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Spatial Characteristics and Factors Influencing the Rural Development Level of Chinese Counties on the Basis of Point Data

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Abstract: Measuring the rural development level of counties is helpful for identifying regional differences and proposing targeted strategies. In this study, 44,743-point data were selected from 17 types of rural lists in China, and a four-dimensional indicator system was constructed following the "point-to-area" principle, to analyse the spatial differentiation and factors influencing rural development levels. The results reveal that the characteristic points of rural development present a "polarized" pattern along the Hu Huanyong Line, with four agglomeration cores in Southeast China. The third quadrant, delineated by the Hu Huanyong Line and the Botai Line, has the lowest rural development level. Meanwhile, the eastern coastal area and the northern coastal area lead in average rural development level among eight socioeconomic zones. Beijing, Tianjin, and Shanghai have either the highest or second highest levels in overall and dimensional development, whereas Tibet has the lowest level. Moreover, the cultural level in most counties remains at a relatively low level or below. The key factors influencing this pattern include the natural environment and economic production, especially river density, cultural resources, and general public budget expenditure per capita. This study deepens the understanding of rural development, aiming to inform global sustainable rural development assessment.

Keywords: rural development level; point-to-area; point data; spatial characteristics; Chinese county

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1. Introduction

Rural areas play a significant role in balancing global and regional development. The European Commission has proposed that "the notion of rural space or the rural world goes beyond a simple geographic limit; it refers to an entire economic and social fabric composed of a set of very diverse activities [1]". As multifunctional and complex territorial entities, rural areas, together with towns, constitute the primary space for human activities and the foundation of national economic and social development. However, as countries worldwide promote urbanization and economic development, rural interests are often sacrificed, resulting in continuous challenges to socioeconomic survival, food and energy security, and the ecological and cultural value protection capabilities of rural areas [2]. In the rapid urbanization process in China, severe issues such as insufficient rural development, a widening urban–rural gap, and "rural diseases"(aging population, abandoned land, infrastructure shortage, unbalanced economic structure, etc.) have emerged [3,4]. The contradiction between the increasing aspirations of people for a better life and unbalanced and

inadequate development is pronounced in rural areas. Therefore, advancing high-quality rural development and narrowing the urban–rural gap have become imperative challenges.

Since the beginning of the 21st century, to address this challenge, governments and international organizations worldwide have successively proposed principles, action plans, and policy guidelines for rural development strategies that support rural construction, new urbanization, urban–rural integration, and targeted poverty alleviation. In 2005, the European Union reformed the Common Agricultural Policy (CAP) and established the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD) as pillars of the CAP to provide funds for economic development and environmental improvement in rural areas [5] to "contribute to the promotion of sustainable rural development throughout the EU community". In 2006, the Common Monitoring and Evaluation Framework (CMEF) was established to evaluate the implementation and performance of rural policy programs and address major development challenges in rural areas in Europe; these included the need to improve employment rates and education levels; conserve energy and protect the environment; and alleviate poverty [6]. In 2020, the Ministry of Agriculture, Forestry, and Fisheries (MAFF) of Japan released its "2020 Basic Plan for Food, Agriculture and Rural Areas", which focused on the concept of "comprehensive regional policies"; its objectives include creating job opportunities, improving livelihoods, revitalizing rural areas, promoting the combination of the agricultural industry with other sectors, and advancing public–private partnerships to achieve regional rural revitalization [7]. In 2021, the United Nations issued the "World Social Report 2021: Reconsidering Rural Development", which focused on rural development and bridging the urban–rural gap. It emphasized accelerating rural economic transformation, reducing poverty and inequality, and building social capital and rural development worldwide. The report aimed to reformulate rural strategic principles, cross-sectoral projects, and department policies to ensure sustainable rural development with high adaptability in achieving the Sustainable Development Goals (SDGs) [8]. Following the 19th National Congress of the Communist Party of China (2017), "the Opinions on Implementing the Rural Revitalization Strategy (2018)" and "the Rural Revitalization Strategy Plan (2018–2022)" were successively issued. Significant progress has since been made in rural development: from 2000 to 2021, the annual per capita disposable income of rural residents increased from CNY 2253.42 to CNY 18,931.00, with an average annual growth rate of 10.67%; rural areas have gradually transformed from a single agricultural system to an integrated urban–rural system and are moving towards prosperity [9]. However, in 2021, the income disparity between urban and rural residents remained high; it was 2.50 times higher in urban areas than in rural ones thus elucidating the urgent need for agricultural and rural modernization.

The study of the rural development level has typically been a hot topic in rural research. Early studies mainly used the rurality index to explore the dynamic changes in rural development; Cloke et al. monitored and evaluated the rurality index at different scales [10,11]. Harrington et al. enriched and improved the rurality index [12]. Long Hualou et al. analysed the strengths and weaknesses of different types of rural development and their rurality in China on the basis of early research experiences [13], revealed internal differences in rural areas, and identified rural regional spaces [10]. As the research has deepened, scholars have begun to build a more comprehensive indicator system to comprehensively measure the overall development level of these areas, aiming to reflect the comprehensive development level of rural areas. The rural development level and residents' well-being in specific regions have been objectively analysed from multiple dimensions—six dimensions [14]; five dimensions [15]; four dimensions [16,17]; three dimensions [1,18]; or one dimension [19,20]. In China, assessments of rural development levels are based mostly on a five-dimensional indicator system [21,22] constructed according to the "20-character guideline" for rural

revitalization. By measuring the rural development level, numerous studies have evaluated the effectiveness of rural development policies [6,23,24]; analysed the urbanization level in rural areas [25], the coupling and coordination with urbanization [26,27], and its impact on rural development [28]; explored the regional classification of rural development types [29] and the development paths of each type [30]; and measured rural development potential [31]. Currently, the focus of evaluating rural development levels lies in analysing regional differences and dynamic evolutionary processes and proposing classified policy recommendations [29,32].

