rural promotion. In terms of rural living circle planning, research has emphasized the division of circles, calculating the optimal radius of public service facilities based on actual travel conditions and time[4], and dividing living circle units through[13] Thiessen polygons. The former has different bases for circle division, and the division is too arbitrary and lacks precision, making it difficult to effectively guide implementation. The latter

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two, although breaking free from administrative boundaries, ignore residents' travel capabilities and population spatial distribution characteristics when calculating the optimal radius.

Accurately identifying the actual travel range of villagers is a prerequisite for building a rural living circle system[14]. Biological migration movements are essentially overcoming landscape resistance, which is similar to residents' daily life trajectories. The county is a space that integrates urban and rural areas[1] and is the most frequent and relatively complete research unit for rural living circles[13]. This paper takes Guanghe County, Gansu Province, as the research unit, combines the theory of "living circles," and uses the MSPA model and MCR model to explore residents' daily life trajectories. Places with small minimum cumulative resistance values are where residents' daily activities are frequent, and conversely, the fewer the frequency of residents' daily activities. Based on this, the scope of living circles is delineated, providing a basis for the construction of a rural living circle system suitable for the hilly and gully areas of the Loess Plateau.

IV. STUDY AREA AND DATA SOURCES

A. Study area

Guanghe County is located between $103^{\circ} 20'$ to $103^{\circ} 50'$ E and $35^{\circ} 15'$ to $35^{\circ} 38'$ N, under the jurisdiction of Linxia Hui Autonomous Prefecture in Gansu Province. It lies in the southwest central part of Gansu Province, the southeastern part of Linxia Hui Autonomous Prefecture. The terrain is characterized by typical loess hills and gullies, with dense ravines and severely fragmented terrain. It governs 6 towns, 3 townships, and 102 villages, covering a total area of 538 km², with elevations ranging from 1745 to 2577 m above sea level. As of the end of 2022, the urbanization rate of Guanghe County was 36.46%, with a significant proportion of rural population.

Guanghe County exhibits geographical features of "one river, two mountains, and five watersheds," namely, the central and northeastern parts are characterized by loess hills and gullies, with crisscrossing valleys and dense hills, while the middle part is traversed by the Guangtong River, forming flat river valleys. The southwestern part features continuous hilly terrain. The location and topography of Guanghe County are depicted in Figure 1.

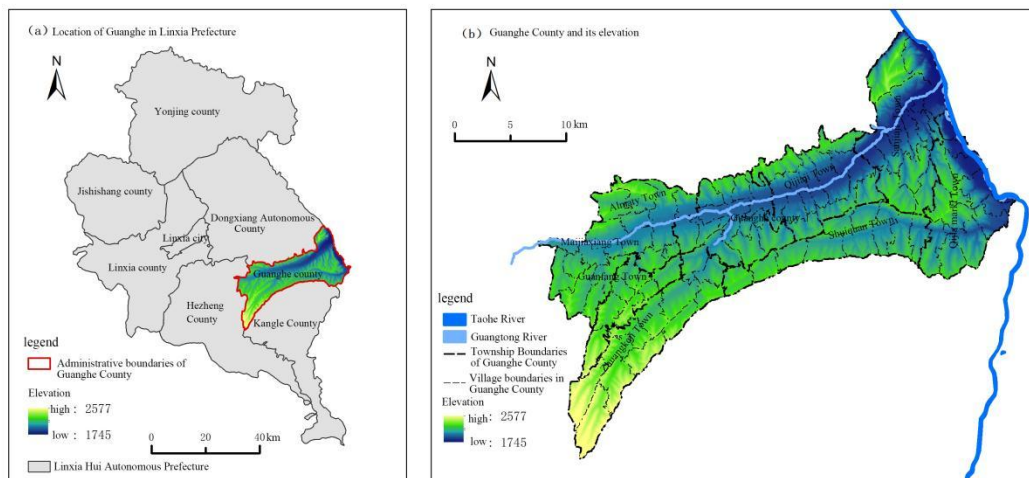


Figure. 1 Overview map of the research area.

B. Data sources

The data utilized in this study comprise the following: the Statistical Bulletin of Guanghe County's National Economic and Social Development, residential point data, road network data, township government point data, and cultivated land ownership data obtained through processing the Third National Land Survey data of Guanghe County; DEM data sourced from the NASA Earth Science Data website, utilized for surface analysis, focal statistics, and hydrological analysis to derive slope, terrain ruggedness, and river distribution maps within Guanghe County; GDP data obtained from the research of scholars such as Chen[29]; population density sourced from the LandScan population dataset; POI data sourced from the Gaode Maps..

