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Spatial Distribution Characteristic and Type Classification of Rural Settlements: A Case Study of Weibei Plain, China

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Abstract: The continuous development of urbanization in China has brought new opportunities to rural settlements but has also led to spatial problems such as disorderly layout and unbalanced morphological structures, and the sustainable development of the countryside faces great challenges. As the core spatial carrier of rural settlements, scientific identification of their characteristics and delineation of their types is conducive to the subsequent spatial optimization of rural settlements to promote the coordinated and orderly development of rural areas. In recent years, several studies have explored the characteristics and classification of rural settlements based on single factor influences, but few studies have comprehensively considered them from a multidimensional perspective. To fill this gap, this paper takes the rural settlements in the Weibei Plain as the research object, uses the continuous spectral transect analysis method, combines the landscape security pattern analysis, establishes a multidimensional feature matrix model, quantitatively analyzes the spatial differentiation characteristics, and classifies the types. The key findings are as follows. (1) According to the analysis of landscape security patterns, it was divided into four types of rural settlements. The rural settlements with high and medium security patterns accounted for 86.79%, and the overall ecological adaptability was good. (2) In terms of spatial distribution, 80% of patches in the Weihe River transect are small and unevenly distributed under the influence of river runoff, gradually changing from dense to discrete; the fluctuation range of the 70% patch area is restricted by the terrain in the Hanyuan tableland transect is small and changes from discrete to dense. In terms of spatial morphology, 70% of the Weihe River transect was irregular and varied greatly. The morphology of the Hanyuan tableland transect tended to be similar, and the degree of fragmentation of the Hanyuan tableland transect was higher than that of the Weihe River transect. (3) The Weihe River transect was divided into six types of settlement space, the Hanyuan tableland transect was divided into seven types, and the characteristics of different settlement space types were quite different. The results can provide a scientific basis for the spatial planning, industrial guidance, and facility layout of rural settlements and have important significance for the rational formulation of spatial agglomeration guidance strategies and the promotion of sustainable rural development in China.

Keywords: rural settlements; spatial distribution characteristic; type classification; continuous spectral transect analysis; Weibei Plain

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1. Introduction

In the context of China's rural revitalization strategy and the requirement of establishing a territorial spatial planning system, in order to continue the spatial relationship of organic integration of humans and nature and promote the sustainable and synergistic development of human-living environments and ecological environments, it is necessary

to strengthen the research and exploration of various territorial spatial elements and patterns [1,2]. A rural settlement, as an important space for residents outside the built-up areas of cities and towns, is an important fulcrum for realizing the strategy of rural revitalization and plays an important role in the coordinated and sustainable development of regions. Since China's reform and opening up, Shaanxi has continued to promote the process of industrialization and urbanization, with increasingly prominent ecological environment problems and increasingly complex rural settlement development [3,4], which are mainly reflected in spatial problems such as disorderly layout and unbalance of form and structure, hindering the realization of rural revitalization [5,6]. Therefore, the study of the rationality of the spatial pattern of rural settlements has attracted the attention of all circles. Weibei Plain is located in the central part of Shaanxi Province. The southern part of Weibei Plain is adjacent to the Weihe River, and the northern part is adjacent to the Loess Plateau. The ecological vulnerability of the two different landforms is more sensitive and far reaching to the regional space. By studying the distribution characteristics and type division of rural settlements in Weibei Plain, more targeted and effective means can be found to alleviate land-use conflicts, improve the rural natural ecological environment [7], and promote sustainable rural development, which is of great significance for optimizing urban and rural settlement patterns and the coordinated and sustainable development of ecological economy [8].

Although countries worldwide have different rural development processes and face different problems, all have continued to explore the rural settlement space. International studies on the spatial characteristics of rural settlements are carried out based on spatial distribution, form, and type. It is found that the settlement space is mainly affected by such factors as topography [9,10], water resources, and traffic accessibility [11], but it also needs to pay attention to the impact of ecological security [12] and living environment guarantee. Landscape safety pattern is an effective way to coordinate rapid urbanization and ecological conservation, it has become a hot spot of attention in recent years, and previous studies have mostly focused on analysis [13–15] of ecological safety in geology, hydrology, atmosphere, biodiversity, and farmland. The ecological and environmental issues caused by urbanization, such as urban sprawl, cultural heritage, and recreational space of the safety pattern, are rarely included in the analysis. Therefore, based on previous research, this paper can select security pattern sources that combine natural and human factors, and conduct landscape security pattern analysis to obtain the results of rural settlement zoning. China's rural areas are vast, with diverse geomorphic types. Some scholars use rural settlement patches and landscape pattern index to study the form, type, spatial distribution characteristics, and influencing factors of typical rural settlements in regions such as mountainous, hilly, and arid oasis areas [16,17]. Research methods on spatial characteristics of relevant rural settlements mainly include spatial interpolation analysis [18], global spatial clustering [19], and continuous spectral transect analysis [20]. Spatial interpolation analysis is not applicable to the Weibei Plain, which does not have the attribute of a circle layer, and global spatial clustering is not suitable to analyze the Weibei Plain with different geomorphic characteristics from a global perspective. In recent years, continuous spectral transect analysis has been gradually adopted by some scholars, which has an obvious classification effect and can centrally display the characteristics of the spatial distribution of research objects and is suitable for research areas distributed with different geomorphic characteristics [21–23]. In addition, some scholars used landscape shape index and cluster analysis to discuss regional differentiation characteristics, regional types, and regulation paths of rural settlements from different dimensions of space, scale, and form [24]. It has become a trend to apply rural settlement patches to analyze landscape pattern indexes when analyzing spatial elements. Usually, indicators such as patch density, mean shape index and mean patch fractal dimension are selected to analyze the rural settlement space [25], and this paper can summarize and filter the relevant research indicators in the past and construct the indicator system of two categories of spatial layout and spatial

morphology to conduct spatial characteristics analysis. It can be seen from previous studies that the spatial characteristics of rural settlements have significant regional differences [26].

In summary, although studies generally discuss the distribution characteristics and classification types of rural settlements influenced by single factors from different perspectives, they overlook the distribution and classification results of rural settlements under the complex influence of different factors. Meanwhile, currently, research on rural settlements is mostly focused on small- and medium-sized areas such as mountains, hills, and plateaus [27]. The research conclusions are not universal, or the spatial units studied are mostly administrative regions with insufficient precision, which weakens the regional environmental influence of the spatial distribution of rural settlements to a certain extent, and it is difficult to grasp the spatial differentiation scientifically at this level. Therefore, it is urgent to explore the spatial distribution characteristics and types of rural settlements from a large-scale ecological background and combine multiple influencing factors. Therefore, this paper takes rural settlements in Weibei Plain as the research object and innovatively starts from the multidimensional process of ecological zoning-transect analysis-spatial characteristics, adopts landscape security pattern analysis and continuous spectrum transect analysis method, selects transects across Weibei Plain, and uses landscape pattern index to analyze the change rule of distribution and morphological characteristics of rural settlements. In order to comprehensively grasp the characteristics and types of regional rural settlements (Figure 1), the research basis and technical support are provided for an ecological security guarantee and rural settlement control in Weibei Plain.

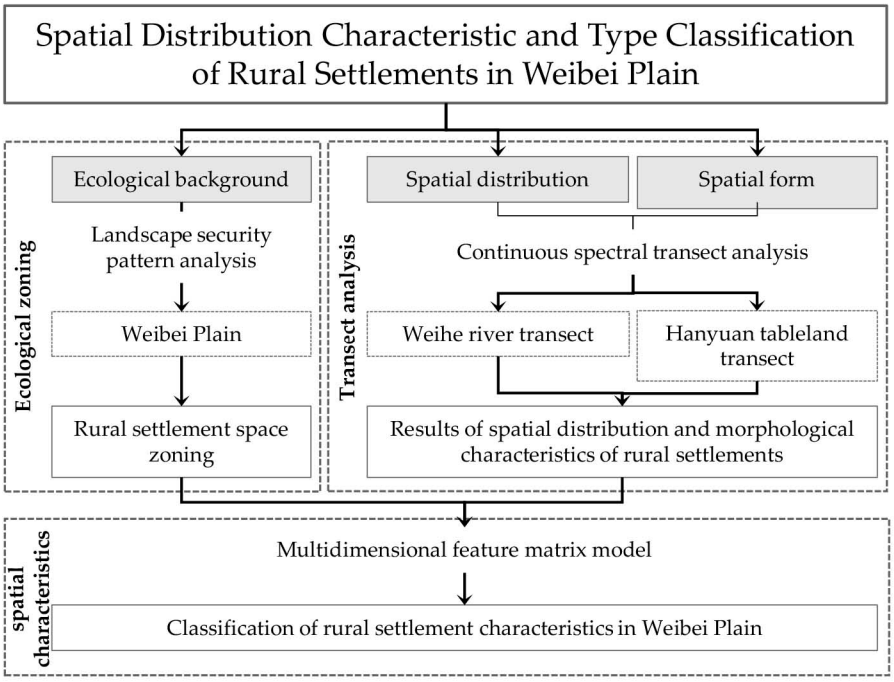

Figure 1. Overall flowchart of the research.