The data used in the research are primarily based on statistical panel data [16] and survey data [28,33]. And the research employs calculation methods such as the entropy weight method [21], Delphi method [34], structural equation model [33], descriptive statistics and kernel density analysis [35,36], or clustering methods, which are used to divide the national rural regional region [12], and based on these divisions, development suggestions are proposed for each zone. Moreover, the research scales are becoming more diverse. At the regional and provincial [32,36] scales, studies have focused on extracting the regional and spatiotemporal differences in rural development in comprehensive indices and dimensional indices through panel data and proposed policy suggestions [31,37]. In studies at the municipal [37], county [38], township [39], and village [31,40] scales, indicator systems that use statistical data have been constructed to analyse the zoning of rural development levels, and corresponding strategies have been proposed. The county is the basic unit and key subject of rural development, and measurements at the county scale can effectively reveal the spatial differentiation patterns of rural development. However, the existing studies have focused primarily on the use of statistical panel data and spatial data, supplemented by point data [16,28]. Although these data are capable of characterizing the overall level and general characteristics of rural development across counties, they lack the systematic integration of point data for evaluation. Consequently, owing to this deficiency in specificity and representativeness, the findings may not be directly applicable to specific villages and towns.

The "point-to-area" principle means that the iconic "points" within an area can represent the typical characteristics of the "area". In ecology, indicator species are often used to characterize the health level of an ecosystem. These species can represent the characteristics of a certain stage in a community succession series, or they can be used to assess natural environment types and features [41,42]. Geographically, enterprise data [43] or patent data [44] are used to study the spatial patterns of industries, where "points" symbolize "areas" and provide a spatial visualization of regional differences in industrial development. This "point-to-area" approach can also be applied to measure the levels of rural development. China has a vast territory, with significant differences in natural environmental resources and socioeconomic foundations among the regions, leading to distinct levels and paths of rural development in different areas. Over the past 20 years, to promote rural development nationwide through demonstration effects, various central ministries and commissions have issued multiple series and batches of rural lists highlighting the representative villages in the different counties, which serve as the most characteristic points and benchmarks for the rural development level in the county. For example, the nationally recognized "One Village, One Product" demonstration villages and towns selected by the Ministry of Agriculture and Rural Affairs refer to "administrative villages and towns which have dominant industries, significant quality and efficiency, close links with agriculture, integrated development of industries and villages, and strong radiation and driving effects" ("National 'One Village, One Product' Demonstration Village and Town Recognition Monitoring and Management Measures (Trial)", 2021). These rural lists can be seen as "point" data, effectively complementing the "area" data (statistical data). By

utilizing these point data, it is possible to scientifically measure rural development levels and regional differences and to analyse the local driving factors behind them, which is highly important for the implementation of China's rural revitalization strategy.

Therefore, this paper constructs a rural development level measurement index system based on the point data from various rural village lists issued by central ministries and commissions. An in-depth analysis of the spatial differentiation characteristics and factors influencing rural development in China's counties is then conducted to provide new ideas and methods for global research on rural sustainable development.

2. Research Design

2.1. Study Area

The study area is China's county-level units. After the county-level administrative regions without village committees are excluded, there are 2727 county-level units in total. Owing to data acquisition limitations, the research scope does not include Hong Kong, Macao, and Taiwan (Figure 1). To more accurately delineate the spatial pattern and elucidate the differentiation characteristics of the rural development level, the analysis is conducted across the following four scales: large regions, socioeconomic zones, provinces and counties. Among them, large regions refer to the four quadrants demarcated by the Hu Huanyong Line and the Botai Line on China's regional development map [45]. Additionally, socioeconomic zones refer to the eight regions of Northeast China (Liaoning, Jilin, and Heilongjiang), the northern coastal area (Beijing, Tianjin, Hebei, and Shandong), the eastern coastal area (Shanghai, Jiangsu, and Zhejiang), the southern coastal area (Fujian, Guangdong, and Hainan), the middle region of the Yellow River (Shaanxi, Shanxi, Henan, and Inner Mongolia), the middle region of the Yangtze River (Hubei, Hunan, Jiangxi, and Anhui), Southwest China (Yunnan, Guizhou, Sichuan, Chongqing, and Guangxi) and Northwest China (Gansu, Qinghai, Ningxia, Tibet, and Xinjiang) [46].