V. METHODS

A. Morphological Spatial Pattern Analysis (MSPA)

MSPA is an image processing method for measuring, identifying, and segmenting the spatial patterns of raster images[15]. This method finds frequent application in ecological network analysis[15-18]. By

characterizing the shapes[19], connectivity, and spatial arrangements of image objects, it segments the image into core areas, islands, voids, edge areas, connecting bridges, loops, and branches. In this study, MSPA is introduced as a component for selecting tool homesteads as "sources" in the construction of rural living circles. The types correspond to ecological characteristics and rural homestead source features as outlined in Table 1.

Table 1 MSPA structure type, ecological characteristics and rural house source characteristics.

Structural Types	Ecological characteristic	Characteristics of Rural Homestead Sources
Core	Core Area of Green Vegetation Coverage	Homestead Agglomeration Patches
Islet	Relative Isolated and Small-Scale Green Patches	Relative Isolated and Small-Scale Homestead Patches
Perforation	Edge Area of Internal Patches	Non-Homestead Patches Enclosed by Homestead Patches
Edge	External Boundaries of the Core Area	Linear Patches Delineating the Boundary of Homestead Core Agglomeration Areas
Loop	Linear Corridor Features Connecting the Same Core Area	Narrow Patches with Linear Features Connecting the Same Core Agglomeration Area of Homesteads
Bridge	Linear Corridor Features Connecting Multiple Different Core Areas within Non-Core Regions	Narrow Patches with Linear Features Connecting Multiple Different Core Agglomeration Areas of Homesteads within Non-Core Regions areas of homesteads within non-core areas.
Branch	Identification of Partial Structures After Recognizing All Landscapes as Branch Lines	Structures Excluding the Other Six Types, Typically Narrow and Small-Scale Homestead Patches

B. Construction of Evaluation Index System

The spatial movement of organisms and the maintenance requirements of habitats overcome landscape resistance to complete^[14]. The "resistance surface" affects the direction and cost of species movement, transitioning from "source areas" to "units" to "residential points" to "public service facility points," influencing the accessibility of the latter, which can also be characterized by the magnitude of "resistance." Starting from the unique "resistance surface" factors in the loess hilly and gully areas of the Loess Plateau, and combining micro-patches with macro-regional conditions, referencing relevant research results^[4,20], twelve resistance factors are selected from geographical location, natural geography, and socio-economic factors. The resistance level of each factor is divided using the natural break method (Table 2), thereby constructing a comprehensive resistance system.

Table 2 Grading system of each resistance factor

Indicator factors	Resistance Value Classification Criteria					
	Resistance Level/ Resistance Score					
indicator layer	I /1'	II /10'	III /20'	IV /40'	V /100'	
geography location Condition	Settlement potential	≥0.265	0.075~0.265	0.026~0.075	0.013~0.026	≤0.013
	Distance from road	≤160	160~390	390~670	670~1050	≥1050
	Distance to town hall	≤2050	2050~3450	3450~4850	4850~6600	≥6600
Nature geography conditions	Road network density	≥5.4	3.5~5.4	2.3~3.5	1.2~2.3	≤1.2
	Distance to river	≤295	295~630	630~1010	1010~1550	≥1550
	altitude	≤1914	1914~2047	2047~2165	2165~2311	≥2311
socio economic conditions	elevation	≤3	3~8	8~15	15~25	≥25
	degree of topographic relief	≤4	4~10	10~18	18~30	≥30
	GDP	≥47	5.5~47	2.9~5.5	2.7~2.9	≤2.7
socio economic conditions	population density	≥3600	1600~3600	684~1600	316~684	≤316
	Arable land holdings area	≥179	145~179	110~145	62.2~110	≤62.2
	POI density	≥19	11~19	5~11	1~5	≤1.2

C. Establishment of Evaluation Factor Weights

Considering that different resistance factors have varying impacts on the construction of rural living circles, this paper adopts the Analytic Hierarchy Process (AHP) to divide each element into three levels: the goal level (A), the criterion level (B), and the index level (C). Pairwise comparisons are then conducted to determine the relative importance of each element. To avoid the emergence of unreasonable data, judgment matrices are constructed to check the data: the consistency ratio should be less than 0.1.