2. Materials and Methods

2.1. Survey of Research Area

Weibei Plain is an alluvial plain formed by the fault subsidence zone alluvial by Weihe River and its tributaries Jinghe River and Luohe River. It forms Weihe River Basin with Weihe River valley and Weihe River hills. It is in the central part of Shaanxi Province, in the area north of Weihe River in Guanzhong Plain, from Tongguan in the east to Baoji Gorge in the west. It is an important ecological security barrier and landscape pattern base in the core area of Guanzhong city group and in the north of Xi'an [28]. Weibei Plain is adjacent to Weihe River in the south, mostly impact plain, adjacent to Xi'an and Xianyang metropolitan areas, and adjacent to the Loess Plateau in the north, mostly a ravine area. The topography

and geomorphology in the north and south regions are significantly different. Figure 2 shows that the land area is 15,819.24 km^2, including 23 districts and counties, of which 10 are districts and counties to the north of Weihe River.

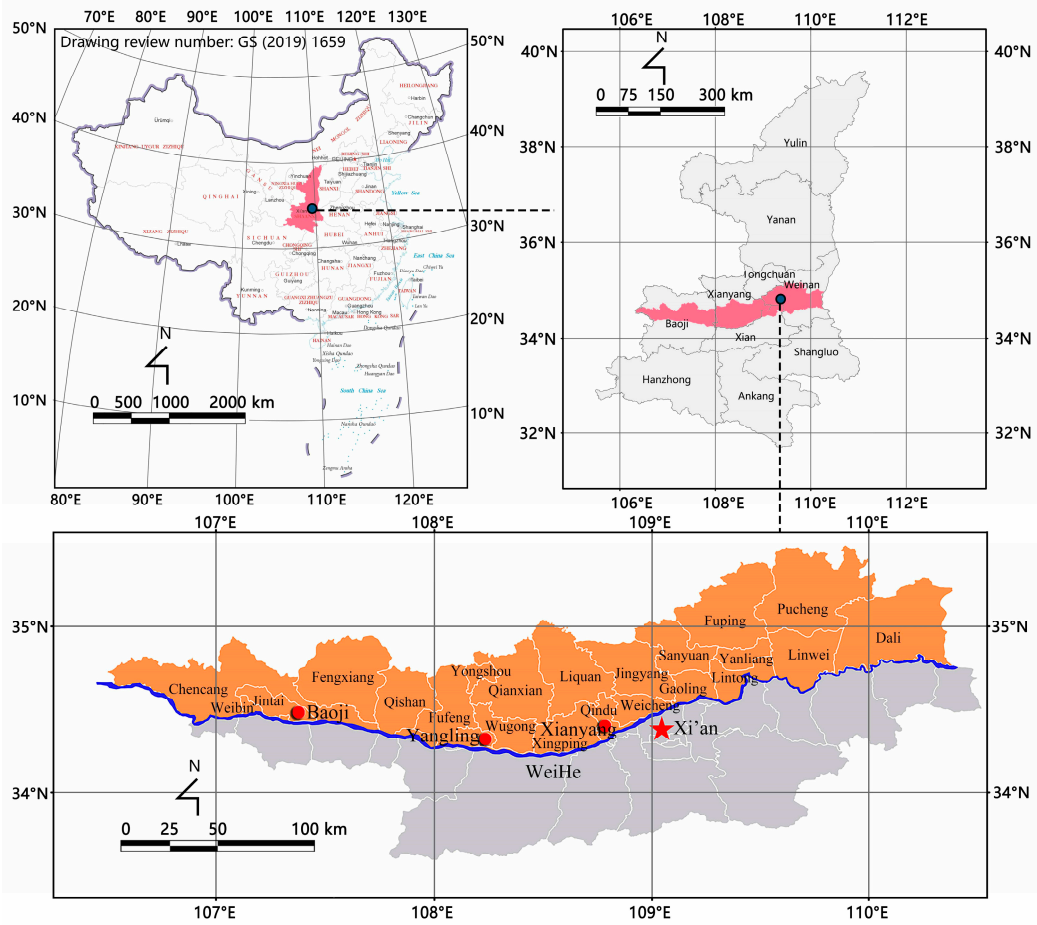

Figure 2. Regional Scope of Weibei Plain.

2.2. Data Sources and Processing

The research data sources of this study were a 2018 Landsat TM remote sensing image map, a vector map of administrative divisions in Shaanxi Province, and a 2018 vector map of the spatial distribution of rural residential areas (1:50,000). Using ERDAS IMAG-INE 9.0, the remote sensing images were processed by coordinate transformation, geometric correction, cropping, and merging. With the support of Map GIS 6.7 software, combined with field investigation, a human–computer interactive visual interpretation method and land-use status classification standard were used. The land-use types in the study area were divided into 7 first-class land types—cultivated land, forest land, grass land, water area, construction land, unused land, and traffic land—by using the method of human–computer interactive visual interpretation and the classification standard of land-use status quo. Among them, the construction land includes two secondary land types of urban land and rural residential land, comprehensively verified by high-resolution images and field correction. The average interpretation accuracy was above 85%. The distribution map of rural residential land in Weibei Plain was made, and the number of rural settlement patches in Weibei Plain was 16,051 (Figure 3). The toolbox of ArcGIS was used to convert the vector data of rural residential land into a grid format, and the Fragtats3.4 software program was used to calculate the landscape index.

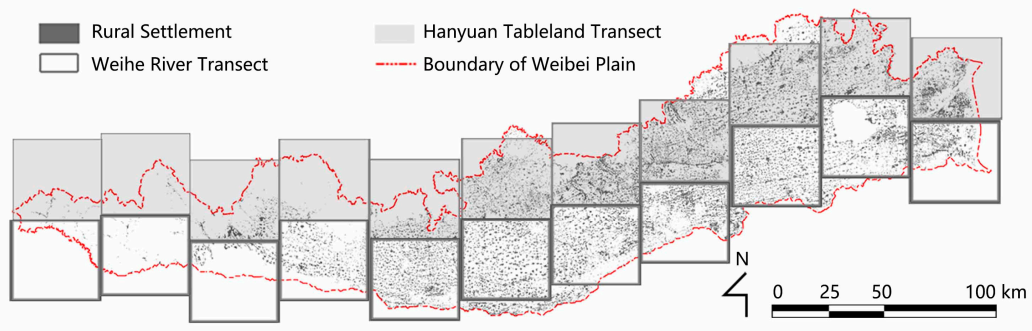

Figure 3. Settlement Distribution and Transect Setting.

2.3. Research Methods

Based on the research idea of ecological zoning-transect analysis-spatial characteristics, this study constructed a research framework for the classification of rural settlements in Weibei Plain (Figure 4). Firstly, the landscape security pattern and ecological background were taken as the conditions to analyze and define the characteristics of the basement where the rural settlement patches are located. Secondly, continuous spectral transect analysis was used, which mainly includes two parts. The transects were divided according to the significant difference between the north and south of Weibei Plain, and then the landscape pattern index was used for calculation and analysis. Finally, a multidimensional characteristic matrix of suitability-distribution form was constructed, and a classification method of rural settlements is proposed, that takes ecological background, spatial distribution, and spatial form as elements.

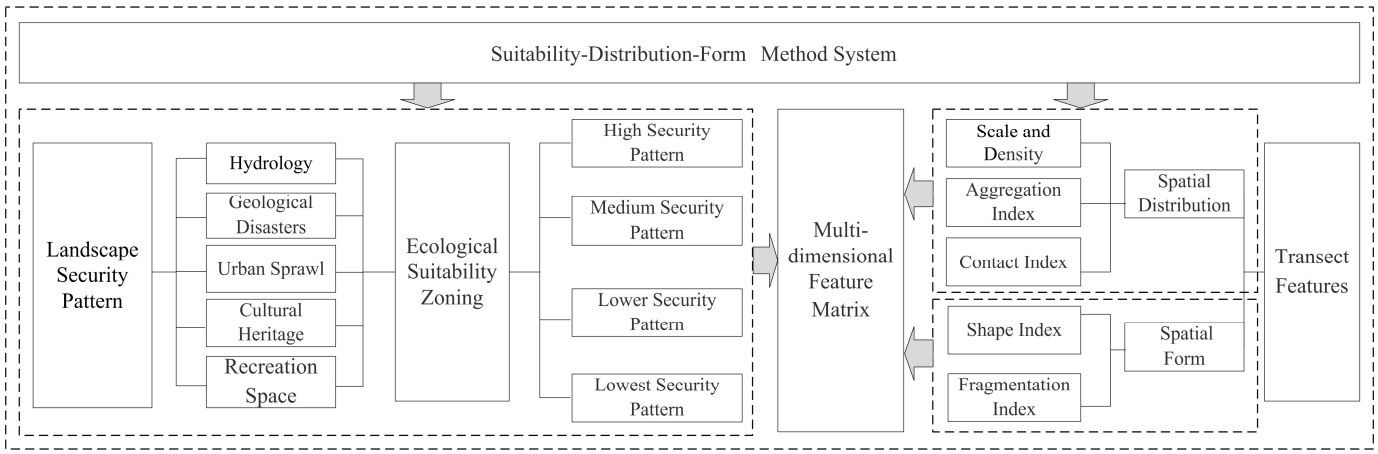

Figure 4. Construction of Suitability-Distribution Form Classification System.