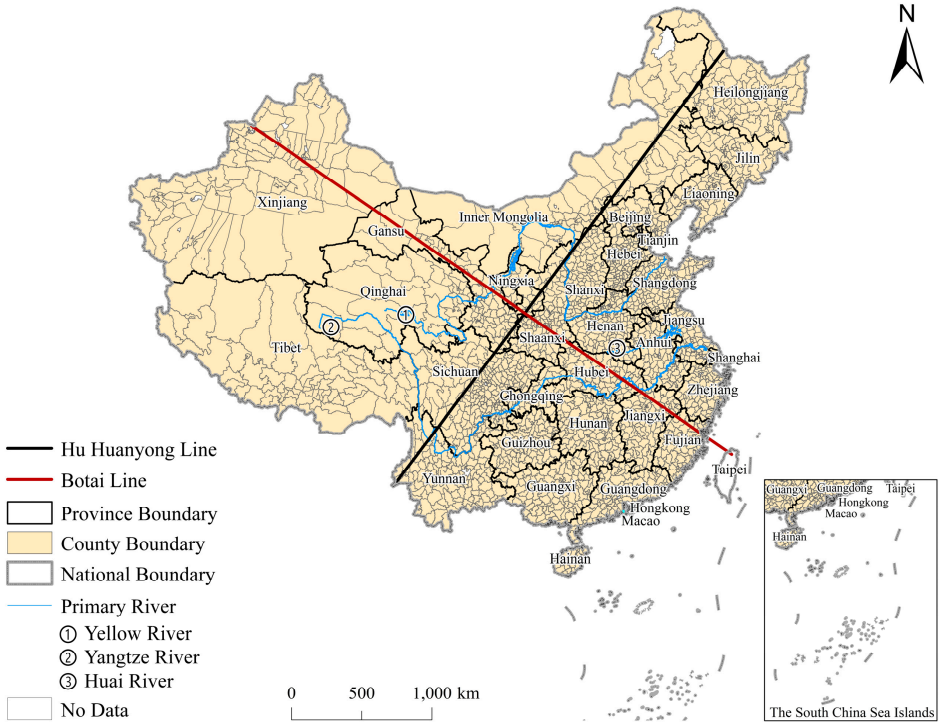


Figure 1. Study area.

2.2. Methods for Measuring the Rural Development Level

(1) Rural Development Framework

Michael Woods proposed that while the concepts of rural revitalization and rural development are interconnected, they nonetheless embody distinct perspectives and objectives. Rural revitalization places undue emphasis on the revival of social, economic, and cultural vitality within rural areas, with the overarching objective of restoring the vitality and attractiveness of rural areas and their appeal to ensure sustainable habitation, while rural development typically aims to improve the economic level and quality of life in rural areas [47]. In 2015, the United Nations adopted the Sustainable Development Goals (SDGs), which aim to address development issues in the three dimensions of society, economy, and environment and promote the global transition to sustainable development. The SDGs cover seventeen goals including poverty eradication, zero hunger, good health and well-being, quality education, gender equality, etc. [48]. The "twenty character" policy of the rural revitalization strategy proposed by China in 2017, namely " thriving business, a pleasant living environment, social etiquette and civility, effective governance, and property" [49], aims to enhance the sustainable development capacity and competitiveness of rural areas and to promote the comprehensive revitalization of rural industries, talent, culture, ecology, and organizations through systematic planning and measures [4,9].

(2) Construction of the indicator system

In 1996, the Organization for Economic Cooperation and Development (OECD) established a pan-European indicator system to assess the level of rural development via four dimensions, namely population and immigration, social welfare and equity, economic structure and performance, and environment and sustainable development [50]. Niloofar Hashemi evaluated the sustainable development of rural areas depending on the tourism industry on the basis of the four dimensions of economy, society, culture, and environment proposed in the "European Charter for Sustainable Tourism in Protected Areas [17]". John Bryden proposed an index system to evaluate the level of rural development based on the European Union's dynamic development indicators for rural areas via three dimensions, namely quality of life and social welfare, economic structure and performance, and population and immigration [51]. In the third dimension, the impact of cultural factors on rural development was considered. The Stockholm Resilience Center categorized the 17 SDGs into the following three main categories: economic goals, social goals, and environmental goals [52]. In recent years, China's rural revitalization assessments have often been limited to the indicator system constructed by the "Twenty-character Guideline for Rural Revitalization" [21,22]. By combining the domestic and foreign rural development goals and evaluation indicators and considering the relevance, reliability, and availability of data, 17 lists (index layers), which were published by the Ministry of Agriculture and Rural Affairs of China and other central ministries and commissions, were selected. These listed could be categorized into four types, "economy, environment, society, and culture" (criteria layer), according to the departmental functions and the connotations of the lists, forming a comprehensive assessment system for measuring rural development levels (Table 1).

The economic dimension, characterized by rural characteristic industries, distinctive products, the rural economy, industrial advantages, and service facilities, represents the cultivation of rural industries, economic transformation, and modernization achievements; therefore, it serves as a crucial pillar for rural development. The environmental dimension is vital for achieving sustainable development in rural areas and represents the quality of rural living environments via improvements in landscapes, villages, and lifestyles. The social dimension reflects the governance capacity of local governments in the rural development process, indicating the level of guarantee for rural governance through the villagers' self-governance, the rules of law construction, moral construction, and organiza-

tional leadership. The cultural dimension references rural cultural inheritance and social harmony through strong customs and unique culture and demonstrates the supportive role of traditional culture in population aggregation and migration. Considering the differences in importance and sample size among the various dimensions and listings, principal component analysis and the entropy weight method are utilized to determine the weights of each dimension and list.

Table 1. Indicator system for measuring the rural development level.