Table 3 Factors and weights of the integrated resistance coefficient system

target level	normative layer	Level 1 indicators Weighting	indicator layer	Level 1 indicators Weighting	weight sorting
Comprehensive Resistance Hierarchy Structure Model (A)	(B1) Geographical location conditions	0.5396	(C1) Settlement Potential	0.0838	5
			(C2) Distance from roads	0.1881	3
			(C3) Distance to township government	0.1946	1
			(C4) Road network density	0.0449	7
			(C5) Distance to river	0.0281	10
	(B2) Physical conditions	0.2970	(C6) Elevation	0.0311	9
			(C7) Slope	0.0767	6
			(C8) Degree of terrain relief	0.1892	2
			(C9)GDP	0.0192	11
	(B3) socio-economic conditions	0.1634	(C10) Population density	0.0981	4
			(C11) Area of arable land holdings	0.0349	8
			(C12) POI density	0.0112	12

D. GIS spatial overlay methodology

Upon extracting and transforming the data in ArcGIS according to the aforementioned factors, it is resampled into raster data with 5m × 5m pixels. Subsequently, the raster calculator is employed to perform weighted summation of each resistance factor, resulting in rasterized comprehensive resistance data. The formula for calculating the comprehensive resistance score is as follows:

$$W = \sum_{i=1}^n P_{ik} \times X_i \quad (1)$$

Where: W represents the comprehensive resistance score; P_{ik} denotes the resistance score corresponding to evaluation unit k on the ith resistance factor; and X_i represents the weight of the (i)th resistance factor.

E. Minimum cumulative resistance model (MCR)

The MCR model was initially proposed by Dutch scholar Knaapen^[21] and possesses excellent scalability. Through modifications by scholars such as Yu^[14] and Chen^[22], it has been widely applied in studies concerning rural settlement layout^[23-24], ecological security pattern construction^[25-26], and land ecological suitability assessment^[27]. The minimum cumulative resistance refers to the minimum cost or the least effort required to overcome resistance encountered by landscape units from source to destination through different resistance factors^[28]. The calculation formula for the MCR model is as follows:

$$MCR = \int \min \sum_{j=n}^{i=m} D_{ij} \times S_i \quad (2)$$

Where: MCR represents the minimum cumulative resistance value; D_{ij} denotes the actual distance of species from source j to spatial unit i; S_i represents the comprehensive resistance coefficient of unit i to species movement; $\int \min$ indicates the positive correlation between minimum cumulative resistance and ecological processes

VI. OPTIMIZATION PATH OF RURAL LIVING CIRCLES

A. Division of Rural Living Circle Layers

Currently, the hierarchy of rural living circles is primarily based on administrative levels, and public service facilities at each level are concentrated at the central points of administrative regions. This has led to issues such as wastage of vacant public service facilities and low accessibility for residents. The placement of public service facilities should consider orderly integration and structural optimization. Based on practical investigations and relevant studies [3-4, 9, 30-31], this paper divides the living circles into four layers.

1) Integrated Living Circles

As residents demand higher quality of life, there arises a need for large-scale service facilities. The essence of comprehensive living circles is to serve all residents of the county, equipped with the highest county-level and most comprehensive types of public service facilities.

2) Daily Living Circles

Given the existing public service facilities system, the service facilities in town centers are relatively complete. Therefore, based on the current service facilities in townships, efforts are made to enhance their service facilities to meet the daily needs of residents. In areas not covered by comprehensive living circles, the daily living circles improve their facilities system by providing advanced service facilities.

3) Alternative Living Circles

Considering the efficiency of public service facilities and the threshold requirements for population distribution, areas not covered by daily living circles are supplemented with public service facilities in the form of alternative living circles. Although the level of public service facilities in these areas is lower than that of daily living circles, they still meet the daily service needs of residents.

4) Self-Sufficient Living Circles

The self-sufficiency of rural living circles is the result of residents' inherent accessibility under spatial and temporal constraints [32]. Residents' daily activity trajectories involve walking and primarily revolve around residential areas and adjacent cultivated land. The configuration of public service facilities in this layer mainly serves the population within the service range for necessary medical, cultural, and commercial activities, thus forming a self-sufficient living circle.