2.3.1. Delineation of Rural Settlement Space Zoning

Table 1 shows that the source of a single security pattern was determined, and the natural and human factors in the region were unified [13–15]. According to the characteristics of the current situation of rural settlement patterns in Weibei Plain, the safety source points with large influencing factors was selected. The natural factors included the source of the safety pattern of hydrology and geological disasters. Human factors include urban sprawl, cultural heritage, and recreational space security pattern source.

Starting from the current situation of Weibei Plain and experts' opinions, four types of resistance factors were selected [29,30]. For this study, we used the analytic hierarchy process (AHP) to establish the index system of each resistance factor of recreation space security pattern, geological disaster security pattern, urban sprawl security pattern, and cultural heritage security pattern, then constructed the judgment matrix. Based on the above analysis, the relative importance of each index was obtained; then, the corresponding

maximum feature root λ max was obtained [31], and the consistency of the matrix was checked. If the consistency passed, the weight vector ω was obtained after normalization according to the maximum feature vector corresponding to the maximum feature root. Therefore, the weight of each resistance factor index system was determined. The resistance factors were weighted and superposed by the Raster Calculator [32]. The comprehensive resistance score formula is shown in (1).

$$S = \sum_{i=1}^{n} R_{ik} \times W_i \quad (1)$$

Here, S is the comprehensive resistance score; R_{ik} is the resistance score of the evaluation unit k corresponding to the resistance factor in item i; W_i is the resistance factor weight of item i.

Table 1. Determination of Single Security Pattern Source.

Security Source Point	Source Point Identification
Source of Hydrological Security Pattern	6 Rivers: Weihe River, Jinghe River, Qianhe River, Qishui River, Zero River, and Shichuan River
	10 Reservoirs: Feng Jiashan Reservoir, Wang Jiaya Reservoir, Dongfeng-Reservoir, Bai Digou Reservoir, Disi Reservoir, Guanwu Reservoir, Yang-Maowan Reservoir, Da Beigou Reservoir, Ganhe Reservoir, and Xijiao Reservoir
Source of Geological Disaster Security Pattern	6 Landslides, Collapses and Mudslides: Weibin District, Jintai District and Chencang District in the central part of Baoji City, the southern bank of Jinghe River in Xianyang City, and the loess tableland area of Pucheng County in the northern part of Weinan City.
Source of Urban Sprawl Security Pattern	23 Counties and Towns: Sanyuan County, Liquan County, Jingyang County, Qian County, Weicheng District, Mei County, Qindu District, Fuping County, Xingping City, Yanliang district, Yangling District, Fufeng County, Lintong District, Gaoling District, Wugong County, Dali County, Pucheng county, Linwei District, Qishan County, Weibin District, Jintai District, Fengxiang County and Chencang district
Source of Cultural Heritage Security Pattern	3 Imperial Mausoleums: Maoling in Xingping City, Zhaoling in Liquan County, and Xianling in Sanyuan County
	2 Temples: Zhougong Temple in Qishan County and Famen Temple in Fufeng County
	2 ancient ruins: Qin Yongcheng ruins and Zhouyuan ruins.
Source of Recreational Space Security Pattern	4 park scenic spots: Wu Shan Forest Park in Chencang district, Daijiawan Ecological Park in Jintai District, Weihe Wetland Ecological Park in Yangling District, and Yunvtan Scenic Spot in Qishan County

Using the Cost–Distance analysis in Arc GIS10.2 spatial analysis, the minimum cumulative resistance surfaces were obtained by introducing hydrology geological disasters, urban sprawl, cultural heritage, and recreation space into a single security pattern source. We reclassified them to obtain suitable zones with a single security pattern and analyzed them by superposition to obtain four types of ecological suitability zones, so that the rural settlement space zoning was obtained.

2.3.2. Select Rural Settlement Characteristic Transect Indicators

Weibei Plain is bounded by Weihe River in the south and Loess Plateau in the north. It is long and narrow in the east and west. The special geographical environment has an important impact on rural settlements. Rural settlement zoning of the Weibei Plain was delineated by ecological background adaptation analysis and by combining two typical geographical features of the southern Weihe River region in the south and the Hanyuan

tableland region in the north [33,34]. The Weihe River transect (WH) and Hanyuan Tableland transect (HY) were taken as measurement objects to obtain a specific understanding of the rural settlements in the whole Weibei Plain area. Figure 3 shows that the object of study has a large east–west span. WH and HY transects were selected from 15 km × 15 km transects, numbered from west to east, and each transect was 11 transects.

The spatial characteristics of rural settlements are the basis for the optimal allocation of settlements. Therefore, this study took the optimization of settlement patterns as the guide and the identification of the spatial distribution of rural settlements as the goal. Table 2 illustrates the selection of 2 major categories and 6 minor categories of indexes for quantitative statistics on the spatial distribution and form of rural settlements [35–37]. Spatial distribution indexes mainly include scale density, aggregation, and connectivity, while spatial form indexes include shape and fragmentation indexes.

Table 2. Summary of Indexes and Calculation Methods.

		Indicator Name	Calculation Method
Spatial Distribution Index	Scale Density	Mean Patch Size (MPS)	$\frac{\text{Total Area of Patch Types in Rural Settlements}}{\text{Number of plaques of this type}}$
		Patch Density (PD)	$\frac{\text{Total number of rural settlement patches}}{\text{Total patch area}}$
	Aggregation	Mean Nearest-Neighborhood Distance (MNN)	$\frac{\text{Sum of the closest distances from the rural settlement patches}}{\text{Total number of patches with the closest distance}}$
	Connectivity	Connectivity (CONNECT)	$C = \sum_{i=1}^{n} n_i / F$ n_i is the number of type i land patches in the area. F is the total land area.
Spatial Form Index	Shape	Mean Shape (SHAPE-MN)	$SHAPE = E/\min(E_i)$ E_i is the ratio occupied by landscape patch shape i.
	Fragmentation	Shannon's Diversity Index (SHDI)	$SHDI = -\sum_{i=1}^{m} p_i / \ln p_i$ p_i is the ratio occupied by landscape patch type i.

2.3.3. Construction of Multidimensional Feature Matrix

In this study, the rural settlement types were divided by the trinity of ecological background, spatial distribution, and spatial form. Starting from the three dimensions of ecological distribution and form, ecological adaptability analysis of the rural settlements was carried out, and the spatial distribution index and spatial form index of rural settlements were calculated. The landscape security pattern tool was used to constrain the hydrological security pattern, geological disaster security pattern, urban sprawl security pattern, cultural heritage security pattern, and recreational space security pattern of rural settlements in Weibei Plain, and the rural settlement space zoning was obtained by superposition, namely, the S1 lowest security pattern, S2 relatively low-security pattern, S3 medium security pattern, and S4 high-security pattern, to obtain the measurement of the ecological background of rural settlements. Based on the index calculation of spatial distribution, the index values were calculated by the geometric average method after the extreme values of each index were standardized. The changes in scale density index, aggregation index, and connectivity index of rural settlements were analyzed, and then the spatial distribution characteristics of rural settlements were judged, i.e., D1 H-PD, D2 L-PD, D3 agglomeration, D4 dispersion, D5 close, and D6 estrangement. Furthermore, the index of spatial form was calculated, and after the same data processing, the change in the shape index and fragmentation index of rural settlements was analyzed to judge the spatial form characteristics of rural settlements, namely, F1 regular, F2 complex, F3 complete, and F4 fragmentation. According to the two typical regional characteristics of Weihe River and Hanyuan Tableland in Weibei Plain, Weihe River transect (WH) and

Hanyuan Tableland transect (HY) were selected as measurement objects. Then, 11 quadrats of the 2 transects were divided by the transect grid tool, and each quadrat was calculated for the indexes of spatial distribution and form. Finally, the results obtained in the three dimensions were integrated and judged for characteristics, the indexes with little difference in the distribution and form of each transect were removed, and the WH transect and HY transect were arranged in a multidimensional feature matrix to ensure the independence of each transect. Finally, a feature matrix model with suitability-distribution form (SDF) as an element was formed to guide the classification of rural settlements (Figure 5).

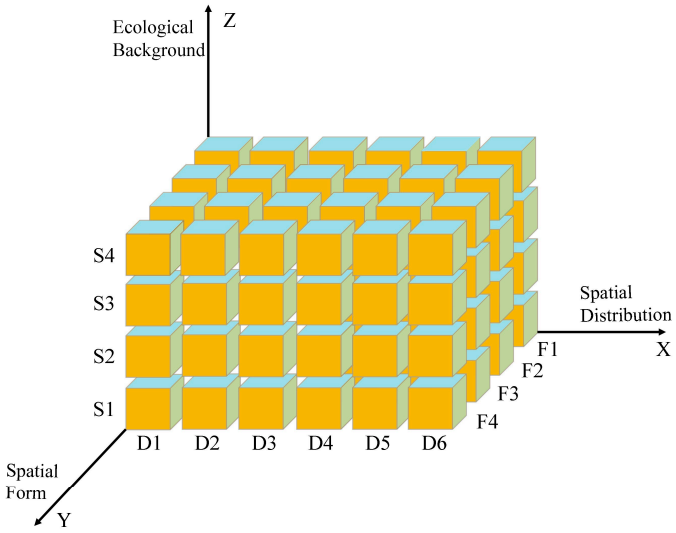

Figure 5. SDF Characteristic Matrix Model.

