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Study on the Level and Type Identification of Rural Development in Wuhan City's New Urban Districts

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Abstract: A quantitative analysis of rural development is required to comprehend the spatial differentiation of a rural area and promote rural sustainable development under the pressure of urbanization and industrialization, especially areas with dramatic changes in rural socioeconomic development of China and other developing countries. Taking Wuhan as the case study, this paper developed an index system including rural settlement, land, industry and human settlement environment for evaluating the level of rural development. Then, using the exploratory spatial data analysis, the principal component analysis and the cluster analysis, this paper analyzes the spatial differentiation and correlation and categorizes the types of rural development. The results are as follows. (1) The spatial differentiation of the level of rural development in Wuhan City's new urban districts is obvious and the areas with a high level of rural development are mainly distributed at the intersection of the new and central urban areas and gradually decrease outward. (2) There is a significant spatial agglomeration of the developed rural areas and the structure of the spatial change in these areas resembles a certain continuity, specifically a circle of "central heat surrounding cold". (3) Rural development in the new urban areas can be divided into the following five types: the ecological leisure type, the traditional farming type, the balanced development type, the industrial-and-agricultural mixed type and the industrial promotion type. The corresponding development path is proposed in combination with different types of rural development to provide a theoretical basis and decision-making reference for rural revitalization.

Keywords: rural development; spatial pattern; type identification; indicator; Wuhan

1. Introduction

A rural area is a complex system under the mutual influence, function and transformation of nature, social, economic and human activities, which reflects the character, function, position and the role of a rural area, as well as its population, resources and environment [1–3]. Currently, approximately 45% of the world's population lives in rural areas [4]. With the acceleration of global urbanization [5], the global population is projected to increase by 1.76 billion and 86% of this growth is expected to

occur in the cities and towns of developing countries during 2000–2024. The above projections from the United Nations Population Division suggest that in developing countries, during this period, there will be a rural growth of about 190 million rural dwellers in total [6]. The emergence of the current post-urban world has a fundamental change in urban–rural relations, also accompanying rural issues, which include rural decline, rural depopulation and exodus, land abandonment, rural poverty and environmental pollution in deteriorating countrysides, have swept both developing and developed countries, as well as hindered rural sustainability [7]. Rural restructuring has been identified in Western Europe and North America [8–10], but for most developing countries like China, India and Brazil, rural area remains the most important inhabitation areas, and the issues of rural development have always been a matter of close attention and committed to improving by governments [11,12]. The study of rural development is helpful to comprehend the spatial differentiation of rural areas and it is critical for guiding the rural transformation and reconstruction.

During the process of rapid urbanization and new rural construction in China, rural social and economic conditions have been greatly improved, reflecting in the increasingly diversified types and subjects of rural industries involved in rural reconstruction, including industrial layout [3], functional zoning [13,14], spatial landscape [15], land use [16,17], etc. By optimizing the allocation and effective management of the material and non-material factors affecting rural development, the rural socioeconomic system can be reconstructed. In the new era, the main contradiction in China's social development has been transformed into a contradiction between the people's growing needs for a better life and the unbalanced and inadequate development, which is most prominent in rural area [18]. Therefore, the report of the 19th National Congress of the Communist Party of China proposed implementing rural revitalization and the comprehensive development of the rural economy. Other countries, including Japan [19,20], South Korea [21] and India [22] have taken a series of measures to promote rural development, and great progress has been made in rural areas. In addition, rural areas have high diversity due to their unique natural and social conditions. Quantitative measurement of rural development provides the basis for rural revitalization.

The level of rural development is the degree of rural modernization starting from a state of imperfect infrastructure and low productivity. Most of the original studies were focused on the conceptual definition and problem comments that arisen [9,23–28]. As rural research becomes more in depth, the studies on rural are mainly about rurality evaluation [29], rural settlement spatial differentiation [30], rural reconstruction and rural multifunction [31,32]. Based on the land structure, employment structure, number of beds in tourism and recreation centers [33], regional differences in employment of agricultural population and urban impact intensity [34], proportion of non-agricultural labor force [35], economic structure and traffic conditions [36–38], land use [39], pillar industries [40], etc., and rural development types and level were identified. In addition, rural area within highly urbanizing areas in Africa and Latin America, promoting rural development has been proposed as a strategy to reduce spatial inequality between urban and rural areas [41–43]. In terms of research methods, there are principal component analysis, comprehensive index method [29], SOFM (self-organizing feature map) artificial neural network [44], geographical weighted regression [45], mechanical balance method [46], K-means clustering [47], etc. However, the study of the evaluation system is relatively rare, and the selection and quantification of evaluation indicators is a complex problem to be solved. Current research focuses on the single topic of spatial types, i.e., economy and agriculture in rural areas [48–50], and rarely depicts the level of rural development from the perspective of a rural regional system, such as in terms of nature, humanity, society and the economy. It is critical to establish an evaluation system for rural development with universality, rationality, and high efficiency to classify rural types. This can measure the rural development from the essence of urban and rural system.

Urban is the spatial territory system with non-agricultural industries and non-agricultural population agglomeration as the main characteristics, while rural is all the spatial territory system except urban. There is no absolute spatial break point in urban–rural territory systems. Therefore, the difference of urban–rural territory systems does not lie in space, but mainly in function. The urban territory system mainly provides

non-agricultural products, non-agricultural services and non-agricultural employment opportunities. Comparatively speaking, rural territory system mainly carries out agricultural production to furnish agricultural products and services, and gives play to its social and ecological functions [51]. As urban–rural links become closer, significant changes have taken place in the regional structure, industrial structure, employment structure and social structure between urban and rural areas. Urban–rural integrated development is proposed to achieve urban–rural equivalent development [52]. We need to know the rate of development in rural areas, which can allow for understanding the extent of increase in urbanization. Moreover, there are few studies on the evaluation of rural development level in Wuhan. Therefore, we need a system of indicators to evaluate the level of rural development in urban areas.

Wuhan, as a national central city in China, has created an obvious core area (central urban area) which is becoming increasingly closely connected to the new urban districts, was used as the case study area. Moreover, the transition between urban and rural areas, border instability and dynamic change are significant. Studying rural development in Wuhan can provide theoretical support and a decision-making reference for rural revitalization.