B. *Division of Rural Living Circle Layers*

In plateau hilly and gully areas, it is advantageous to determine the service radius of rural living circles according to local conditions, which helps to improve the efficiency of public service facilities at all levels and enhance residents' convenience. Through practical investigations and related studies, the service radius of comprehensive living circles is determined to be within a 60-minute ride on agricultural vehicles for residents, with an agricultural vehicle speed of 10 km/h, thus setting the service range of comprehensive living circles at 10 km. Daily living circles cater to residents' daily needs, and it is generally considered acceptable for residents to reach daily public service facilities within a maximum time limit of 30 minutes. Therefore, the service range of daily living circles is set at 5 km. Alternative living circles supplement areas not covered by daily living circles. In plateau hilly and gully areas, these areas often include mountainous regions where daily living circles cannot reach. Due to greater transportation resistance in mountainous regions, an introduced resistance coefficient [30] of 0.75 is applied, determining the service radius of alternative living circles to be 3.75 km. Self-sufficient living circles represent the smallest range of living circles and are the most frequently used by residents. Oriented towards aging and child-friendliness, walking time is set at 15 minutes and walking speed at 0.5 m/s. Therefore, the service radius of self-sufficient living circles in river valley areas is determined to be 750 m. Similarly, the service radius of self-sufficient living circles in mountainous areas is set at 560 m.

C. *Optimization of Rural Living Circle Supply Pattern*

Addressing the issue of low service rate and wastage of public service facilities in plateau hilly and gully areas requires the rational arrangement of public service facilities through different levels and types of living circles. Comprehensive living circles need to meet the diversified service demands and personalized service needs of various groups. Daily living circles should fulfill residents' daily public service needs and enhance the types of public service facilities available. Alternative living circles should focus on precise configuration to avoid wastage of public service facilities. Based on the concept of "resistance," whether accessibility is achievable should be judged. Self-sufficient living circles can be categorized into concentrated growth type, orderly reorganization type, and gradual withdrawal type. Public service facilities should be configured according to their types, incorporating both flexible and rigid types of facilities. Precise and customized configuration can be achieved through characteristic industries and living scenarios within different living circles.

VII. PROCESS AND RESULTS OF CONSTRUCTING RURAL LIVING CIRCLES IN GUANGHE COUNTY

A. *Construction of Resistance Surfaces for Rural Living Circles in Guanghe County*

1) Utilization of Morphological Spatial Models to Determine Target "Sources"

This study introduces morphological spatial models to identify and segment spatial patterns of rural residential land, with rural residential land designated as the study area or foreground area, and other land types

as background areas. Utilizing GuidosToolbox 2.8 software for computation, variations in pixel size and edge width parameters lead to differing types and areas. Considering the scale of rural residential land, and synthesizing parameters from Figure 2, an edge width of 2, corresponding to Figure 2(c), is selected as the parameter for identifying "sources" in this study. The corresponding structural types and areas are presented in Table 4.

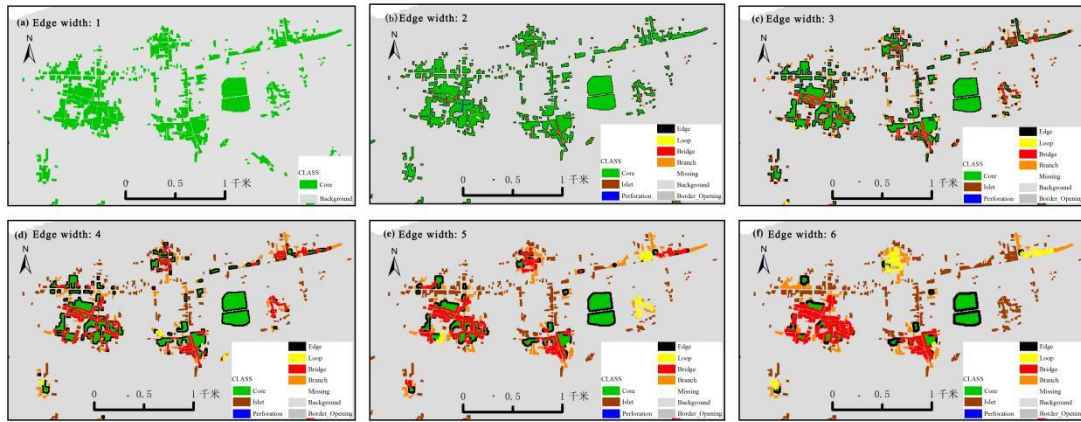


Fig. 2 Comparison of image recognition with different edge widths

Table 4 Various structure types and areas based on MSPA

Structural Types	Area/km ²	Percentage/%
Core	7.30	25.21
Islet	4.41	15.24
Perforation	0.02	0.06
Edge	8.66	29.93
Loop	0.43	1.48
Bridge	4.55	15.72
Branch	3.58	12.35