Dimension (Guideline Layer)	Indicator Level			Number of Villages/ Communities/ Townships	Weights
	List	Published by	Batch and Time		
Economics	National Key Village and Town for Rural Tourism	Ministry of Culture and Tourism, National Development and Reform Commission	1–4 batches, 2019–2022	1597	0.06
	National Demonstration Tourism Town (Village) with Characteristic Scenic	Ministry of Housing and Urban–Rural Development, Ministry of Culture and Tourism	1–3 batches, 2010–2015	553	0.08
	National Town and Village, with over 1 billion yuan and 100 million yuan of characteristic industries, respectively	Ministry of Agriculture and Rural Affairs	1–3 batches, 2020–2022	1159	0.07
	National "One Village One Product" Demonstration Village and Town	Ministry of Agriculture and Rural Affairs	1–12 batches, 2011–2022	4069	0.06
	National Green Well-off Village	Publicity Department, CPC Central Committee, General Office, Central Commission for Guiding Cultural and Ethical Progress et al.	2007	990	0.06
Environments	National Forest Country	National Forestry and Grassland Administration	1–2 batches, 2019–2020	7585	0.07
	Demonstration Village for Improving Rural Living Environment	Ministry of Housing and Urban–Rural Development, The Office of the Central Leading Group for Rural Work et al.	2017	295	0.01
	National Eco-Village	Ministry of Ecology and Environment	1–3 batches, 2008–2011	238	0.06
	Demonstration of Beautiful and Liveable Town and Village	Ministry of Housing and Urban–Rural Development	1–4 batches, 2013–2016	755	0.03

Table 1. *Cont.*

Dimension (Guideline Layer)	Indicator Level: List	Published by	Batch and Time	Number of Villages/ Communities/ Townships	Weights
Social	China's Beautiful Leisure Village	Ministry of Agriculture and Rural Affairs	1–13 batches, 2010–2022	1954	0.06
	National Creation Village for "Beautiful Countryside"	Ministry of Agriculture and Rural Affairs	2013	1100	0.05
	National Civilized Town and Village	Central Commission for Guiding Cultural and Ethical Progress	1–6 batches, 2005–2020	6690	0.07
	National Demonstration Village and Town in Rural Governance	The Office of the Central Leading Group for Rural Work, Ministry of Agriculture and Rural Affairs et al.	1–2 batches, 2019–2021	2197	0.04
	National Demonstration Village (Community) in Democracy and Legal system	Ministry of Justice, Ministry of Civil Affairs	1–9 batches, 2004–2022	4939	0.05
Culture	China's Historical and Cultural Town and Village	Ministry of Housing and Urban–Rural Development, National Cultural Heritage Administration	1–7 batches, 2003–2018	799	0.10
	China's Traditional Village	Ministry of Housing and Urban–Rural Development, Ministry of Agriculture and Rural Affairs et al.	1–6 batches, 2012–2022	8171	0.10
	China's Ethnic Minority Village	State Ethnic Affairs Commission	1–3 batches, 2014–2019	1652	0.04

Note: In these lists, each village (community) is assigned a value of 1 and each township is assigned a value of 5, considering the importance and representativeness.

The number of relevant village lists falling within the scope of each county was counted and their weights were calculated. On this basis, the formula for calculating the rural development level based on the 17 lists in four dimensions is as follows:

$$RR_i = \sum_{a=1}^{5} \omega_a I_{ia} + \sum_{b=1}^{4} \omega_b E_{ib} + \sum_{c=1}^{5} \omega_c S_{ic} + \sum_{d=1}^{3} \omega_d C_{id} \quad (1)$$

where RR_i represents the comprehensive rural development index of county i(the sum of the rural development indices in the four dimensions); I_{ia}, E_{ib}, S_{ic}, and C_{id} represents the scores of the a, b, c, and d lists in the four dimensions of county i, and ω_a, ω_b, ω_c, and ω_d represents the corresponding list weights.

2.3. Methods for Analysing Influencing Factors

Based on the evaluation of the rural development level via point data, further analysis of the factors influencing the rural development level is carried out via statistical data. This serves as a confirmatory analysis of the results obtained from the point data analysis.

(1) Selection of independent variables

The rural development level is influenced by a variety of factors. For example, the "economy" is affected by factors such as the labour force, transportation accessibility, and industrial development status; the "environment" is related to factors such as precipitation and vegetation coverage; and the "society" is associated with the quantity of cultural resources. On the basis of theories such as the human–land system and rural regional system [29], considering data availability and quantification, the analysis of factors influencing the rural development level is conducted from the following four aspects: the natural environment, economic production, resource endowment, and social services. A total of 22 independent variables are selected (Table 2).

Table 2. Indicator system of the factors influencing the rural development level.

Factor	Independent Variable	Unit	Interpretation of Indicators
Natural Environment	X1 Average Elevation	m	Higher altitude areas tend to have more fragile ecosystems and less advanced agriculture.
	X2 Average Slope	°	Steeper slopes tend to hinder plantation growth, whereas they may conversely favour the advancement of forestry.
	X3 Precipitation (Annual Average)	mm	Regions with higher precipitation levels tend to exhibit better ecological conditions and are more likely to have advanced development in industries and agriculture.
	X4 River Density	m/km^2	Regions with higher river densities have greater biodiversity and better natural environments.
	X5 Vegetation Index (NDVI)	—	Regions with higher Normalized Vegetation Index (NDVI) tend to have better plant growth conditions and higher vegetation coverage.
	X6 Percentage of Forest Cover	%	Areas with high forest cover are more ecologically liveable and have better-developed forestry specialties.
Economic Production	X7 Per capita GDP	Ten Thousand Yuan	Areas with high GDP per capita have better infrastructure and a more developed tertiary industry.
	X8 Primary Industry Value Added Per capita	Ten Thousand Yuan	Better development of planting and agricultural and sideline product processing industries.
	X9 Secondary Industry Value Added Per capita	Ten Thousand Yuan	To promote the entry of young rural adults into industry, construction, and other vocations.
	X10 General Public Budget Income Per capita	Ten Thousand Yuan	The higher the fiscal revenues, the more developed the society as a whole.
	X11 General Public Budget Expenditure Per capita	Ten Thousand Yuan	Regions with high fiscal expenditure invest more in people's livelihoods and infrastructure.