2. Materials and Methods

2.1. Research Area

Wuhan is located in the center of the hinterland of China, specifically in the east of Jiangnan Plain and at the intersection of the Yangtze River and Hanjiang rivers. Wuhan is the central city of central China and the capital of Hubei Province. The city enjoys superior natural conditions and a long history of agricultural development. The research area consists of 2206 administrative villages in six new urban districts with a total area of 7614 km² under the jurisdiction of Wuhan City; the six new urban districts are Dongxihu District, Hannan District, Caidian District, Jiangxia District, Huangpi District and Xinzhou District. As of 2017, the permanent population of the new urban districts was 3.7528 million, of which 2.563 million is the agricultural population, which accounts for 68.3% of the total population. The rural hinterland is vast, and the characteristics of the metropolitan area are obvious. The disposable income of rural residents is 18250 yuan, and the output value of the primary industry is 38.269 billion yuan. Wuhan is in the advanced stage of urbanization (the urbanization rate in 2017 was 80%), and the central urban areas have essentially achieved a 100% urbanization rate. With the strengthening of the interaction between urban and rural elements in Wuhan, urbanization is an important factor in rural development in the new urban districts. Therefore, the six new urban districts were selected as a typical case study (Figure 1).

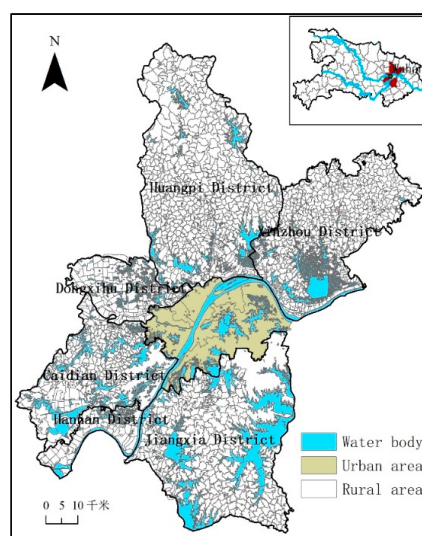


Figure 1. Location of the research area.

2.2. Data Source

The data used in this study mainly included data on the administrative village in Wuhan, data on basic geographic information in Wuhan and data on socioeconomic development. Data details are as follows:

2.2.1. Data on the Administrative Village in Wuhan

The data of the administrative village came from the Wuhan Geomatics Institute. The data mainly included settlement, land, industry and human settlements environment (Figure 2). The total number of the administrative villages identified in Wuhan City's new urban districts was 2206 in 2017, and are stored in the formats of texts and tables. Through a scientific analysis, the data together with the vector data of the Wuhan map were stored in the format of ArcGIS vector data, as were the data on Wuhan's social and economic development.

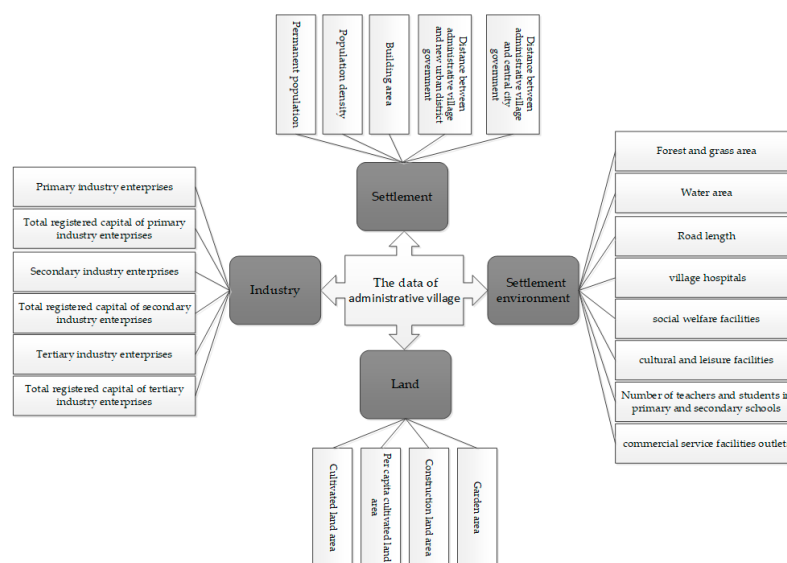


Figure 2. Data of the administrative village used in this study.

2.2.2. Data on Basic Geographic Conditions in Wuhan

Under the unified arrangement of Chinese government, Wuhan carried out a geographical conditions census in 2017. This dataset was derived from Census of Geographical Conditions Data. There are technical and procedural regulations concerning every step of data collection, including filed survey, data checking, data entry into the database and statistical analysis. Data of basic geographic information of Wuhan map are kept in the format of ArcGIS vector data. The obtained data of the basic geographic information of the Wuhan map were geospatially matched with the data of the administrative village. Table 1 presents the Geographical Conditions Data used in this study.

2.2.3. Data on Social and Economic Development

This dataset was derived from the Wuhan Statistical Yearbook 2018, Wuhan Census of the Geographical Conditions Report 2018. Population distribution data are from the survey of “Actual Housing and Actual Population” in Wuhan in 2018.

2.3. Research Methods

This study discusses the significance of studying rural development and explains the target of our research, then constructs an index system for evaluating the level of rural development, attempts to

analyze the spatial pattern of the rural development level, and identifies the types of rural development (Figure 3).

Table 1. List of Wuhan geographical conditions census data used in this study.

Category	Feature	Attributes Used
Land coverage	Land coverage data	Type
Road networks	Centerline of highway Centerline of city road Centerline of country road and rural road	Type, length, width, road grade
Geographic units	District (county) boundaries Industrial enterprises Residential areas	Location, area
Thematic data	Survey of population	Population
The POI data	Service facilities	Science and education culture Health care industry Sports and leisure industry General market

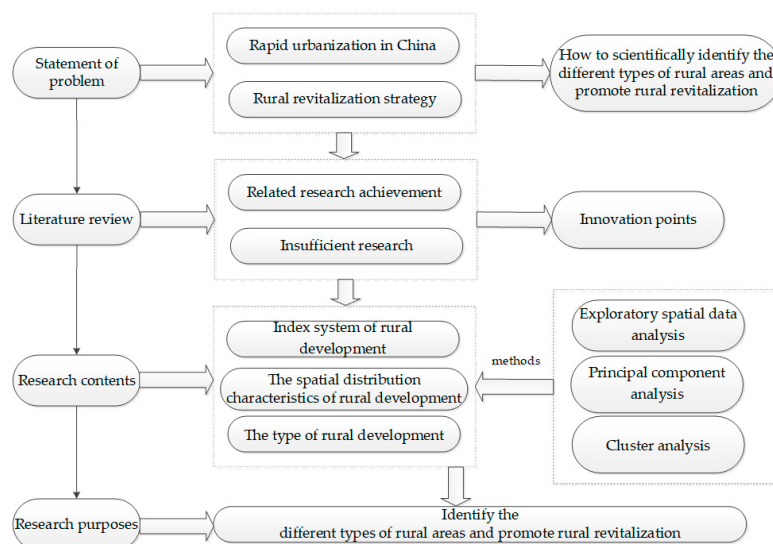


Figure 3. Technology roadmap.