2)Constructing Resistance Surface through Minimum Cumulative Resistance Model

Based on the determination of "sources" and resistance systems, the cumulative minimum "resistance values" from rural residential land to each grid cell are computed, where the magnitude of these "resistance values" reflects the trajectories of residents' daily activities. Based on the computed results, the areas are categorized into four classes: easily accessible areas, generally accessible areas, moderately accessible areas, and scarcely accessible areas. The area sizes and proportions of each class are presented in Table 5, while their distribution is depicted in Figure 3.

The moderately and scarcely accessible areas collectively account for 30.08% of the total, primarily concentrated in the northern parts of Sanda Township and Qijia Township. These regions are situated predominantly within the Liangmiao mountainous area and have largely lost their developmental potential. The easily accessible and generally accessible areas represent residential spots with developmental prospects, where an appropriate allocation of public service facilities should be planned

Table 5 Size and percentage of "resistance" zones to the composite factor accessibility

Types	Accessible region	General access area	Less accessible areas	hard-to-reach area
Area	187.35	188.18	117.21	44.34
Percentage	34.88	35.04	21.82	8.26

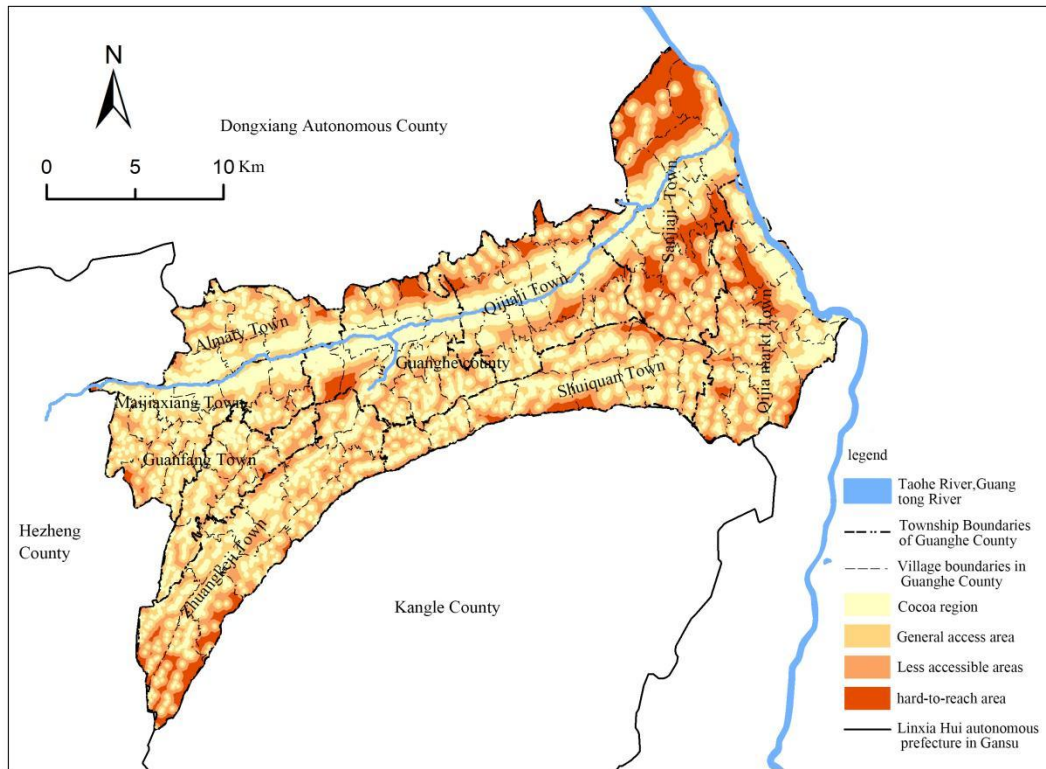


Fig. 3 Distribution of "resistance" to accessibility of the composite factor

B. Constructing Rural Living Circle System in Guanghe County

1) Determining the Layered System of Rural Living Circles

Addressing the issues arising within the rural living circles of Guanghe County involves three main aspects: hierarchical simplification, diversified types, and meeting differentiation. Based on the current distribution of population within rural living circles, a differentiated approach is adopted to reshape the "four-level, three-category" rural living circles in Guanghe County. Considering that the central urban area of Guanghe County exhibits minimal cumulative "resistance values" and high accessibility, the