Table 2. *Cont.*

Factor	Independent Variable	Unit	Interpretation of Indicators
Resource Endowment	X12 Population Density	Persons/km^2	Areas with higher population densities have better infrastructure, higher productivity, and more employment opportunities.
	X13 Number of Cultural Resources	Induvial	Regions with many cultural heritage units and national intangible cultural heritages, have better development of the cultural tourism industry.
	X14 Proportion of Arable Land Area	%	Higher food production in areas with more arable land.
	X15 Proportion of Forested Land Area	%	The forest product processing industry is better developed in areas with more forested land areas.
	X16 $\geq$ 10 °C Cumulative Temperature	°C	The higher the sum of the average daily temperatures during the year, the greater the total number of crop types, and the longer the maturity of the crops.
	X17 Net First Productivity (NFP)	—	The higher the net first productivity, the greater the population carrying capacity of the biosphere.
	X18 Farmland Production Potential	—	The higher the production potential of the farmland, the stronger the output of the arable land.
Social Service	X19 Number of Transport Stops	Induvial	A wider range of services in areas with many airports, railway stations, harbours, and coach stations.
	X20 Road Network Density	m/km^2	The higher the density of the roads, the more convenient the production and life in rural areas.
	X21 Number of Schools Per 1000 Population	Institutions/thousand persons	Areas with a high number of primary, secondary, and early childhood schools per 1000 inhabitants tend to have a wider coverage of rural education.
	X22 Number of Hospitals Per 1000 Population	Institutions/thousand persons	Areas with a high number of general hospitals with 1000 inhabitants tend to have a higher level of health care.

(2) Analysis via geographically weighted regression (GWR)

As an extension of the ordinary least squares (OLS) model, the GWR model incorporates spatial dimensions into the regression parameters. It performs a series of local linear regressions and evaluates the spatial variations in the relationship between the independent variable and the dependent variable by deriving local parameters [53]. The model was implemented via the GWR tool within ArcGIS 10.2 software. By estimating the impact of different counties, this approach highlights the spatial heterogeneity of regression parameters and investigates how the relationships between 22 independent variables and the dependent variable (rural development level) vary across geographic space. The specific methodology and steps are referenced from the previous scholarly research approaches [54,55].

2.4. Data Sources

(1) Data required for measuring rural development levels

The 2020 national administrative division vector data come from the Standard Map Service Website of the National Bureau of Surveying and Mapping, China, with the review number GS (2020) 4619, and the base map has not been modified. The list of county- and village-level administrative districts in 31 provinces/autonomous regions/municipalities

(excluding Hong Kong, Macao, and Taiwan, the same below) comes from the official website of the National Bureau of Statistics, China. After excluding the county-level administrative districts without village committees, 2727 county-level units remained. The 44,743 "village/community/township" names in the 17 rural lists come from the official websites of central ministries and commissions such as the National Development and Reform Commission, the Ministry of Agriculture and Rural Affairs, the Ministry of Ecology and Environment, the Ministry of Housing and Urban–Rural Development, the Ministry of Culture and Tourism, and the National Forestry and Grassland Administration. The spatial location data of the villages in the list are crawled through Baidu Maps.

The study utilizes rural list data spanning up to 2023. Unlike continuous statistical data, the rural list data's evaluation batches and years are determined by central ministries and commissions according to practical requirements. These data can be classified into the following two distinct types: one consists of a continuous inventory, which is subject to evaluation annually or at multi-year intervals; the other comprises a phased inventory, whose evaluation has already been completed. Both types of data provide indicative representations of the rural development status under specific conditions. They serve as effective point data that reflect the relative level of rural development and play a crucial role in uncovering the spatial disparities in rural development levels.

(2) Data required for analysing the factors influencing rural development

Among the natural environment data, the 30 M elevation data come from NASA SRTM1 v3.0; the river density data come from OpenStreetMap; the precipitation data come from the National Tibetan Plateau Data Center; the normalized difference vegetation index (NDVI) comes from the Resources and Environmental Science Data Center of the Chinese Academy of Sciences; and the forest coverage rate comes from the Global Forest Watch website. Among the economic production factors, the data of the six indicators are all collected from the "China County Statistical Yearbook 2022". Among the resource endowment factors, population density comes from the seventh national population census of China; the number of cultural resources (national key cultural relic protection units and national intangible cultural heritage items) comes from the official website of the Ministry of Culture and Tourism and the China Intangible Heritage Network; the accumulated temperature $\geq$10 °C, the net primary productivity, and the farmland production potential data come from the Resources and Environmental Sciences and Data Center of the Chinese Academy of Sciences; and the cultivated land and forest area data come from GLC_FCS30D. Among the social service factor data, the data of the four indicators are all collected from Baidu Map POI data.