2.3.1. Construction of the Evaluation Index System

A rural area is a system composed of many elements, the so-call development elements are start-up forces that drive rural development but cannot be replicated and substituted easily [53,54]. For the areas with different development modes and levels, the natural resource endowment, location conditions, economic basis, human resources and other elements have different positions in rural development, among which the three elements of “population-land-industry” are the core [55,56]. Human behavior is often regarded as one of the direct drivers that influences and changes the rural system. Land is an important element and a space carrier for rural development [57]. Industry plays an essential role as the internal impetus for rural system development [58,59]. Human settlements are the foundation and guarantee of rural construction, reflecting the most basic and real life of human beings [60]. From the perspective of rural settlement, land, industry and human settlements, this paper constructs an index system of rural development level.

(1) Indicators of rural settlement

Rural settlement is an important index to measure rural development. Among the indexes, the permanent population and population density reflect the population quantity. The more rural the population, the more abundant the rural labor force [61]. The building area plays a crucial role in rural landscapes, reflecting the scale and living standard of rural development [62]; the higher the value, the better the level of rural development. These are all positive indicators. The distance between the administrative village and the government reflects the location conditions of rural transportation; the smaller the value, the higher the degree of urbanization in the future, which is more conducive to rural development. Both are negative indicators.

(2) Indicators of rural land

Land has the three attributes—resources, property, and capital—as in the main carrier and material basis of rural production and living. Different types of land use bring different effects to rural development. In the area of urban–rural integration, the larger the proportion of cultivated land area is, the slower the urbanization process is and the lower the level of rural development; these are negative indicators. The per capita cultivated land area reflects the rural mechanization level and resource endowment condition from the side; the proportion of construction land area reflects the development capacity of villages and towns; the proportion of garden area reflects the yield capacity of cash crops in rural areas. The higher the value, the higher the level of rural development. These are all positive indicators.

(3) Indicators of rural industry

Industry reflect the rural economic sustainable and modern development level, which is the core of rural revitalization. The total number of companies in the primary, secondary, and tertiary industries and the total registered capital were selected as indicators, and they are all positive indicators. The larger the value, the weaker the dominant position of the agricultural industry and the stronger the dominant position of the non-agricultural industry.

(4) Indicators of rural human settlement environment

The rural human settlement environment focuses on reflecting the rural ecological and human environment. Among them, the proportion of forest and grass area and water area reflects the richness of the forest, water and biological resources in rural areas. This is a sustainable indicator to measure the self-regulation and restoration function of rural ecosystems. The higher the value, the better the ecological environment quality. The number of village hospitals (health centers), social welfare facilities, cultural and leisure facilities, commercial service facilities outlets, the ratio of teachers to students in primary and secondary schools and the road density reflect the rural public service capacity. The larger the value the better the rural public service supporting facilities, which is conducive to rural development. All of the above are positive indicators.

Based on the above analysis, the evaluation index system of the rural development level of Wuhan was developed according to the principle of the entropy weight method, as shown in Table 2.

Table 2. Evaluation index system of rural development level.

Systems	Indicators	Indicator Character	Weight	Remark
Rural Settlement (0.271)	Permanent population (person)	+	0.320	Permanent population of administrative villages
	Population density (person/m ²)	+	0.132	Permanent population/administrative village area
	Building area (m ²)	+	0.281	Building area of each administrative village
	Distance between administrative village and new urban district government (km)	—	0.147	Road network analysis (including National Road, provincial road, county road and Township Road)
	Distance between administrative village and central city government (km)	—	0.12	Road network analysis (including National Road, provincial road, county road and Township Road)
Rural land (0.220)	Proportion of cultivated land area (%)	—	0.264	Cultivated land area/administrative village area
	Per capita cultivated land area (m ² /person)	+	0.236	Total cultivated land area/permanent population
	Proportion of construction land area (%)	+	0.245	Construction land area/administrative village area
	Proportion of garden area (%)	+	0.255	Garden area/administrative village area
Rural industry (0.253)	Total number of primary industry enterprises	+	0.165	/
	Total registered capital of primary industry enterprises (100 million yuan)	+	0.136	/
	Total number of secondary industry enterprises	+	0.134	/
	Total registered capital of secondary industry enterprises (100 million yuan)	+	0.179	/
	Total number of tertiary industry enterprises	+	0.154	/
	Total registered capital of tertiary industry enterprises (100 million yuan)	+	0.232	/
Rural human settlement environment (0.256)	Proportion of forest and grass area (%)	+	0.107	Forest and grass area/administrative village area
	Proportion of water area (%)	+	0.103	Water area/administrative village area
	Road density (m/km ²)	+	0.117	Total mileage of administrative village road/area of administrative village
	Number of hospitals (health centers)	+	0.109	/
	Number of social welfare facilities	+	0.188	Nursing home and welfare home
	Number of cultural and leisure facilities	+	0.190	library, cultural center
	Ratio of teachers to students in primary and secondary schools (%)	+	0.091	Number of primary and secondary school teachers/number of primary and secondary school students
	Number of commercial service facilities outlets	+	0.095	Supermarket, convenience store and comprehensive market

2.3.2. Data Standardization and Weight Determination

The entropy weight method was used to determine the indicator's weight in the index system based on the amount of available information provided by each indicator [63,64]. The “entropy weight” theory is an objective weighting method; the weight of each indicator can be calculated according to its variation degree, which avoids the influence of human subjectivity on the results, and makes up for the limits of inter-correlations between indicators to some extent. The entropy-based indicator weights are calculated as the following steps:

(1) Data Standardization

The system for evaluating the rural development level consists of multiple indicators (including multiple measurement units), and the attribute of indicators is positive and negative. To allow for comparisons of original data with different scalar dimensions, maximum value standardization processing was applied to the data, and the data standardization processing formula is as follows:

$$\text{Positive index : } x'_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \quad (1)$$

$$\text{Negative index : } x'_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})} \quad (2)$$

In the formula, x'_{ij} is the value of the j index of the administrative village i after standardization, x_{ij} is the actual value; $\max(x_{ij})$ and $\min(x_{ij})$ are the maximum value and the minimum values, respectively, of the j index of administrative village i .

(2) Weight Determination

First, the proportion p_{ij} of index j of the administrative village i is calculated as follows:

$$p_{ij} = \frac{x'_{ij}}{\sum_{j=1}^p x'_{ij}} \quad (3)$$

Then, the entropy value of index j is calculated as follows:

$$e_j = -k \sum_{i=1}^m p_{ij} * \ln p_{ij}, \quad \text{where } k = \frac{1}{\ln m} \quad (4)$$

The index weight is calculated as follows:

$$w_j = \frac{1 - e_j}{\sum_{j=1}^p (1 - e_j)} \quad (5)$$

Finally, the comprehensive development score of each administrative village is calculated as follows:

$$RD = \sum_{j=1}^p w_j * x'_{ij} \quad (6)$$

In the formula, e_j is the entropy of index j , w_j is the weight of index j , x'_{ij} is the standardized value of index j of the administrative village i , m is the total amount of the evaluation unit, p is the total number of indicators, and RD is the rural development level; the higher the numerical value, the better the rural development.