3. Results

3.1. Analysis of Rural Settlement Space Zoning of Weibei Plain

From the hydrological, geological disasters, urban sprawl, cultural heritage, and landscape security pattern (Figure 6a–e), security differences exist between the north and the south. Especially in terms of urban sprawl and geological disasters, the area near the big cities in the south is better than that near towns in the north. The south area near cities is better than the north area towns. The comprehensive landscape security pattern of Weibei Plain (Figure 6f) shows that the ecological background in the southern area near Weihe River has obvious advantages, especially in the rural settlements around Xianyang and Xi'an, mainly due to its flat terrain without large geological disasters, convenient transportation, and rich tourism resources. The north arid plateau is poorly adapted and is heavily affected by natural factors such as rainfall, land salinization, vegetation cover, and the Loess Plateau. While the southern area is in the alluvial plain, rural settlements are distributed along the Weihe River. The north part belongs to a typical hilly gully area of the Loess Plateau, so rural settlements are more likely to be distributed in the low and slow zone of the channel, which looks like striped distribution. It also shows consistent results of the comprehensive landscape security pattern analysis and the actual settlement distribution. According to the classification of comprehensive security patterns, the rural settlement patches in each district were statistically analyzed (Table 3). Rural settlements in high-security and medium-security patterns accounted for more than 86% of the total patches, indicating good ecological adaptability.

3.2. Analysis of Characteristic Transect of Rural Settlements in Weibei Plain

3.2.1. Spatial Distribution Measurement Analysis

Theoretically, the spatial distribution of rural settlements is generally affected by topography, traffic accessibility, water source conditions, residents' income, population size, land type, industrial structure and other aspects [25], and relevant indicators such as density size and difference, aggregation degree, and connection are usually selected to analyze

the spatial distribution characteristics [19]. In this paper, the above relevant indicators are selected, and the obtained research results show that the spatial distribution of rural settlements in the Weibei Plain is mainly influenced by topography, traffic accessibility, and land type.

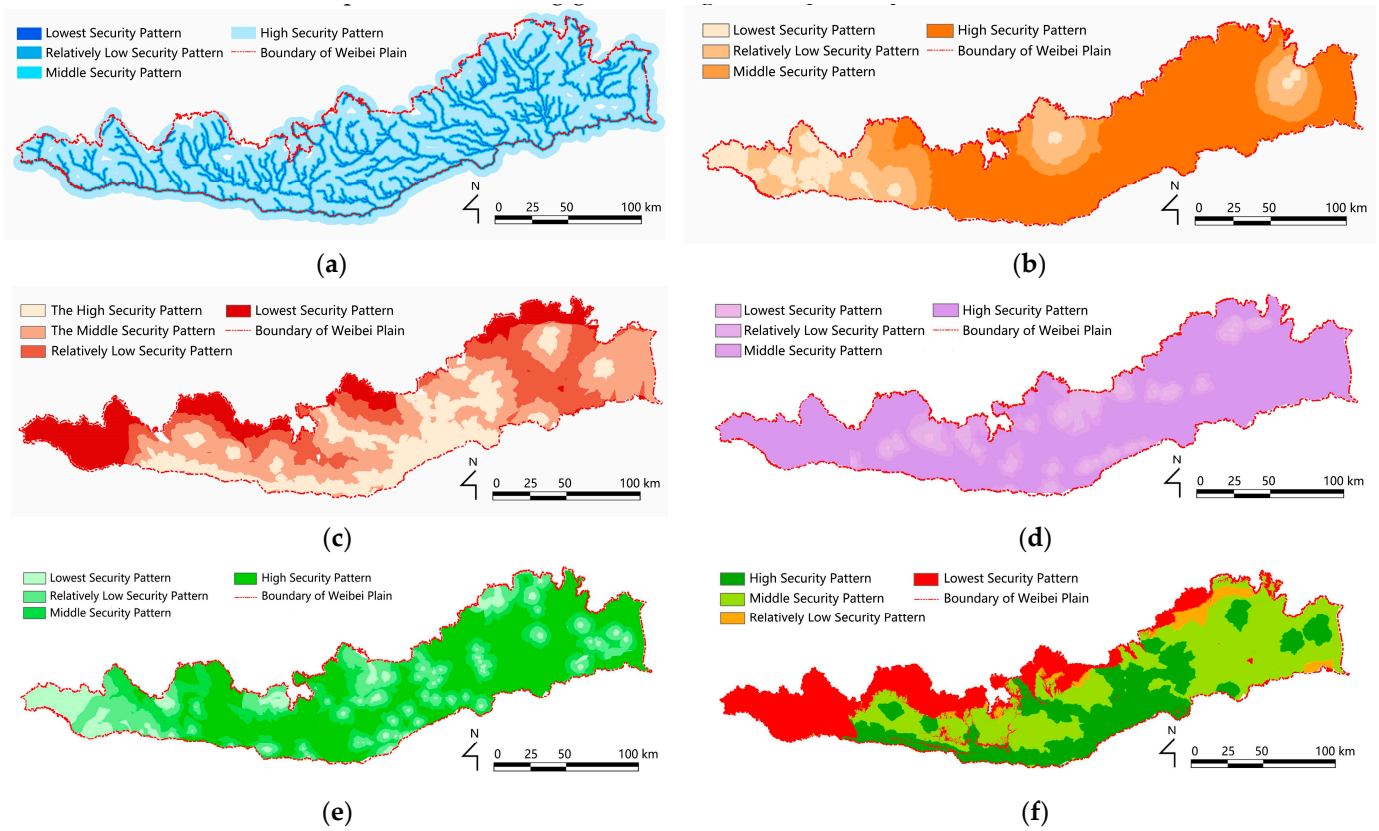

Figure 6. Security Pattern in Weibei Plain. (**a**) Security Pattern of Hydrology; (**b**) Security Pattern of Geological Disasters; (**c**) Security Pattern of Urban Sprawl; (**d**) Security Pattern of Cultural Heritage; (**e**) Security Pattern of Recreational Space; (**f**) Comprehensive Landscape Security Pattern.

Table 3. Statistics on Spatial Zoning of Rural Settlements in Weibei Plain.

Ecological Suitability Zoning	Area (ha)	Patches Quantity in Rural Settlements	Patches Area of Rural Settlements (ha)	Proportion of Total Patches (%)
The High Security Pattern	127,164	2929	22,689.16	18.25
The Middle security Pattern	882,412	11,002	89,712.47	68.54
The Relatively Low Security Pattern	202,524	1849	14,186.36	11.52
The Lowest security Pattern	286,302	271	1957.27	1.69

Among them, after calculating the landscape pattern index (Table 4), it can be seen from indexes for each patch that the rural settlements in the WH transect are adjacent to the urban suburbs, and the changes from west to east are not obvious (Figure 7a). A total of 80% of the patch areas are small without obvious peaks, and the settlement size has equidistant characteristics. The patch areas in the HY transect gradually decrease from west to east, while 70% of the rural settlement's fluctuation is small. In quadrat I, there is a peak value within 15 km. The rural settlement area within 135 km of quadrat IX is the smallest and gradually increases. It is mainly restricted by the topographic factors of an arid plateau. From this, the area of rural agglomerative patches is highly affected by urbanization and topography, and the closer to the city and suburbs, the flatter the terrain is, and it is more likely to form large aggregations.

Table 4. Summary of Index Calculation by Region.