2.5. Research Framework

In this paper, we adhere to the methodological principle of " point-to-area " and propose to conduct two aspects of research as follows: First, the spatial differentiation analysis of rural development levels in Chinese counties (Section 3), including the spatial pattern of rural development characteristic points (Section 3.1) and the assessment of rural development levels (Section 3.2); Second, the analysis of influencing factors of rural development levels (Section 4). Through the discussion of the above content, conclusions are drawn, and further discussions are conducted based on this. The overall methodological process for studying the rural development level of Chinese counties is depicted in Figure 2.

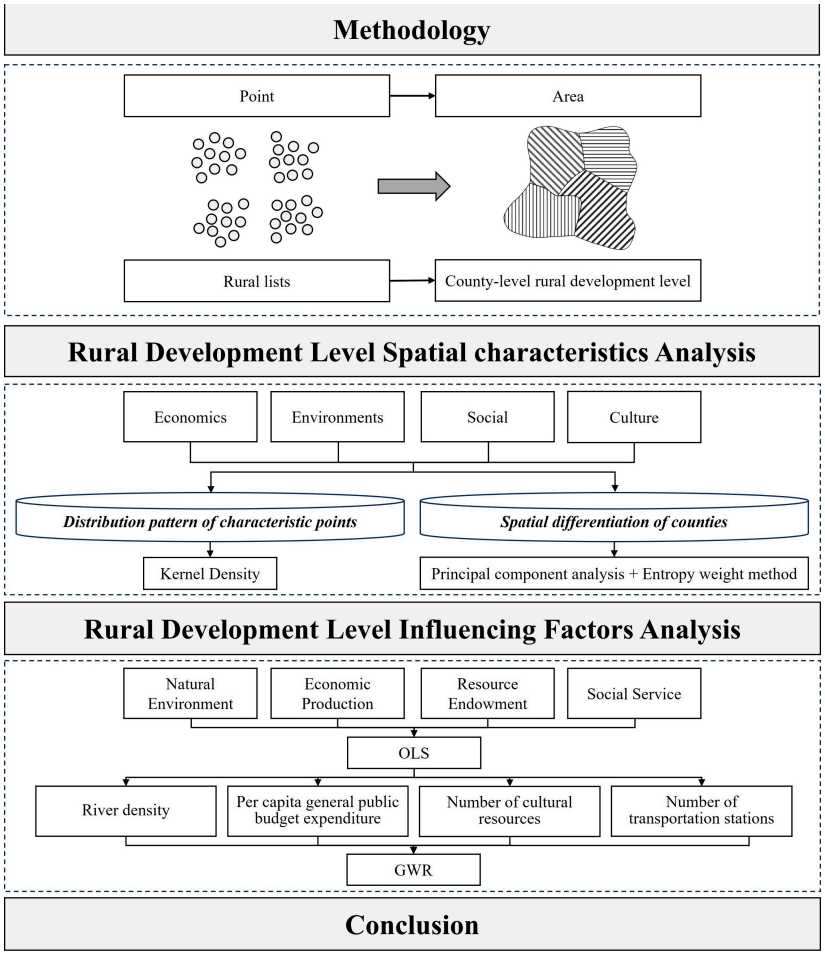


Figure 2. Research Technical Route.

3. Spatial Characteristics

3.1. Distribution Pattern of Characteristic Points

Each "village/community/township" in the rural list is regarded as a characteristic point, and the agglomeration and uneven distribution of these points characterize, to some extent, the regional disparities in the national rural development level. To explore the spatial pattern of characteristic points of rural development, a kernel density analysis was performed for both the overall and dimensional aspects, yielding the following insights:

From the overall perspective, a "polarized" pattern is presented along the Hu Huanyong Line (Figure 3a). The characteristic points of rural development are distributed mainly on the southeast side of the Hu Huanyong Line thus forming four agglomeration cores—Shanghai, Zhejiang, and southern Jiangsu and Anhui; Beijing, Tianjin and surrounding areas; the border areas of Hebei, Henan, and Shanxi; southeast Guizhou; and the border areas of Guizhou, Hunan and Guangxi. Points in the regions radiating outwards from the agglomeration cores are densely distributed. However, the kernel density value along the line of the Qinling–Huaihe River is relatively low. This region has considerable mountainous terrain, numerous village-level administrative units, and an outflow of the rural population, all of which have significantly hindered rural development. In addition to the four agglomeration cores, several secondary centres have formed around provincial capital cities, such as Jinan, Xi'an, Wuhan, Chengdu, Changsha, Chengdu, and Guangzhou, with a small radiation range and a punctate distribution pattern. On the northwest side of the Hu Huanyong Line, the characteristic points are clustered on a small scale in Xining and Yinchuan.