2.3.3. Exploratory Spatial Data Analysis (ESDA)

The exploratory spatial data analysis involves using a collection of technologies that describe and display the spatial distribution, identify unconventional spatial locations, and discover implicit spatial relationships. The exploratory spatial data analysis can be divided into the global autocorrelation analysis and the local autocorrelation analysis.

(1) Global Autocorrelation Analysis. Global autocorrelation is used to measure the spatial clustering situation of objects. This measure is evaluated by the global index *Moran's I* and the calculation formula for this index is as follows:

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (RD_i - \overline{RD})(RD_j - \overline{RD})}{S^2 \sum_{i=1}^n \sum_{j=1}^n w_{ij}} \quad (7)$$

where $S^2 = \frac{1}{n} \sum_{i=1}^n (RD_i - \overline{RD})^2$; w_{ij} is the spatial weight matrix; n is the number of administrative villages; and RD and $\overline{RD}$ are, respectively, the comprehensive score and the average comprehensive score of the administrative villages. The value range of *Moran's I* is $[-1, 1]$. If *Moran's I* > 0 and passes the significance test, the index indicates a positive correlation among the levels of rural development in the new urban districts. If *Moran's I* < 0 and passes the significance test, the index indicates a negative correlation among the levels of rural development in the new urban districts. If *Moran's I* $= 0$ and passes the significance test, the index indicates that the rural development space distribution of the new urban districts presents a random state.

(2) Local Autocorrelation Analysis. Global autocorrelation studies the overall distribution characteristics of an attribute of a spatial object in a region while neglecting heterogeneity within the region. Therefore, the local autocorrelation method is used to analyze the correlation degree of each spatial unit attribute and its adjacent spatial unit attribute, which is measured by the index *Local Moran's I* and the local *G* statistic. The calculation formula of *Local Moran's I* is as follows:

$$LocalI = \frac{(RD_i - \overline{RD})}{S^2} \sum_{j=1}^n w_{ij} (RD_j - \overline{RD}) \quad (8)$$

When *Local Moran's I* > 0 and passes the significance test, the administrative villages with a high level of rural development in the new urban districts are adjacent to each other (this type of cluster was recorded as H-H), or the administrative villages with a low level of rural development are adjacent to each other (this type of cluster was recorded as L-L); when *Local Moran's I* < 0 and passes the significance test, the administrative villages with a high level of rural development in the new urban districts are adjacent to the administrative villages with a low level of rural development (this type of cluster was recorded as H-L), or the administrative villages with a low level of rural development in the new urban districts are adjacent to the administrative villages with a high level of rural development (this type of cluster was recorded as L-H).

The Local *G* statistics can further evaluate the spatial clustering of high and low value elements, and the calculation formula for this statistic is as follows:

$$G_i^* = \frac{\sum_{j=1}^n w_{ij}(d) RD_j}{\sum_{j=1}^n RD_j} \quad (9)$$

Standardized G_i^* , $Z(G_i^*) = (G_i^* - E(G_i^*)) / (\sqrt{VAR(G_i^*)})$, $E(G_i^*)$ and $VAR(G_i^*)$ represent mathematical expectations and variation coefficients, and $w_{ij}(d)$ represents spatial weights. A significant positive $Z(G_i^*)$ value indicates that administrative villages with a high development level tend to gather in space and form hot spots while a significant negative $Z(G_i^*)$ value indicates that administrative villages with a low development level tend to gather and form cold spots.

2.3.4. Cluster Analysis

The cluster analysis, which is a quantitative method used to study the classification of multi-factor objects, is an important link in the classification of rural development types. The basic principle of this method is to quantitatively determine the relationship among the samples according to their attributes and some similarity or difference indexes by using mathematical methods and clustering the samples according to the degree of the relationship [65]. Because many samples and calculations are required, the rapid clustering (k-means clustering) method is used to classify the types of rural development. Fast clustering involves randomly selecting k initial clustering center points according to the final number of classification k, continuing to iterate until the maximum offset of the formed cluster center point is lower than the specified amount (using the SPSS default value of 0.02) to terminate the clustering, and then dividing the data into k categories. The calculation formula is as follows:

$$C_j^{(t+1)} = \frac{1}{N_j} \sum_{s_i \in D_j^t} S_i \quad (10)$$

where $j = 1, 2, 3, K$; N_j is the sample size contained in cluster j ; S_i represents the sample; t represents the number of iterations; and D_j^t represents the cluster domain.

Because the algorithm is efficient and easy to understand, k-means clustering is widely used in large-scale data clustering. This paper contains data on 2206 administrative villages. At present, we conducted field surveys in 36 of these administrative villages, but it is difficult to conduct field surveys and classify all administrative villages. In addition, according to China's strategic plan for rural revitalization (2018–2022), rural development types were divided into four categories. Moreover, each rural area can be divided according to the actual situation. We know that the final number of classification k is at least 4, so we use k-means clustering to classify rural types.

3. Results

3.1. Spatial Pattern of the Rural Development Level

Based on the evaluation formula of the rural development level, the level of rural development in the administrative villages in Wuhan City's new urban districts was calculated and is visualized in ArcGIS (Figure 4). It can be seen from Figure 4 that the spatial differentiation of rural development in the new urban districts is obvious and that the level of rural development gradually decreases from the center to the surrounding area. The maximum rural development score is 0.581 and the minimum score is 0.074; thus, the gap between the high and low values is large. The average value is 0.164; thus, the level of rural development is not high. The coefficient of variation is 1.31 and the development level of the administrative villages is quite different; thus, there is significant spatial differentiation. Generally, the level of rural development shows a decreasing spatial distribution from the center to the periphery.

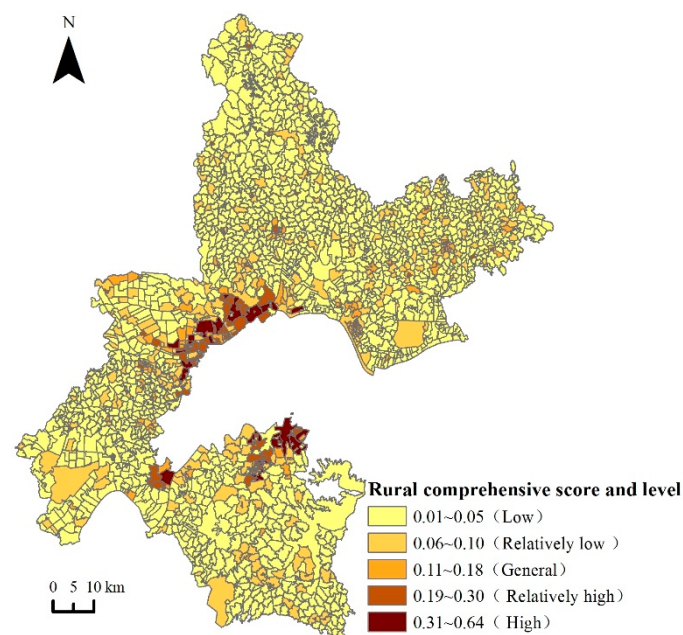


Figure 4. Spatial distribution of rural development level in administrative villages of Wuhan City's new urban districts in 2017.