Transect	Index Area	Spatial Distribution Index				Spatial Form Index	
		Scale Density		Aggregation	Connectivity	Shape	Fragmentation
		(MPS)	(PD)	(MNN)	(CONNECT)	(SHAPE-MN)	(SHDI)
WH Transect	I (0,15)	7.0058	21.4026	51.0641	0.952	1.2902	0.9371
	II [15,30)	8.0360	16.1341	50.2512	0.9476	1.2595	0.9036
	III [30,45)	9.1426	12.6938	56.1419	0.3545	1.3214	0.5489
	IV [45,60)	8.1746	16.629	53.0675	0.267	1.2663	0.6419
	V [60,75)	7.9688	20.2355	50.4927	0.6898	1.2027	0.7885
	VI [75,90)	7.8653	21.5189	45.6846	0.4782	1.2261	0.7813
	VII [90,105)	8.4858	13.7413	42.6065	0.529	1.31	0.7555
	VIII [105,130)	8.6914	14.0783	52.5586	0.373	1.3434	0.6772
	IX [130,145)	8.2019	16.5494	52.1784	0.5777	1.2829	0.5892
	X [145,160)	8.6200	7.5616	73.7696	0.2089	1.3229	0.3829
	XI [160,175]	8.9537	11.6753	69.1115	0.0983	1.2758	0.6134
HY Transect	I [0,15)	14.6837	1.2096	111.2703	0.3133	1.2002	0.7394
	II [15,30)	9.2682	4.0349	100.781	0.9824	1.1851	0.737
	III [30,45)	10.9121	2.5809	94.746	0.258	1.2525	0.8729
	IV [45,60)	9.0624	7.506	64.1748	0.5281	1.3871	0.8592
	V [60,75)	8.2561	15.1017	57.2523	0.2025	1.2565	0.8856
	VI [75,90)	7.1684	25.6328	55.9147	0.9823	1.2046	0.7187
	VII [90,105)	7.0799	25.8073	55.9153	0.1474	1.201	0.859
	VIII [105,130)	7.3268	25.7646	46.5722	0.1838	1.2468	0.8922
	IX [130,145)	4.5311	31.4878	47.7	0.2578	1.2291	0.7942
	X [145,160)	7.4558	19.4276	54.9818	0.1162	1.2495	0.8477
	XI [160,175]	8.5334	9.326	70.8449	0.1058	1.2905	0.4834

The patch density index of the transect shows that the WH transect has a fluctuating pattern (Figure 7b), while quadrats I and VI are affected by mountains on both sides of the east and west, making settlement density similar and showing a peak value, of which quadrat X has the lowest density within 150 km. The peak quadrat is sandwiched between Xianyang and Xi'an. The city greatly attracts it, with more people staying and a high density of settlements. HY transect presents a single peak type. The settlement density of quadrat I, II, and III are relatively low due to the large area of ecological land. The density of quadrat IV gradually increases after 60 km due to the flat terrain and more constructive lands. The density of quadrat VII and VIII are high. In quadrat IX, it peaks within 135 km, then the value gradually decreases. The density of patches of rural settlements is not only affected by the landscape's natural topography but also closely related to land type.

The aggregation index of transect patches shows that the distance between the rural settlements in the WH transect changes from near to far, and the distribution changes from intensive to discrete in Figure 7c. Moreover, the rural settlements in quadrat X have higher dispersion and present a peak value, which is consistent with the desertification characteristics of large areas of Dali County. The distance between the settlements in the HY transect changes from far to near, and the distribution changes from discrete to intensive, which is mainly because the rural settlement patches in remote channels are mostly distributed in scattered spaces with small clusters of single households. There is a peak in quadrat I, and settlements are the most scattered. It shows that the area is close to the lowest security zone and is seriously affected, with scattered settlements.

From the change in the connectivity index in Figure 7d, the rural settlements in the WH transect show fluctuation, with a large change mainly caused by the runoff of the Weihe River, Jinghe River, Qianhe River, and other rivers in the transect zone. The density connectivities of settlements in quadrats I and IX show a peak value and are closely linked. Affected by the comprehensive security pattern, quadrat XI has the lowest security pattern with poor road connectivity and the lowest connectivity. HY transect presents a double peak distribution with peaks on quadrat II and VI, which is consistent with the actual

situation of flat terrain and convenient road traffic in Fengxiang County and Liquan County in this region. The rural settlements in this region have the highest connectivity. The settlements in quadrat XI have the lowest connectivity, mainly because Dali County has the lowest security situation, land desertification is serious, and transportation is difficult to reach. It can be seen from this that the connection degree of rural settlements is strongly influenced by traffic. The rural settlements near the national and provincial roads are closely connected, but due to the restriction of channel topography, traffic is difficult to maintain, and the rural settlements are gradually estranged.

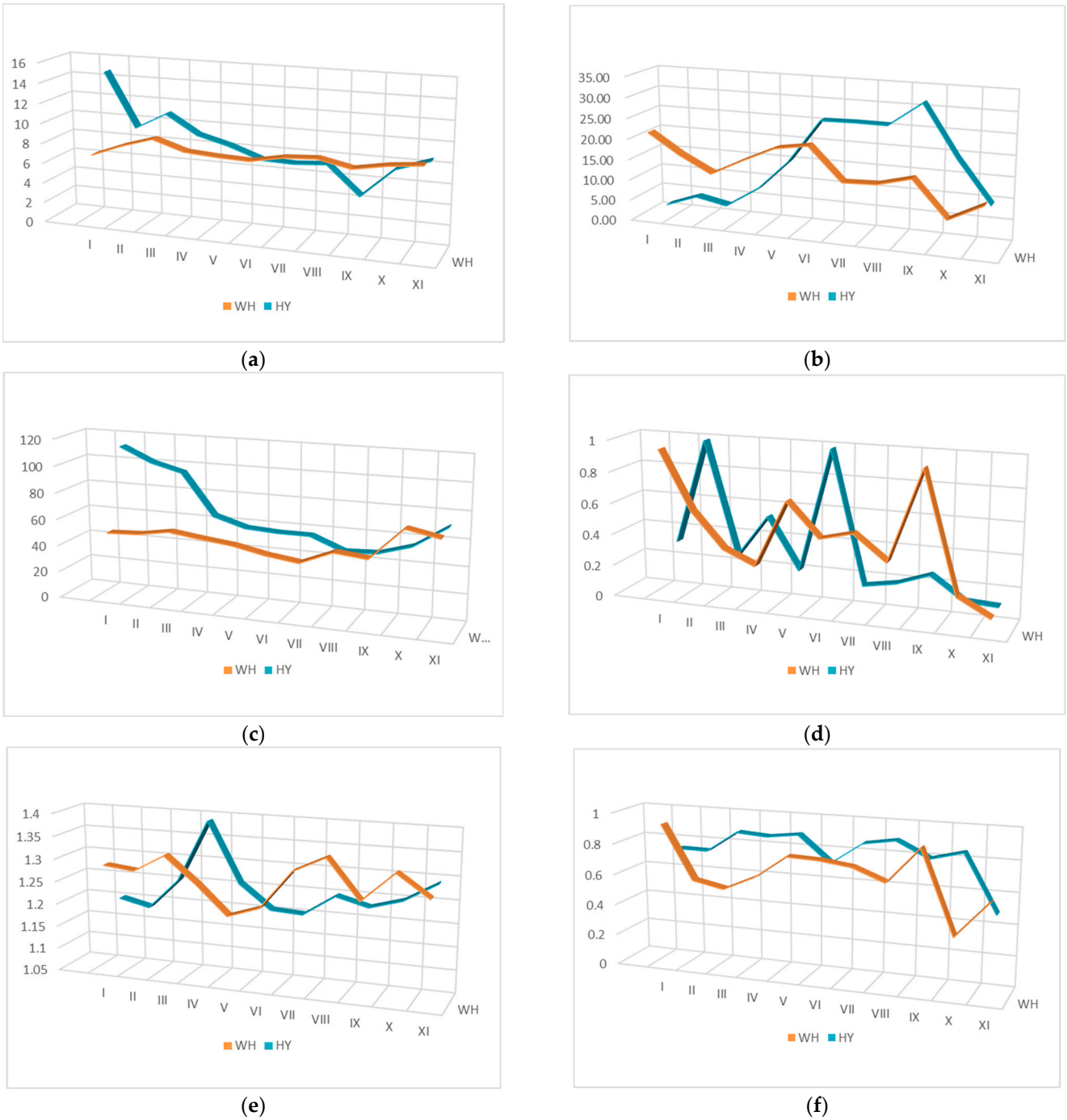

Figure 7. Statistics of WH Transect and HY Transect Index. (**a**) MPS; (**b**) PD; (**c**) MNN; (**d**) CONNECT; (**e**) SHAPE-MN; (**f**) SHDI.

3.2.2. Spatial Form Measurement Analysis

Generally speaking, the spatial morphology of rural settlements is mainly influenced by the geographical environment and agricultural production methods [23]. From the results of this paper, which do not differ much from previous scholars' studies, the factors influencing the spatial morphology of rural settlements in the Weibei Plain are mainly influenced by two aspects, namely rivers and topography.

Among them, the shape index in Figure 7e shows that the WH transect presents wave type, which is affected by the hydrological distribution of the Weihe River. The shape of rural settlements is complex. More than 70% of patches are irregular and vary greatly, with peaks appearing in samples III and VIII. The quadrat V is affected by the flat terrain, which has the lowest value. The settlement status is regular. HY transect presents a single peak type distribution and a peak value in quadrat IV. Yongshou County in this area is mostly a valley and hilly area, and settlement boundaries are distributed along the valley floor with complex shapes. After quadrat VI, the change of settlement shape is little, and the rural settlement shape tends to be similar. It can be seen that the patch shape is greatly affected by natural factors such as rivers and topography, and the boundary shape changes with the surrounding landform.

The fragmentation index in Figure 7f shows that the WH transect fluctuates greatly, and the degree of fragmentation of settlements in different quadrats changes. Quadrats I and IX show peaks due to the influence of urban sprawl. Rural settlements in this region are highly fragmented. Quadrat X is in a region with the lowest degree of fragmentation due to its high degree of urbanization. HY transect has a less fluctuation range than the WH transect, but it has a higher degree of fragmentation than the WH transect rural settlements. It is mainly distributed in gullies and valleys of the Loess Plateau with severe terrain fragmentation. This indicates that the fragmentation degree of rural settlements in the HY transect is highly affected by topography.