current county-level rural community living circle is maintained and designated as the comprehensive living circle. The daily living circle is based on the existing town-level service facilities, enhancing their service provision to meet residents' needs. Areas not covered by the daily living circle are supplemented in the form of alternative living circles, considering the efficiency of public service facilities. The self-sufficient living circle is identified based on the reachable areas of residents' daily activity trajectories and whether the population size meets the threshold for setting up public service facilities. Accordingly, it is categorized into concentrated growth type, orderly reorganization type, and gradual withdrawal type (see Figure 4).

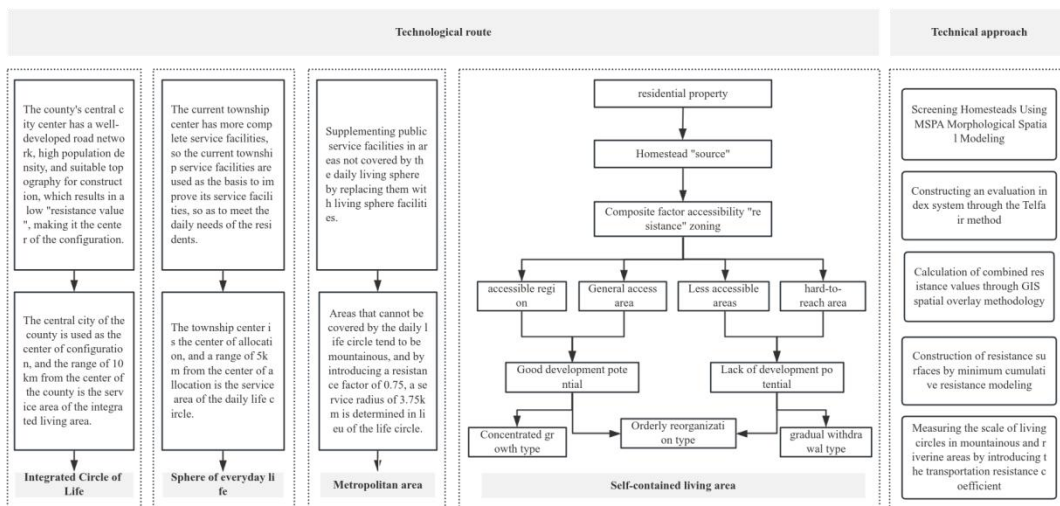


Fig. 4 The path of "four levels and three types" rural community life circle division in Guanghe County

2)Determining the Layered System of Rural Living Circles

The comprehensive living circle is centered around the central urban area of the county, with a service range extending 10km from the county center (see Figure 4(a)). The daily living circle encompasses an area within 5km of the town center, resulting in the establishment of seven daily living circles, five of which require the provision of some advanced service facilities (see Figure 4(b)). Areas not covered by the daily living circle are supplemented by alternative living circles, with a determined service radius of 3.75km. Seven alternative living circles are ultimately selected (see Figure 4(c)). The self-sufficient living circle is defined by a walking time of 15 minutes, with a speed set at 0.5m/s. The service radii for river valley areas and Liangmiao mountainous areas are determined to be 750m and 560m, respectively. These areas are then classified into concentrated growth, orderly reorganization, and gradual withdrawal types based on population thresholds[9]. There are 346 concentrated growth self-sufficient living circles, 7 orderly reorganization self-sufficient living circles, and 15 gradual withdrawal self-sufficient living circles (see Figure 4(d)).