The following three areas have a high or relatively high level of rural development (score ≥ 0.19): the first area includes the south of Huangpi District, the east of Dongxihu District and some administrative villages in Caidian District; the second area includes the east of Hanan district; and the third area is the north administrative village in Jiangxia District. For example, the survey found that in 2017, the total population in Liudian village in Huangpi District and the Gexin community in Dongxihu District were 13,772 and 7822, respectively. Liudian village and the Gexin community are 14.19 km and 20.25 km, respectively, away from the central urban area. Most residents in the village live in the residential area, and most of the land had been transferred. The construction land area in Liudian village and the Gexin community accounted for 37% and 58%, respectively, of the total land area, and the number of enterprises in Liudian village and the Gexin community reached 2068 and 759, respectively. These administrative villages are adjacent to the central urban area and have significant geographical advantages, good natural conditions and a social and economic foundation. Rapid urbanization and industrialization promote rural nonagricultural land development. Under the economic drive and radiation of the central urban area, capital and technology flow into the countryside, township enterprises develop rapidly, rural labor employment and industrial structure are adjusted, the number of employees and output value of secondary and tertiary industries gradually increase, and nonagricultural industrialization accelerates. The nonagricultural development of land and industry accelerates the urbanization of the population and the extension of urban public service facilities to the countryside changes the rural style, improves the rural living environment, and promotes the overall development of rural communities.

Areas with a general rural development level (score > 0.11 but ≤ 0.18) are mainly distributed in dots along the periphery of high and relatively high rural development areas and some areas are distributed in Chengguan town and the surrounding areas of Huangpi District and Xinzhou District. For example, the survey found that the total population of Daqiao group in Dongxihu District in 2017 was 2292; this area is 46.79 km away from the central urban area, and in 2017, the proportion of construction land was 7%, and the number of enterprises was 62. These administrative villages have no obvious location or transportation advantages and have a short development time, a general economic foundation development, and no close relationship between the villages. Rural development is in its early stage of agricultural industrialization. In addition, some administrative villages strengthened the rural management and construction of central villages, improved the rural public service infrastructure,

and reduced the hollowing out of rural areas and excessive population concentration in the main city. Currently, the local government is conducting demolitions and mergers to ensure the combination of rural construction with new urbanization and agricultural modernization, improve infrastructure construction, and address the urgent practical interests of farmers.

Administrative villages with a relatively low or low level of rural development are widely distributed (score ≤ 0.11), and their internal differences are also small. The traditional farming area in these administrative villages is large; the infrastructure is imperfect; the popularization rate of public services, such as education and medical treatment, is low; the living conditions and cultural life are poor; the level of industrial development is low; the number of migrant workers is large; and the level of economic development is backward. For example, in 2017, the total population of Yaotou village in Hannan District was only 774, 60% of which were migrant workers. Many elderly people have been left-behind in the village. The lack of rural construction as a main force leads to the lack of support for rural development and increases the aging of the rural population.

3.2. Spatial Connection of the Rural Development Level

3.2.1. Global Spatial Characteristics

To further explain the spatial connection of the degree of rural development in Wuhan City's new urban districts, the global *LocalMoran**I* is calculated based on the comprehensive rural development score of each administrative village in the new urban districts in 2017. The results show that *LocalMoran**I* = 0.644, (i.e., the index is greater than 0) and passes the significance test ($p < 0.05$, $z > 1.96$). Therefore, rural development in the new urban districts has significant spatial agglomeration characteristics, i.e., the agglomeration of high- and low-value areas is significant.

3.2.2. Local Spatial and Hot Spot Characteristics

The global *Moran**I* can identify whether there is spatial agglomeration in the development of administrative villages in the new urban districts, but there is potential instability in ignoring the spatial process. To further analyze the local spatial characteristics of the administrative villages in the new urban districts, an LISA map of the rural development of the administrative villages was drawn (Figure 5a). As shown in Figure 5a, 277 administrative villages are of the H-H type, thus accounting for 12.56% of the total number of all administrative villages; the distribution range of these 277 administrative villages is basically consistent with that of the administrative villages with a high and relatively high level of rural development (Figure 4). In total, 366 administrative villages are of the L-L type, thus accounting for 16.59% of the total number of all administrative villages; these 366 administrative villages are mainly located in the middle of Huangpi District, the north of Xinzhou District and the south of Jiangxia District and are consistent with the distribution range of administrative villages with a low level of rural development. The L-H type has 13 (and thus, the lowest number of) administrative villages; the villages of this type account for 0.59% of the total number of administrative villages and are mainly distributed around H-H administrative villages. Twenty-four administrative villages are of the H-L type, thus accounting for 1.09% of all administrative villages; the villages of this type are scattered in other areas, except for Dongxihu District. The spatial correlation of most administrative villages is not significant, thus showing a trend of random distribution.

This paper used Getis-Ord *Gi** in ArcGIS to identify the location of statistically significant high-value (hot spots) and low-value (cold spots) spatial clustering in the administrative villages of Wuhan City's new urban districts and used a 95% confidence level as the criterion. According to the natural breakpoint method, the administrative villages were divided based on the degree of rural development into hot spots, sub-hot spots, moderate areas, sub-cold spots and cold spots (Figure 5b). Generally, the structure of rural development in the new urban districts resembles a circle of "central heat, surrounding cold". The administrative villages in Dongxihu District, the east of Caidian District, and the north of Jiangxia District near the central urban area are hot spots. The development level of

these administrative villages is close to or higher than that of the surrounding administrative villages. The sub-hot spots are formed around the hot spots and the east of Hannan District. Three sub-hot spots are formed around Chengguan Town in Huangpi District, Chengguan Town in Xinzhou District, and the south. The moderate area is mainly around the sub-hot spots and forms a separate area in the south-central region of Jiangxia District; the sub-cold and cold spots are widely distributed in each area.