3.3. Classification of Rural Settlement Pattern in Weibei Plain

3.3.1. WH Transect Rural Settlement Pattern Classification

According to the arrangement of the characteristic transects, the indexes with little difference in patch size and density were removed. The WH transect selected the index of the spatial distribution's degree of connection and the index of the spatial form's degree of fragmentation. The two indexes have a strong positive correlation with a linear correlation coefficient of 0.769, which is significant at the level of 0.01 (two-sided test). According to the multidimensional characteristic matrix (Figure 5), the connection index can be divided into two levels of tightness and estrangement, and the fragmentation index can be divided into two levels, completeness and fragmentation. The four sub-regions with ecological background adaptability are substituted into the matrix for a matrix arrangement of $4 \times 2 \times 2$. Theoretically, 16 kinds of rural settlement divisions in the WH transect were obtained, and irrational divisions were deleted, totaling 6 kinds (Figure 8).

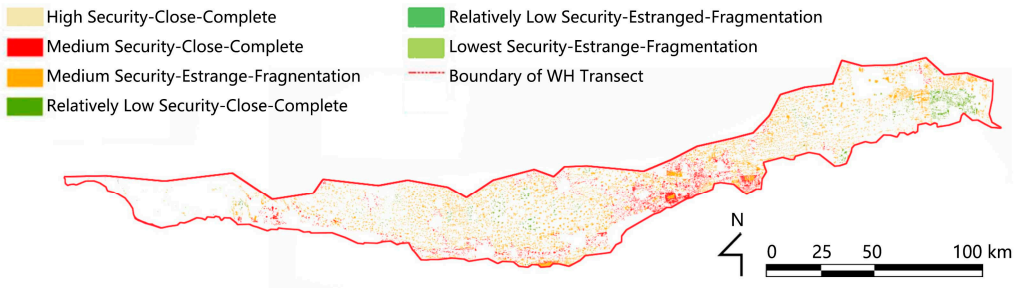

Figure 8. Zoning of WH Transect.

The high security-close-complete type (HSCC) includes 1301 rural settlements in Table 5. The average patch area of rural settlements is relatively large, mainly distributed in

Qindu District, Weicheng District, Gaoling District, and Lintong District, which are adjacent to the city center. This type of settlement has a superior ecological background, large location advantages, and obvious development momentum and is the ideal distribution mode of rural settlements in the WH transect.

Table 5. Summary of WH Transect Zoning.

Zoning Type	Patches Quantity	Proportion of Patches Quantity	Average Patch Area (m^2)	Average Patch Area Ratio	CONNECT	SHDI
HSCC	1301	13.93%	42,376.96	43.16%	0.92	0.92
MSCC	4890	52.34%	25,760.78	26.23%	0.78	0.78
MSEF	2445	26.17%	11,349.28	11.56%	0.61	0.65
RLSCC	411	4.40%	9860.37	10.04%	0.49	0.72
RLSEF	205	2.19%	5260.82	5.36%	0.31	0.58
LSEF	90	0.96%	3587.76	3.65%	0.19	0.39

The middle security-close-complete type (MSCC) is mainly distributed in the village areas where villages and towns are located, involving 4890 settlements. This type has good ecological advantages, relatively flat terrain, few geological disasters, superior natural environment, convenient transportation, convenient travel for rural residents, large population and land-use scale, perfect infrastructure, good economic foundation, and certain development potential. The middle security-estrange-fragmentation type (MSEF) comprises 2445 rural settlements. Although it has a good ecological background, it is inconvenient for transportation, the connection between settlements is estranged, and the degree of internal fragmentation is high. Therefore, the main optimization approach is to strengthen the overall connection of rural settlements, promote the circulation of elements between villages and towns, and form a scale effect.

The relatively low security-close-complete type (RLSCC) includes 411 rural settlements. This type is mainly distributed in the surrounding villages where the township government is located and is close to the main traffic arteries. It has good traffic conditions and can be developed in groups.

The relatively low security-estranged-fragmentation (RLSEF) and the lowest security-estrange-fragmentation (LSEF) are the two most undesirable types of WH transect rural settlement patterns, involving 295 settlements. The main problems of the two types lie in the poor ecological background, mostly distributed in the fragmentation zone far away from villages and towns, the poor traffic location conditions, and the poor connection between settlements. The best way to optimize this type of settlement is to relocate the settlements while providing good transportation and infrastructure conditions for the new settlements.

3.3.2. HY Transect Rural Settlement Pattern Classification

The HY transect selected the aggregation index of spatial distribution and the shape index of spatial form, and its linear correlation coefficient is 0.816, which is significant at the level of 0.01 (two-sided test), showing a positive correlation. Using a multidimensional characteristic matrix, the aggregation index can be divided into two levels: aggregation and dispersion, and the shape index into two levels: regular and complex. It is also arranged in a matrix with four kinds of security pattern zoning; finally, seven zones were obtained (Figure 9).

The high security-agglomeration-regular type (HSAR) and high security-agglomeration-complex type (HSAC) are mainly distributed in Qishan County, Fufeng County, and Qian County in Figure 8, with a total of 1470 rural settlements in Table 6. All villages of this type are in the hinterland of the Weibei plain, with few geological disasters and sufficient ecological advantages, and the ecological background advantage is high and densely distributed, which is a better distribution mode of rural settlements in the Hanyuan Tableland transect.

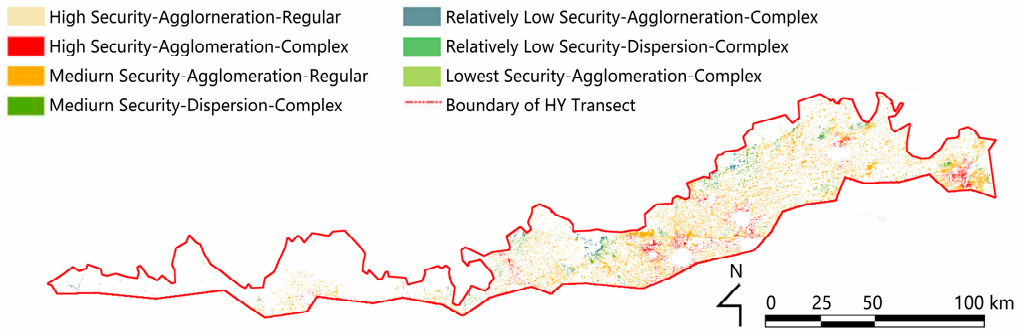

Figure 9. Zoning of HY Transect.

Table 6. Summary of HY Transect Zoning.

Zoning Type	Patches Quantity	Proportion of Patches Quantity	Average Patch Area (m^2)	Average Patch Area Ratio	MNN	SHAPE-MN
HSAR	977	14.56%	33,410.04	27.27%	112.38	1.15
HSAC	493	7.35%	28,454.69	23.23%	94.74	1.24
MSAR	646	9.63%	25,246.32	20.61%	80.69	1.17
MSDC	740	11.03%	15,674.14	12.79%	57.25	1.25
RLSAC	535	7.97%	6798.45	5.55%	70.49	1.18
RLSDC	2667	39.75%	8887.17	7.25%	50.43	1.29
LSAC	651	9.70%	4046.05	3.30%	46.57	1.38

The middle security-agglomeration-regular type (MSAR) and the middle security-dispersion-complex type (MSDC) are distributed in Fuping County and Pucheng County. There are 1386 rural settlement patches. The average patch area of this type of settlement is 15,000–25,000 m^2, which has certain natural or human value. Its characteristics are mainly a large population, large land-use scale, perfect infrastructure, and good economic foundation. This type of village should meet the demand for construction land by tapping the potential inside. The production and living conditions in the region have been improved by obtaining a certain amount of arable land resources through layout optimization.

There are 3202 rural settlement patches in the relatively low security-agglomeration-complex type (RLSAC) and the relatively low security-dispersion-complex type (RLSDC). The rural settlements are mainly adjacent to the northern Loess Plateau and the western mountain terrain, which leads to an insufficient ecological background. The main problem is that the settlement patches are small and numerous. There are 535 settlements that are relatively concentrated. This type can be taken as the preferred object of the central village. The optimization focus is on integrating residential areas and the supporting services of corresponding public facilities. A total of 2667 settlement patches are scattered, and the focus of type change optimization is the spatial integration of settlements within or among multiple settlements.

The lowest security-agglomeration-complex type (LSAC) includes 651 rural settlements. This type of village is seriously affected by the northern Loess Plateau, with obviously insufficient ecological background and complex settlement shapes. Therefore, the focus of optimization should be to strengthen rural ecological restoration, increase financial support, improve transportation and infrastructure conditions, integrate residential areas, organize group development, and provide convenient conditions for residential lives.