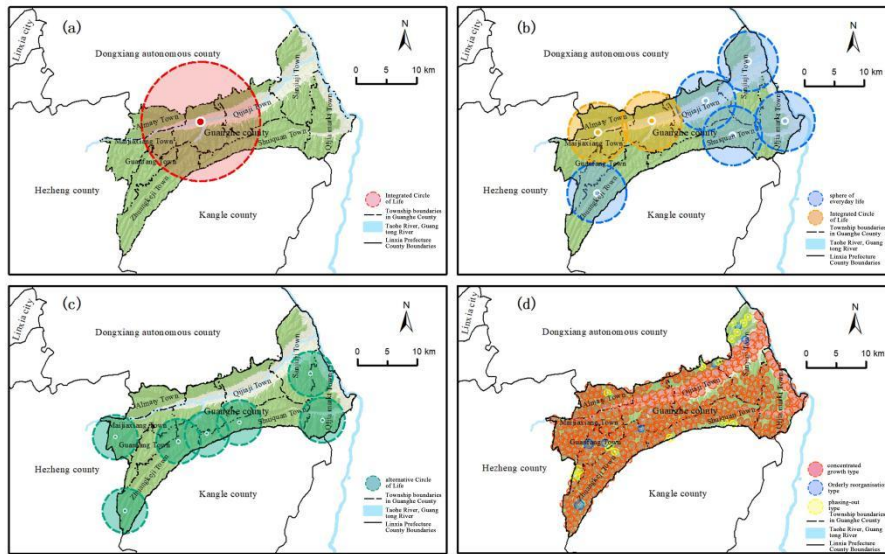


Fig. 5 Guanghe County Rural Living Area Delineation Results

3)Rural Living Circle Supply Mode

To enhance the comprehensive coverage, universal access, and integration of urban and rural public service facilities, a combination of flexible and rigid types of public service facilities is proposed. Following the planning principle of "equality and differentiation," a modular customization approach termed "mandatory allocation + optional allocation" is adopted for the configuration of rural public service facilities. Concentrated growth-oriented self-sufficient living circles prioritize new construction, requiring comprehensive facilities, and functional perfection, combined with multi-point configuration within the service radius. Orderly restructured self-sufficient living circles focus on transformation and minor updates, emphasizing the utilization of existing resources and the prioritized completion of mandatory facilities. Gradual withdrawal-oriented self-sufficient living circles primarily maintain the status quo, utilizing existing building spaces to meet mandatory functions, prohibiting new expansions. This paper, in conjunction with the practical situation of Guanghe County and relevant research findings^[9,30], presents specific supply patterns as outlined in Table 6.

Table 6 The "modularized" configuration of public service facilities at all levels and in all types of living areas

Circle of life type	Public Service Facilities Module	
	"Rigid" Mandatory Facilities	"Flexible" Optional Facilities
Integrated circle of life	Emergency shelters, disaster prevention facilities, junior high schools, high schools, general hospitals, cultural centres, libraries, large parks, homes for the elderly	Quality of life: cultural activity centres, sports venues, libraries, commercial centres, etc. Industry guidance: talent training platform, exhibition and exchange centre, etc. Speciality: Specialist hospitals, technical training schools, senior citizen universities, etc.
Sphere of everyday life	Emergency shelters, disaster prevention facilities, health	Quality of life: nursing homes, high schools, township cultural activity centres, township sports centres, bus

		service centres, day care centres for the elderly, kindergartens, primary schools, cultural activities rooms	terminals, etc.
	in place of the circle of life	Emergency shelters, disaster prevention facilities, health service stations, kindergartens, primary schools	Industry guidance: tourist distribution centres, agricultural product processing sites, etc. Specialty: agricultural training centre, agricultural service centre, etc. Quality of life: nursing homes, cultural centres, bus terminals, etc.
Self-sufficient Living	Concentrated Growth Type	Emergency shelters, disaster prevention facilities, health rooms	Industry-led: speciality workshops, agricultural products primary processing sites, etc. Specialty: agricultural training centre, agricultural service centre, etc. Quality of life: village kindergarten, day care home, etc.
	Orderly reorganisation type	Emergency shelters, disaster prevention facilities	Industry guidance: visitor service centre, village creation centre, cultural exhibition hall, agricultural products sales exhibition centre, etc. Specialty: Village Talent Apartment, Farmers' Bookstore, Makers' Space, etc. Quality of life: convenience stores, express service stations, kindergartens, etc.
	phasing-out type	Emergency shelters, disaster prevention facilities	Industry guidance: agricultural service facilities, etc. Quality of life: medical service facilities, convenience stores, etc. Industry guidance: agricultural service stations, etc.

4)Short

Based on the above, optimization of the rural living sphere of Guanghe County can be approached from three aspects: the hierarchical system, scale, and supply mode. Taking Sanjia Township in Guanghe County as an example (see Figure 6), the living sphere delineated by the MCR model shifts from facility allocation based on administrative levels as planning management units to allocation based on residents' travel capabilities, population spatial distribution characteristics, and actual travel ranges. A very small portion of residential patches appear fragmented and loosely distributed, with extremely weak development potential and minimal population according to calculations. These areas can be improved by gradually promoting the relocation and reconstruction of residential patches to enhance their backward locational conditions and economic development status.