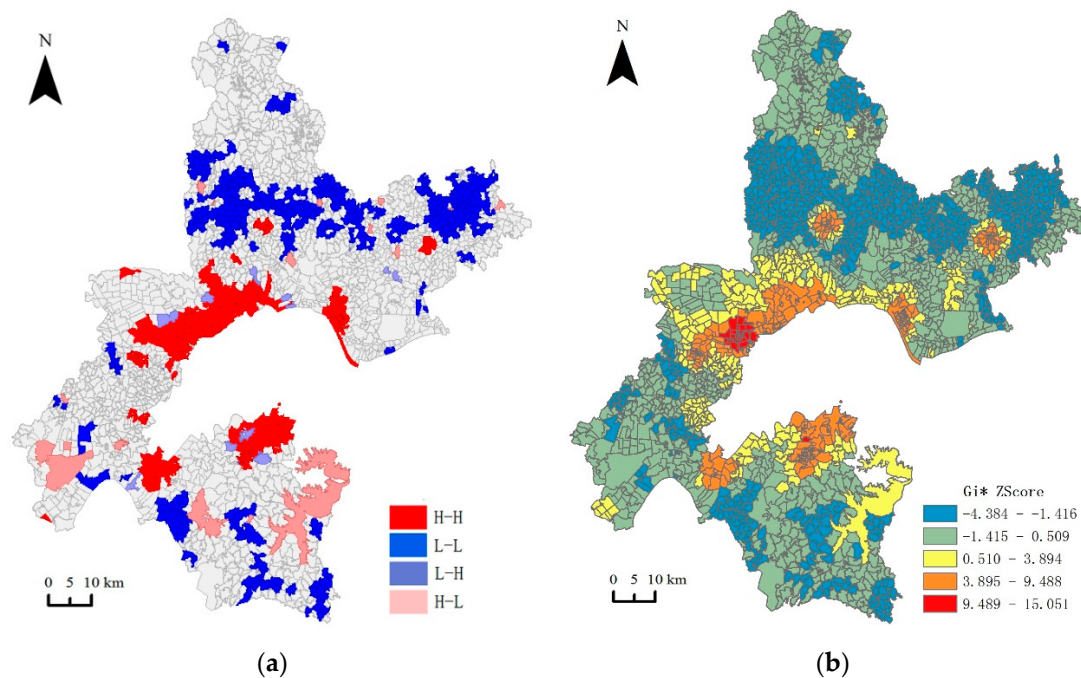


Figure 5. Local Indicators of Spatial Association (LISA) (a) and cold hot spots (b) of rural development level in administrative villages of Wuhan City's new urban districts.

3.3. Type and Path of Rural Development

The type of rural development indicates the level of rural development [66]. In rural areas with industry as the carrier, there are various interactions between material and nonmaterial elements in production and living behaviors, and thus, different types of rural development have been formed [67]. Because villages are always dynamically evolving, the contribution of various factors affecting rural development differs. Additionally, rural development is a multilevel and multifactor system. The basis for classifying the types of rural development can be summarized as the integration of the economic development level, industrial structure, regional space and other factors. This basis is an objective description of the differences in regional spaces in the current characteristics of rural development features. Therefore, it is impossible to comprehensively evaluate the type of rural development by considering only industry. Using the abovementioned rural development index system, this study first assessed the settlement, population, industry, land, resources and environment-carrying capacity, human settlements and other elements of the rural regional system. Additionally, this study used a principal component analysis to extract the main factors of the indicator system of the rural development level while considering the value, function and polarization of the power elements of the rural areas in the relationship between urban and rural development; information from relevant articles [68–71]; and the actual situation of rural development in Wuhan City's new urban districts. Then, according to the scores of the main factors in each rural settlement, a rapid cluster analysis was used to classify the villages in Wuhan City's new urban districts. Finally, the cluster results were analyzed by using the GIS analysis tool to explore the spatial distribution of each rural development type and present the revitalization path.

3.3.1. Principal Factor

Based on an analysis of 23 variables selected by the administrative villages in the new urban districts of Wuhan in 2017, the KMO statistics were 0.804 and the Bartlett's test of sphericity results are significant; thus, the level of rural development is suitable for a principal component analysis. Seven principle factors with a characteristic value greater than 1 and a cumulative variance contribution rate greater than 80.69% were selected, and then, a k-means clustering analysis involving seven principal factors was carried out using SPSS software.

The following seven principle factors (Table 3) were extracted by using principal component analysis: the tertiary industrial factor (F1); population density and housing factor (F2); planting land and construction land factor (F3); per capita cultivated land factor (F4); forest, grass and water area factor (F5); garden area factor (F6) and infrastructure factor (F7).

3.3.2. Types of Rural Development

Based on the scores of the seven principal factors of each administrative village, rural development types with five dominant characteristics were determined (Figure 6).

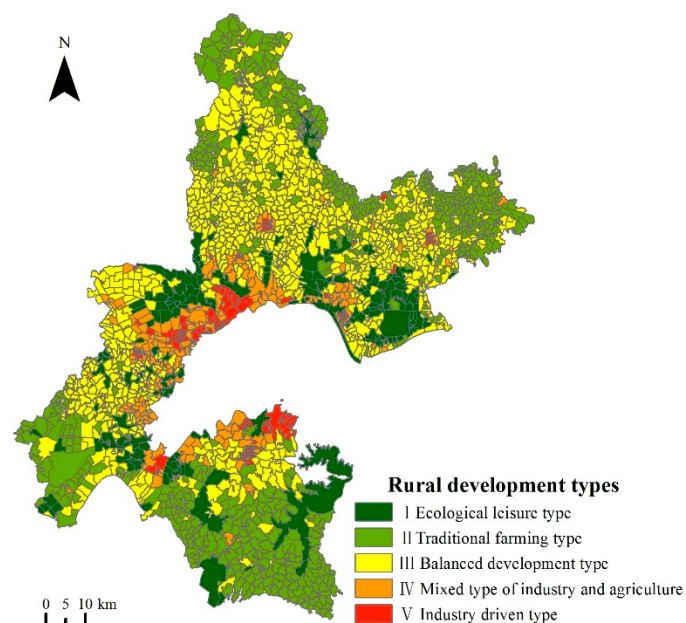


Figure 6. Spatial distribution of rural development types in administrative villages of Wuhan City's new urban districts in 2017.

I Ecological leisure type. This type consists of 173 villages accounting for 7.84% of the total number of administrative villages. This type has the highest score in forest and grass areas, the highest score in water areas, the second highest score in garden areas, and a lower score in resident populations and construction land areas. The typical features of this type include a large area of forest and grass, a water area and an outstanding natural landscape. The degree of rural economic development is relatively low; rural economic development is mainly distributed in the central part of Dongxihu District, the southern part of Xinzhou District and the eastern administrative villages of Jiangxia District.

Table 3. Principal factor analysis of rural development in administrative villages of Wuhan City's new urban districts in 2017.