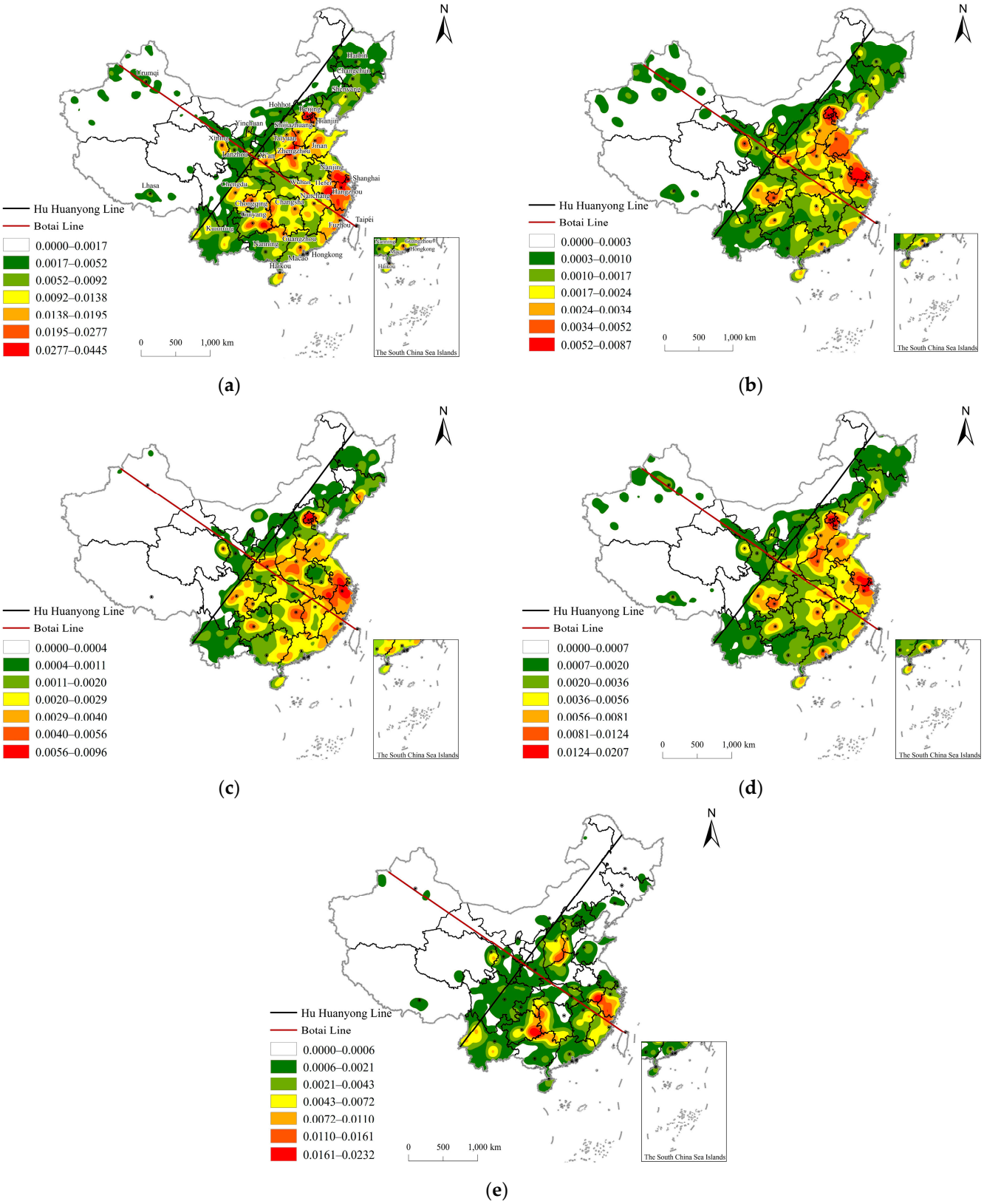


Figure 3. Spatial patterns of the characteristic points of the rural development level in China ((**a**) Spatial Pattern of Characteristic Points of Rural Development Level; (**b**) Spatial Pattern of Economic Characteristic Points; (**c**) Spatial Pattern of Environmental Characteristic Points; (**d**) Spatial Pattern of Social Characteristic Points; (**e**) Spatial Pattern of Cultural Characteristic Points).

While the spatial pattern of the characteristic points exhibits distinct variations across different dimensions, overall, there is a pronounced pattern of polarization along the Hu Huanyong Line, and most of the points present a multicentre pattern with Beijing and Shanghai as the poles. ① The economic characteristic points are concentrated in the eastern coastal area, northern coastal area, and middle region of the Yellow River in the first quadrant but are less distributed in Northeast China and the Inner Mongolia region. The number of characteristic points in the second quadrant is lower than in the first quadrant, and the concentration is relatively high in Sichuan, Chongqing, and Hubei. The number of characteristic points in the third and fourth quadrants is significantly lower than in the first and second quadrants, with a concentration of the characteristic points in the surrounding areas of Xining and Yinchuan (Figure 3b). ② The environmental characteristic points are distributed mainly on the southeast side of the Hu Huanyong Line, except for Northeast China and the Inner Mongolia region, forming two agglomeration centres in Beijing–Tianjin and the eastern coastal area, as well as several secondary centres in regions such as Xi'an, Changsha, Guiyang, etc. On the northwestern side of the Hu Huanyong Line, the distribution of thecharacteristic points is relatively sparse, except for around Xining (Figure 3c). ③ Social characteristic points are concentrated in the northern coastal area and the eastern coastal area of the first quadrant, whereas small-scale clusters are formed in northern Henan, the Chengdu–Chongqing urban agglomeration, and the Pearl River Delta. Additionally, points are sparsely distributed in the third and fourth quadrants (Figure 3d). ④ Cultural characteristic points form three agglomeration centres within the first and second quadrants, namely eastern Guizhou–western Hunan–northeast Guangxi, southern Anhui–Zhejiang–northern Fujian, and southeastern Shanxi–northern Henan, whereas the point distribution is sparse in Northeast China, the Huaihe River Basin, and the third and fourth quadrants (Figure 3e).