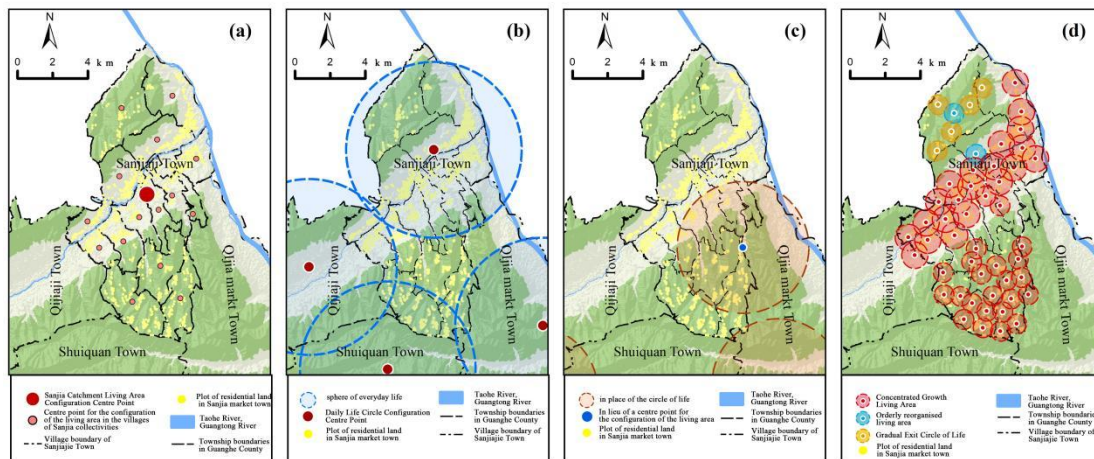


Fig. 6 Before and after optimization of the rural living area of Sanjia market towns

VIII. CONCLUSION AND DISCUSSION

A. Conclusion

The rural settlements and dispersed population distribution in the hilly and gully areas of the Loess Plateau present complex terrain features, significant undulations, and inadequate infrastructure. Allocating public service facilities based on the current rural living sphere system would inevitably result in resource wastage. Therefore, facility allocation should be based on residents' life activity trajectories and population distribution. This paper utilizes the MSPA model and MCR model to explore the "resistance surfaces" of residents' life activity trajectories and, combined with the actual situation of Guanghe County, draws the following conclusions:

(1)Based on the results of the Analytic Hierarchy Process and MCR model calculations, the distance from township government and terrain undulation significantly influences the "resistance surfaces" of Guanghe County. Easily accessible areas and generally accessible areas within Guanghe County constitute 69.92% of the total area, while relatively difficult-to-access areas and hard-to-access areas constitute 30.08% of the total area, with weaker development potential.

(2)This paper innovatively constructs a method path for identifying rural living spheres: it determines Guanghe County's rural living sphere system as "four levels, three types," namely "comprehensive living sphere - daily living sphere - substitute living sphere - self-sufficient living sphere," and "concentrated growth type - orderly restructuring type - gradual withdrawal type," breaking the constraints of administrative boundaries, and proposing a modular customized "mandatory + optional" public service facility allocation approach.

(3)Based on the combination of "resistance surfaces" for travel, using the speed of commonly used transportation as a calculation basis, and introducing transportation resistance coefficients, the service scale ranges of various living sphere levels are accurately calculated. The different living sphere scales in the river valley and mountainous areas are specified, with the "comprehensive living sphere - daily living sphere - substitute living sphere" each having a service radius of "10km - 5km - 3.75km," and the self-sufficient living sphere having a service range of 750m and 560m in the river valley and mountainous areas, respectively.

B. Discussion

Starting from the trajectory of rural residents' life activities, this paper explores a theoretical system of county rural life circle that breaks through the administrative boundary restriction, taking Guanghe County as an example. In this paper, the allocation point of the facilities is selected at the low value of the minimum cumulative "resistance", but the optimal allocation place of each public service facility is not determined, and the study of the optimal allocation place of each type of public service facility at all levels is conducive to the promotion of the rural residents to enjoy the public services more equitably and conveniently

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