Principal Factors	Characteristic Value	Contribution Rate	Characteristic
F1 Tertiary industry factors	6.043	30.17%	It has a significant positive correlation with the number of primary, secondary and tertiary industry enterprises, registered capital and road density, a negative correlation with the distance from the center of the district and the city center, and a negative correlation with the per capita cultivated land area and the proportion of garden land area. Rural enterprises are close to the central urban area, driven by the radiation of the central urban area, with better economic development
F2 Population density and housing factors	2.353	14.538%	There is a significant positive correlation with population density and building area, but a certain negative correlation with the proportion of forest, grass and water area
F3 Planting land and construction land factor	1.971	10.882%	There is a positive correlation with the proportion of planting land area, construction land area, population density, road density, etc., but a negative correlation with the proportion of forest and grass area
F4 Per capita cultivated land factor	1.601	9.404%	It has a positive correlation with the per capita cultivated land area, the proportion of cultivated land area, the distance from the center of the area, the city center, and a negative correlation with the construction land area.
F5 Forest, grass and water area factor	1.145	6.589%	It is positively related to the proportion of forest and grass area and water area, and negatively related to the proportion of permanent population and construction land area
F6 Garden area factor	1.067	4.768%	There is a positive correlation with the proportion of garden area, the proportion of forest and grass area, the distance from the city center, etc., and a negative correlation with the proportion of resident population and construction land area, etc.
F7 Infrastructure factor	1.06	4.339%	It has a positive correlation with road density, business service outlets, social welfare facilities, cultural facilities, etc., but not correlated with other indicators

II Traditional farming type. This type consists of 638 villages, accounting for 28.93% of the total number of administrative villages. The scores of the per capita cultivated land area factor and the proportion of cultivated land area factor in these administrative villages are relatively high; the second highest scores include the housing construction area factor and the distance from the central urban area, and the scores of the garden area factor and resident population factor are relatively low. Typical features of this type include rural development dominated by crop planting, an area far away from the central urban area, difficulty radiating the economy of the central urban area, a large level of rural industrialization and specialization, a serious outflow of the rural labor force, widespread abandonment of cultivated land, a hollowing of rural areas, insufficient endogenous power of rural development, farm land usage for housing construction, and traditional rural settlements with obvious characteristics. This type of rural development is mainly distributed in the north of Huangpi District, the northeast of Xinzhou District, the southwest of Caidian District and the administrative village in the south (basically in the outer suburb) of Jiangxia District.

III Balanced development type. This type consists of 929 villages accounting for 42.11% of the total number of administrative villages. The scores of various factors describing these administrative villages are relatively balanced, and there is no obvious leading factor. Rural development is in the stage of advancing from agriculture to industrialization or the early stage of industrialization. Under the joint action of various factors, the rural settlements, land, economy and human settlements are developing together, and the traditional rural characteristics are gradually weakening. The balanced type of rural development is distributed in all districts.

IV Mixed type characterized by industry and agriculture. This type consists of 310 villages, accounting for 14.05% of the total number of administrative villages. These villages have relatively high scores in the factors of construction land area, population density and housing construction (areas); the second highest scores include the factors of planting land area, number of tertiary industrial enterprises and registered capital. The typical features include industry and trade service industry, which are based on the planting industry, at a preliminary development level, and relatively perfect infrastructure. The type of rural development characterized by a mix of industry and agriculture is mainly distributed in the south of Huangpi District, the east of Dongxihu District and the north of Jiangxia District and is circular along the central urban area. In addition, this type of rural development is distributed in the towns of Chengguan in Huangpi District and Jiangxia District.

V Industry-driven type. This type consists of 156 villages, accounting for 7.07% of the total number of administrative villages. The scores of the three industrial factors of these villages are particularly high; the scores of the construction land area, population density and infrastructure factors are the second highest. However, the scores of the forest, grass, and water area factor, and the garden area factor are negative. The typical features of the industry-driven type of rural development include rural close to the central urban area, an area with good natural conditions and socioeconomic foundation, large enterprise construction land, and rapid industrial nonagricultural development, which promotes not only the rural economy but also the construction of infrastructure, and high economic aggregate income and high income among the rural residents. This type of rural development is mainly concentrated in the eastern part of the Dongxihu District, the eastern part of the Hannan District and the northern part of the Jiangxia District. Compared with rural areas that have a mix of industry and agriculture, industry-driven rural areas are closer to the central urban area and are distributed randomly.

3.3.3. Rural Development Path

Considering the five rural types existing in Wuhan City's new urban districts and the spatial distribution and natural environment features of these types, this paper proposes corresponding ways and measures of rural revitalization to promote rural development and better implement a rural revitalization strategy.

The ecological leisure type of rural development should be based on the geographical advantages of the adjacent central city; the historical conditions and industrial basis of industrial development

should be considered from a practical perspective; tourist attractions that can rely on mountain, forest, water and grass environmental resources should be vigorously developed; scientific planning should be carried out, and a reasonable layout should be created; the ecological leisure functions of leisure and sightseeing, tourism and vacation, health recuperation, catering and entertainment should be developed; and to improve supporting facilities, leisure and holiday agricultural parks with the characteristics of agricultural production, the rural landscape and rural life customs as the main carrier should be developed. By integrating the resources of rural scenic spots, connecting points and lines, connecting lines and surfaces, and organizing the overall tour route, we can promote the development of rural tourism for functional leisure, spatial clustering and cooperative organization.

Regarding the traditional farming type, the first task is to strictly protect the cultivated land and strengthen the construction of high-quality farmland. The second task aims to achieve large-scale planting, which can guide the orderly transfer of the contracted management right of agricultural land, transfer waste or agricultural land with low management efficiency to family farms, large-scale planting households or professional farmer cooperatives, and create moderate-scale operations. Under the guidance of leading agricultural enterprises and professional cooperatives, decentralized farmers should be united, and agricultural production, processing, sales and other aspects should be integrated. We should increase investment in science and technology, raise the level of agricultural modernization, and adhere to the path of industrialization and intensive agricultural development.

In the balanced development type, the rural ecological environment is relatively good. This type of rural development is based on characteristic resources and is dominated by the agricultural industry; in this type of development, the agricultural product processing industry and tourism industry develop rapidly, and the configuration of agricultural and commerce industry is relatively balanced. The focus of development should be on the characteristics of regional development, the historical basis of development and resource endowment, and the construction and guidance of main functional areas to create regional leading functions. Development should also focus on stable food production to strengthen and improve infrastructure construction; improve the rural living environment; strengthen the education of rural residents in culture, ecology, skills and other aspects; and improve the comprehensive quality of farmers. Efforts should be exerted to develop modern, characteristic and leisure agricultural production; accelerate industrial transformation and the upgrading of traditional industries, upgrade the level of agriculture and modernization, and promote the coordinated development of agriculture, the processing industry and the service industry.