4. Discussion

The development of rural settlement space carries the dual functions of promoting rural revitalization and alleviating urban congestion. A comprehensive grasp of the characteristic composition and differentiation pattern of rural settlement space can provide a scientific theoretical and practical basis for studying rural development issues and ter-

ritorial spatial planning. Different from previous studies that only selected unilateral factors [38] to analyze the characteristics of the spatial distribution of rural settlements, this paper breaks out of the limitation of combination analysis of a single factor [39] and reveals the spatial pattern characteristics of rural settlements in Weibei Plain from a large-scale and multidimensional perspective.

Through the previous research, in the analysis of settlement spatial zoning based on ecological background, it can be concluded that due to the influence of terrain, climate, and transportation facilities, the overall ecological adaptability of the Weibei Plain is good, and the southern part is significantly better than the northern part. Similar to previous studies, multiple factors were used for overlay analysis to obtain ecological security results. However, this study starts from the large-scale ecological background and divides the spatial characteristics of rural settlements into spatial zones, which is different from other small-scale studies [40]. In the analysis of spatial distribution measurement, it can be concluded that the distribution of rural settlements is mainly affected by the topography and the traffic accessibility, which is consistent with the research results of scholars such as Rongtian Zhang [41], but different from their results that rural settlements are less distributed in areas close to built-up areas, the research results of this paper show that rural settlements are more concentrated in areas close to the suburban areas of cities with flat terrain and convenient traffic. In the analysis of spatial morphology measurement, it can be concluded that due to natural factors such as rivers, terrain, and landforms, the rural settlement morphology in the southern WH transect is relatively regular, while the rural settlement morphology in the northern HY transect is relatively fragmented. The research results are similar to those of scholars such as Lin Wang [42]. However, different from their research results that the physical geography environment is only a secondary influencing factor, the physical geography environment of the Weibei Plain has a decisive impact on the spatial form of rural settlements. In terms of rural settlement feature classification, this study uses the SDF feature matrix model to classify rural settlement types based on the three-dimensional features of background, distribution, and morphology mentioned above. The classification results are similar to those of scholars such as Zongfeng Chen [19], who obtained multiple rural settlement types with different characteristics and proposed improvement strategies based on different types. However, this study takes into account the different spatial characteristics of the Weihe River and the Hanyuan tableland in the Weibei Plain region, as well as the independence of the spatial indicator characteristics of each transect. Therefore, a total of 13 types of rural settlements in different zones were designated to ensure that the results were more targeted, which has important theoretical and practical significance for sustainable rural development.

In terms of theoretical significance, this study enriches the research content of ecologically sustainable development theory in Weibei Plain and also provides new ideas for the study of spatial characteristics and classification of rural settlements in Weibei Plain and even in various regions of China. According to the spatial zoning of rural settlements delimited by this study, local governments can formulate more suitable development policies for rural settlements according to different regional characteristics. In high-security areas with flat terrain, settlement production efficiency, and local economic development are the primary considerations. Policymaking should emphasize the balance between ecological and historical sites and people's production and life in medium- and relatively low-security areas. Due to the fragile natural ecosystem of the lowest security areas, relevant laws, and regulations should be passed to restrict the development of rural settlements and encourage residents to settle in a centralized way to maintain the ecosystem. HSCC and HSAR are the better distribution modes of rural settlements, and the two types of zoning should be centralized allocation of resources and strengthen the allocation of infrastructure. The optimization of RLSCC and RLSAC focuses on the spatial integration of multiple settlements and the large-scale development of clusters. LSEF should carry out the relocation of residential areas. It has guidance and reference significance for solving the spatial decay of

rural settlements in Weibei Plain, improving the rural living environment, and realizing rural revitalization and new urbanization.

Based on theories related to sustainable development, this paper studies the spatial distribution, morphological attributes, and the matrix in which the rural settlements are located and combines the two into different types according to their different characteristics. However, some shortcomings still need to be further developed in this paper: (1) This paper takes the settlement space as a whole for analysis and fails to analyze and discuss the mechanism of the detailed space of individual patches inside rural settlements. Therefore, it is necessary to explore further the influence mechanism of micro-spatial structure factors on settlement patterns. (2) This study only analyzes the spatial characteristics and types of rural settlements and lacks the analysis of the links between rural settlement patches and other social and economic attributes other than natural attributes [43]. Therefore, the research on rural settlements' economic types and structural efficiency need to be improved. (3) The spatial characteristics of rural settlements are the spatial forms that evolved in the process of long-term historical development. It is necessary to further explore the dynamic evolution law and influence mechanism of rural settlements space in the time dimension. In the future, on the basis of this study, the comprehensive effects of social and economic factors can be incorporated into the evaluation system, and the spatial pattern of rural settlements can be evaluated more comprehensively and accurately combined with the changes in time and space, which can also provide support for the spatial planning of national territory, the construction of new countryside and the optimization decision of spatial pattern of villages and towns.

5. Conclusions

In this study, a multidimensional feature matrix model was established from three dimensions: background, distribution, and morphology. The spatial differentiation characteristics of rural settlements in the Weibei Plain on two characteristic zones of the Weibei Plain were analyzed using landscape safety pattern theory, spatial data, and sample grid methods, and rural settlement types were classified:

(1) The spatial partitioning of rural settlements in the Weibei Plain was finally classified into four categories using landscape security pattern theory calculation and analysis. The number of rural settlements in high- and medium-security patterns accounted for 86.79%, and the overall ecological adaptability was good. Moreover, the ecological background of rural settlements in the southern region was better than that in the northern region, consistent with the current investigation of Weibei Plain.

(2) In the rural settlement space of Weibei Plain, the WH and HY transects were selected according to the results of ecological adaptability zoning; the spatial distribution measure analysis showed that 80% of the rural settlements in the WH transect from west to east had small patch area and small change range, patch density fluctuated, and patch aggregation changed from intensive to discrete. Due to the influence of river runoff, patch connectivity fluctuates greatly. In the HY transect, 70% patch area fluctuated a little and decreased from west to east. Patch density was unimodal; patch aggregation changed from discrete to intensive; patch connectivity was strongly influenced by traffic and was closely connected near roads. According to the analysis of spatial morphology measure, 70% of the patches in the average shape index of the WH transect were irregular and varied greatly, while the rural settlement morphology in the HY transect tended to be similar. The rural settlements in the HY transect are mainly distributed in the gully area of the Loess Plateau, and the topography is severely fragmented, which is higher than that in the WH transect.

(3) According to the characteristic transect analysis results, the WH transect in Weibei Plain was divided into six types and the HY transect was divided into seven types by a multidimensional characteristic matrix. Among them, LSEF and LSAC are the key areas of rural settlement optimization. The local government should adjust to

local conditions and orderly carry out village renovation and construction planning according to different types.

Compared with the existing studies, this paper extends the current research methods for classifying the spatial characteristics of rural settlements. The constructed multidimensional characteristic matrix makes up for the deficiencies in the classification criteria based on single analysis tools and single dimensions. It is also an extension and supplement to the objects constructed by the analysis of transect and quadrat. It is gradually applied to studying the urbanization system and the spatial characteristics of settlements in urban and rural planning and can form a complete range, scale, and morphological characteristics of settlements and a multidimensional classification system. In summary, this study scientifically classified rural settlement areas for sustainable development and proposed key areas for rural settlement optimization. The research results can provide a reference and basis for studies on spatial structure optimization, allocation of public service facilities, integrated urban-rural development, and rural policy formulation in the Weibei Plain or similar areas.

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References

1. Vaz, T. Traditional Food Production and Rural Sustainable Development. *Tijdschr. Voor Econ. Soc. Geogr.* **2011**, *102*, 380–383.
2. Yi, S.M.; Liao, L.P.; Li, K. The Symbiosis Strategy In Rural Revitalization And Guangxi Practice. *Planners* **2018**, *34*, 68–73.
3. Zeng, X.; Zhao, Y. The Characteristics of Rural Settlement Landscape in Hilly Area from the Perspective of Ecological Environment. *J. Coast. Res.* **2020**, *103*, 506. [CrossRef]
4. Ji, H.; Li, X.; Wei, X.; Liu, W.; Zhang, L.; Wang, L. Mapping 10-m Resolution Rural Settlements Using Multi-Source Remote Sensing Datasets with the Google Earth Engine Platform. *Remote Sens.* **2020**, *12*, 2832. [CrossRef]
5. Fang, F.; Ma, L.; Fan, H.; Che, X.; Chen, M. The spatial differentiation of quality of rural life based on natural controlling factors: A case study of Gansu Province, China. *J. Environ. Manag.* **2020**, *264*, 110439. [CrossRef]
6. Cai, J.; Li, X.; Liu, L.; Chen, Y.; Wang, X.; Lu, S. Coupling and coordinated development of new urbanization and agro-ecological environment in China. *Sci. Total Environ.* **2021**, *776*, 145837. [CrossRef]
7. Tu, S.S.; Zhou, X.Y.; Long, H.L.; Liang, X.L. Research Progress and Prospect of Spatial Evolution and Optimization of Rural Settlements. *Econ. Geogr.* **2019**, *39*, 142–149.
8. Qu, Y.; Jiang, G.; Ma, W.; Li, Z. How does the rural settlement transition contribute to shaping sustainable rural development? Evidence from Shandong, China. *J. Rural Stud.* **2021**, *82*, 279–293.
9. Du, Y.; Hu, Y.; Yang, Y.; Peng, J. Building ecological security patterns in southwestern mountainous areas based on ecological importance and ecological sensitivity: A case study of Dali Bai Autonomous Prefecture, Yunnan Province. *Acta Ecol. Sin.* **2017**, *37*, 8241–8253.
10. Li, J.; Cai, Z.; Duan, L. Spatial Distribution Characteristics and Optimum Layout of Urban and Rural Areas in Different Geomorphological Types. *Earth Sci. Res. J.* **2020**, *24*, 267–275. [CrossRef]
11. Ajaero, C.K.; Onokala, P.C. The Effects of Rural-Urban Migration on Rural Communities of Southeastern Nigeria. *Int. J. Popul. Res.* **2013**, *2013*, 610193. [CrossRef]
12. Otiman, P.I. Romania'S Agri-Food And Rural Development Strategy. *Agric. Econ. Rural Dev.* **2013**, *10*, 133–153.