The type of rural development characterized by a mix of industry and agriculture consists of areas that have relatively superior location conditions, convenient transportation and certain resource endowments; thus, undertaking the industrial diffusion and layout of the core urban areas and forming a division of labor and cooperation is convenient, the rural industry has a good foundation for development, the township industrial enterprises cluster, and conflicts exist between the development of nonagricultural industries and the development of agricultural production in the development process. These conflicts mainly manifested in nonagricultural industries occupying cultivated land and the flow of agricultural workers to nonagricultural industries; these conflicts also have a certain impact on agricultural production. We should make full use of the existing nonagricultural land, improve the land utilization rate of nonagricultural land, promote the development of agricultural mechanization and scale, actively explore the effective integration and connection of agricultural and nonagricultural production, and consider both agricultural production and nonagricultural development; Additionally, we should strengthen the construction of rural infrastructure and public services, accelerate the transfer of rural surplus labor, transform the traditional rural agricultural development model, optimize the agricultural industrial structure, extend the industrial chain, and improve the added value of agricultural products in science and technology.

The industry-driven type of rural development has a strong rural economic and social foundation and is affected by the “trickle-down effect” of urban economic development. Additionally, in this type of rural development, high-end factors gather, the nonagricultural production function is relatively

prominent, and the land-use mode, industrial structure, farmer' lifestyle, etc., gradually change to the urban type during urban expansion. In the future, we should optimize the allocation of nonagricultural construction land, pay attention to the construction of the ecological spatial pattern, actively undertake the industrial transfer of urban core areas, strengthen the nonagricultural technical training of rural residents, and ensure the orderly and healthy expansion of the city. Additionally, we should guide the intensive and efficient development of township enterprises, strengthen the economic, social and cultural cooperation between the city and the countryside, fully allow regional advantages, strengthen the construction of central villages and professional villages, strengthen the investment in and construction of infrastructure and public service facilities in rural areas, promote rural industrialization and nonagricultural elements, and promote the benign interaction among urban and rural areas, industry and agriculture.

4. Discussion

4.1. *Impact of Metropolitan Areas and Non-metropolitan Areas on the Surrounding Rural Development Is Quite Different*

The Wuhan metropolitan area, which is in an advanced stage of urban development, is characterized by many factors, such as capital, enterprises, and immigrants. This area has a strong urbanization drive and a strong land demand. The radiation of the economy and the demand for land have promoted the upgrading of the surrounding rural industry and change in the nature of land use. The small and medium-sized cities that surround nonmetropolitan areas have a relatively slower urbanization rate, a weaker economic radiation capacity, and less demand for land. Rapid urbanization in metropolitan areas often has multiple impacts on rural development; consequently, the types of rural settlements in metropolitan areas appear diverse.

The distribution of the different rural development types in the metropolitan area presents a more obvious circle structure, which is explained by the "rural settlement location theory". The large rural hinterland of the metropolitan area differs from the core urban area; consequently, the urban settlements received by rural settlements have different levels of radiation, such as industry, population, and management. The types of rural settlements from the periphery to the core of the main urban area are constantly changing; these settlements evolved from traditional farming-type rural settlements to modern professional-type rural settlements. In general, the level of urbanization from peripheral to urban settlements has continued to increase.

4.2. *Spatial Characteristics of Rural Development Promote Top-Level System Design of Wuhan Government*

This paper constructed an evaluation system of rural development level in Wuhan City's new urban districts, and revealed the geospatial distribution of rural development level explicitly. On a macro level, the value of the research lies in that it provides information of the present situation of rural development, and a top-level system design for scientific treatment, such as rural planning and policy formulation, for the reference of the Wuhan government. The Wuhan government should make a differentiated development path according to the spatial characteristics of rural development. The evaluation of rural development in other areas, especially in metropolitan areas, can refer to the evaluation indexes of Wuhan and formulate a rural development evaluation system suitable for this area.

4.3. *Identification of the Rural Area Types Is the Basis of Orderly Classification to Promote China's Rural Revitalization Strategy*

Based on the theory of rural regional system development, this paper studied the rural development and types in Wuhan City's new urban districts through the identification system and technical methods of rural revitalization. The rural regional system is a rural space system with a certain structure, function and interregional connection; this system is formed by the interaction between humans, the economy,

resources, and the environment. Driven by the rapid urbanization and industrialization of metropolitan areas, the evolution of rural settlements to higher levels is an inevitable trend. Rural revitalization is not the revitalization of all existing villages but rather targeted support and development. To solve the problem of the imbalance between urban and rural development and inadequate rural development, researchers and policy makers must scientifically identify the types of villages, classify and implement policies based on the dominant types and limiting factors of the different types of villages, and use limited financial and material resources to address real needs.

4.4. Limitations of the Study

This research was a relatively basic study; however, the results provide some guidance and suggestions for rural development. In future study, we need ① to further explore the spatial and temporal process of the level of rural development in Wuhan City's new urban districts, compare the spatial pattern differentiation and evolution law of the rural development level during different periods, analyze the internal mechanism of differentiation formation, and adjust the direction of rural development in a timely manner. ② Under the influence and drive of rapid urbanization and industrialization development in metropolitan areas, the cultural, ecological and traditional settlement patterns of rural settlements will inevitably come into conflict with economic development. Therefore, it is necessary to formulate differentiated development strategies for different types of rural settlements, and on the basis of classifying the rural development types, we can propose more operational rural development policies for specific administrative village cases to guide rural planning and construction.

5. Conclusions

This paper used Wuhan City's new urban districts as the research area, constructed an index system for evaluating the level of rural development, used the exploratory spatial data analysis and k-means clustering, comprehensively analyzed the regional differences and spatial correlation of rural development levels in the new urban districts, categorized the rural development types, and proposed development directions for different rural types.

(1) There are obvious spatial differences in the levels of rural development in Wuhan City's new urban districts. The areas with a high level of rural development are distributed in the south of Huangpi District, the east of Dongxihu District and some administrative villages in Caidian District, the east of Hannan District, and the north of Jiangxia District. The administrative villages with a general and the lower level of development are widely distributed. The farther an area is from the central city, the lower the level of rural development, which is also closely related to location conditions, urban radiation, industrial structure, etc.

(2) There is a significant spatial agglomeration in the rural development of the new urban districts of Wuhan. Thus, administrative villages with a high level of rural development and administrative villages with a low level of rural development tend to be adjacent. In part, the structure of rural development in the new urban districts resembles a circle which is "hot in the middle and surrounded by cold". The hot spot areas are mainly distributed in the administrative villages in Dongxihu District, the east of Caidian District and the north of Jiangxia District, which are at the junction of the central urban areas and the new urban districts; the cold spots areas are mainly located in the middle of Huangpi District, the north of Xinzhou District and the south of Jiangxia District; the sub-hot spots areas are mainly distributed in the administrative villages around the hot spots, and the mild and sub-cold spots are successively distributed around the sub-hot spots. In addition, two sub-hot spots are formed in Chengguan town in Huangpi District and Xinzhou District.

(3) Based on the rural development level index and by using a cluster analysis, the rural development of the new urban districts in Wuhan was categorized into the following five types: the ecological leisure type, traditional farming type, balanced development type, mixed type, which is characterized by both industry and agriculture, and industry-driven type. The development direction and focus of different types of rural areas could also differ in the future.

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