13. Peng, J.; Pan, Y.; Liu, Y.; Zhao, H.; Wang, Y. Linking ecological degradation risk to identify ecological security patterns in a rapidly urbanizing landscape. *Habitat Int.* **2018**, *71*, 110–124. [CrossRef]
14. Su, Y.; Chen, X.; Liao, J.; Zhang, H.; Wang, C.; Ye, Y.; Wang, Y. Modeling the optimal ecological security pattern for guiding the urban constructed land expansions. *Urban For. Urban Green.* **2016**, *19*, 35–46. [CrossRef]
15. Du, P.; Xia, J.; Du, Q.; Luo, Y.; Tan, K. Evaluation of the spatio-temporal pattern of urban ecological security using remote sensing and GIS. *Int. J. Remote Sens.* **2013**, *34*, 848–863. [CrossRef]
16. Tan, X.L.; Zhou, G.H.; Zhu, S.H.; Ou, C. Landscape Pattern Changes and the Characteristic of Spatio-temporal Differentiation of Rural Residential Area in Changsha in Recent 20 Years. *Sci. Geogr. Sin.* **2015**, *35*, 204–210.
17. Zhang, B.L.; Zhang, F.R.; Gao, Y.; Li, C.; Zhu, F.K. Identification and spatial differentiation of rural settlements'multifunction. *Trans. Chin. Soc. Agric. Eng.* **2014**, *30*, 216–224.
18. Cheng, X.L.; Zeng, Y.N.; Liu, W.J. A Comparative Study of Spatial Interpolation Methods for Meteorological Elements in Subtropical Mountainous and Hilly regions of China. *Geo Spat. Inf. Technol.* **2017**, *40*, 51–56.
19. Chen, Z.F.; Li, Y.R.; Liu, Y.S. Distribution pattern characteristic and type classification of rural settlements in loess hilly-gully region. *Trans. Chin. Soc. Agric. Eng.* **2017**, *33*, 266–274.
20. Li, Y.; Fu, H.; Zhang, Y.; Ma, H.; Xu, X. The spatiotemporal differentiation characteristics and response mechanism of landscape pattern gradient in Haikou City. *J. Northwest For. Univ.* **2020**, *35*, 258–268.
21. Wang, Y.Y.; Wang, H.W.; Yang, S.T.; Liu, J.J.; Liu, X.Y. Distribution characteristics and influencing factors of rural settlements in Ebinur Lake Basin—Taking Jinghe County of Xinjiang as an example. *Jiangsu Agric. Sci.* **2019**, *47*, 254–259.
22. Yao, F.; Chen, L.; Wang, B.Y.; Zhang, T.; Zhou, T.J.; Zhang, Y. Analysis on Gradient Characteristic of Landscape Pattern of Land Use in Chaohu Lake-Land Ecotone. *Res. Soil Water Conserv.* **2016**, *23*, 214–219.
23. Xu, Y.; Zhong, Y.X.; Xu, L.T.; Wu, W. Spatial-Temporal Characteristics and Driving Forces of Rural Settlements in Background of Rural Revitalization Strategy: A Case Study of Jiangxi Province. *J. Agro For. Econ. Manag.* **2018**, *17*, 100–108.
24. Ma, X.D.; Li, Q.L.; Shen, Y. Morphological Difference and Regional Types of Rural Settlements in Jiangsu Province. *Acta Geogr. Sin.* **2012**, *67*, 516–525.
25. Wang, J.; Zhang, Y. Analysis on the Evolution of Rural Settlement Pattern and Its Influencing Factors in China from 1995 to 2015. *Land* **2021**, *10*, 1137. [CrossRef]
26. Shi, M.; Xie, Y.; Cao, Q. Spatiotemporal Changes in Rural Settlement Land and Rural Population in the Middle Basin of the Heihe River, China. *Sustainability* **2016**, *8*, 614. [CrossRef]
27. Cao, Y.; Bai, Z.; Sun, Q.; Zhou, W. Rural settlement changes in compound land use areas: Characteristics and reasons of changes in a mixed mining-rural-settlement area in Shanxi Province, China. *Habitat Int.* **2017**, *61*, 9–21. [CrossRef]
28. Tao, H.; Ding, J.; Zheng, M.M.; Li, W.L.; He, X.B. Evaluation and evolution law of groundwater quality in Weihe River Plain. *J. Water Resour. Water Eng.* **2018**, *29*, 50–56.
29. Zhang, Z.; Hu, B.; Qiu, H. Comprehensive assessment of ecological risk in southwest Guangxi-Beibu bay based on DPSIR model and OWA-GIS. *Ecol. Indic.* **2021**, *132*, 108334. [CrossRef]
30. Ersayin, K.; Tagil, S. Ecological sensitivity and risk assessment in the Kizilirmak Delta. *Fresenius Environ. Bull.* **2018**, *26*, 6508–6516.
31. Guo, P.; Zhang, F.; Wang, H.; Qin, F. Suitability Evaluation and Layout Optimization of the Spatial Distribution of Rural Residential Areas. *Sustainability* **2020**, *12*, 2409. [CrossRef]
32. Jin, Y.; Che, Y.; Yang, K. Zoning of River Network Protection Based on Minimum Cumulative Resistance Model. *Resour. Environ. Yangtze Basin* **2013**, *22*, 8–14.
33. Zhou, Y.; Chen, Y.; Xie, B.P.; Pei, T.T.; Yi, X.C. Connection and Influence Scope of Guanzhong Plain Urban Group. *Areal Res. Dev.* **2019**, *38*, 54–59.
34. Wei, X.H.; Bai, Y.P.; Che, L.; Wang, D.; Xiao, R.; Zhang, W.X. Evaluation of human settlement environment quality of urban agglomeration in Guanzhong Plain based on grid data. *Arid Land Geogr.* **2019**, *42*, 1176–1184.
35. Xie, L.; Li, X.K.; Yu, T. Spatial Distribution of Rural Settlement in the Hilly Three Gorges Reservoir Area Based on GIS: A Cases Study of Tujing and Shibao Towns, Zhongxian. *Res. Soil Water Conserv.* **2014**, *21*, 217–222.
36. Zhou, T.; Jiang, G.; Ma, W.; Li, G.; Qu, Y.; Tian, Y.; Zhao, Q.; Tian, Y. Dying villages to prosperous villages: A perspective from revitalization of idle rural residential land (IRRL). *J. Rural Stud.* **2021**, *84*, 45–54.
37. Bao, R.; Bo, Y.U. Spatial Reconstruction of Rural Settlements in Central China. *J. Landsc. Res.* **2018**, *10*, 12–14+24. a.
38. Li, G.; Jiang, C.; Du, J.; Jia, Y.; Bai, J. Spatial differentiation characteristics of internal ecological land structure in rural settlements and its response to natural and socio-economic conditions in the Central Plains, China. *Sci. Total Environ.* **2020**, *709*, 135932. [CrossRef]
39. Dou, H.; Ma, L.; Li, H.; Bo, J.; Fang, F. Impact evaluation and driving type identification of human factors on rural human settlement environment: Taking Gansu Province, China as an example. *Open Geosci.* **2020**, *12*, 1324–1337. [CrossRef]
40. He, J.H.; Jia, N.; Li, Y.J.; Tan, R.N.; Yan, C. Layout optimization of rural residential areas in Hehuang Valley of northeast Qinghai Tibet-Plateau. Trans. *Chin. Soc. Agric. Eng.* **2021**, *37*, 258–265.
41. Zhang, R.; Zhang, X. Distribution Characteristics and Influencing Factors of Rural Settlements in Metropolitan Fringe Area: A Case Study of Nanjing, China. *Land* **2022**, *11*, 1989. [CrossRef]

42. Wang, L.; Zeng, J. Spatial differentiation characteristics and types classification of rural settlements in southwest Shandong: A case study of Heze city. *Geogr. Res.* **2021**, *40*, 17.
43. Liu, S.; Ma, L.; Yao, Y.; Cui, X. Man-land relationship based on the spatial coupling of population and residential land—A case study of Yuzhong County in Longzhong Loess Hilly Region, China. *Land Use Policy* **2022**, *116*, 106059. [CrossRef]