3.2. Spatial Differentiation of Counties

In this study, the natural break method was utilized to categorize the rural development level of Chinese counties into five levels—high, relatively high, medium, relatively low, and low. The results show that the average level of rural development in the national counties and each dimension is relatively low; there are significant spatial differences in rural development levels among the various areas in large regions, socioeconomic zones, provinces, and provinces.

(1) Overall rural development level: The proportions of counties categorized as low, relatively low, and medium levels account for 29.95%, 27.53%, and 25.06%, respectively, significantly exceeding the percentages of counties classified as relatively high (12.89%) and high (4.57%) levels. Counties with relatively high rural development levels are located primarily in the first and second quadrants. The average rural development level in the northern coastal area and the eastern coastal area is the highest, reaching a relatively high level, while rural development in the southern coastal area and the middle region of the Yangtze River reaches only a medium level. Most counties in Northwest China are at a low level; furthermore, the vast majority of counties in the third quadrant are classified as low.

At the provincial scale, the average rural development levels of Beijing, Tianjin, and Shanghai are the highest, reaching a high level, followed by those of Chongqing, Zhejiang, Ningxia, Hainan, and Jiangsu, which reach relatively high levels. In 15 provinces, average rural development is at a medium level; these provinces include Fujian, Hubei, Guizhou, Jilin, Shandong, and Anhui. Inner Mongolia, Sichuan, Yunnan, Gansu, Xinjiang, Hebei, Heilongjiang, and Tibet merely attain relatively low levels. Rural development in Beijing, Chongqing, and Zhejiang is fairly balanced, with almost all the counties having a medium or higher level. The average level of rural development in Jiangsu is comparable to that

in Zhejiang, but there is a significant gap between southern Jiangsu and northern Jiangsu, resulting in unbalanced development. Sichuan, Gansu, and Xinjiang also exhibit spatial characteristics of unbalanced development, with a distinct gap in rural development levels between the Sichuan Basin and other regions in the province, between the Hexi Corridor and southern Gansu, as well as between northern Xinjiang and southern Xinjiang. The reason for this spatial difference is the large disparity between natural environmental conditions and socioeconomic levels within the province. Spatial differences are also observed in the Beijing–Tianjin–Hebei region and the Pearl River Delta, which present a "poverty belt around Beijing and Tianjin" [56] and a "poverty zone in northern Guangdong adjacent to the Pearl River Delta" [57] (Figure 4a).

(2) Economic level: The percentages of counties with low to high levels are 51.02%, 26.95%, 13.89%, 6.23%, and 1.91%, respectively. The average economic level of counties in the first quadrant is slightly higher than that in the second quadrant, and the vast majority of counties in the third and fourth quadrants reach only the low level. The average economic level of the counties in the eastern coastal area is at a medium level, which is significantly higher than that of the other socioeconomic zones. On the provincial scale, only the economic averages of Beijing and Tianjin attain high or relatively high levels, followed by those of Shanghai, Nanjing, Chongqing, Jiangsu, and Hainan, which attain medium economic levels. The remaining provinces and regions are at a relatively low level, except for Tibet which is at a low economic level; moreover, Hubei is close to a medium level. The reason is that in the provinces of the northern coastal area and eastern coastal area, the urbanization rate is higher, the urban–rural integration is better, and the e-commerce economy and the processing industry of agricultural and sideline products are well developed. In addition, Ningxia's economic average level is significantly higher than that of other provinces in Northwest China (Figure 4b).

(3) Environmental level: The proportions of counties with low to high levels account for 50.57%, 34.45%, 11.18%, 3.46%, and 0.34%, respectively. The average environmental level of counties in the second quadrant is greater than in the first quadrant and is even greater than in the third and fourth quadrants. Among the eight socioeconomic zones, only the eastern coastal area reaches a medium average environmental level; Northwest China reaches a low level, and the remaining zones are at a relatively low level. At the provincial level, Beijing is the highest, reaching a relatively high level, followed by Tianjin, Zhejiang, Jiangsu, Shanghai, and Chongqing, which reach a medium level. In addition, Heilongjiang, Hebei, Xinjiang, and Tibet reach only a low level, and the remaining provinces are at a relatively low level (Figure 4c).

(4) Social level: The percentages of counties with low to high levels are 38.75%, 27.61%, 19.90%, 10.26%, and 3.47%, respectively. The average social level of counties in the first quadrant is significantly greater than in the other quadrants, followed by the second quadrant, and that in the third quadrant is the lowest. Among the eight socioeconomic zones, the average social level in the eastern coastal area reaches a relatively high level; the average social levels in Northeast China, the middle region of the Yangtze River, the northern coastal area, and the southern coastal area reach a medium level; and the other socioeconomic zones are all at relatively low levels. Furthermore, the social levels of counties in the Yangtze River Basin and the Southeast Coastal River Basins are much higher than those in the Yellow River Basin and the Huai River Basin. At the provincial scale, the average social level of counties in Beijing, Tianjin, and Shanghai is the highest, reaching a high level, followed by Chongqing, Zhejiang, and Hainan, which reach a relatively high level; Ningxia, Jiangsu, Jilin, Hubei, Fujian, Shandong, Guizhou, Anhui, Hunan, and Jiangxi reach a medium level. The average social levels of all the counties are relatively low in the

remaining 15 provinces, such as Guangdong, Liaoning, Henan, Qinghai, Shanxi, etc., and Tibet is the lowest (Figure 4d).

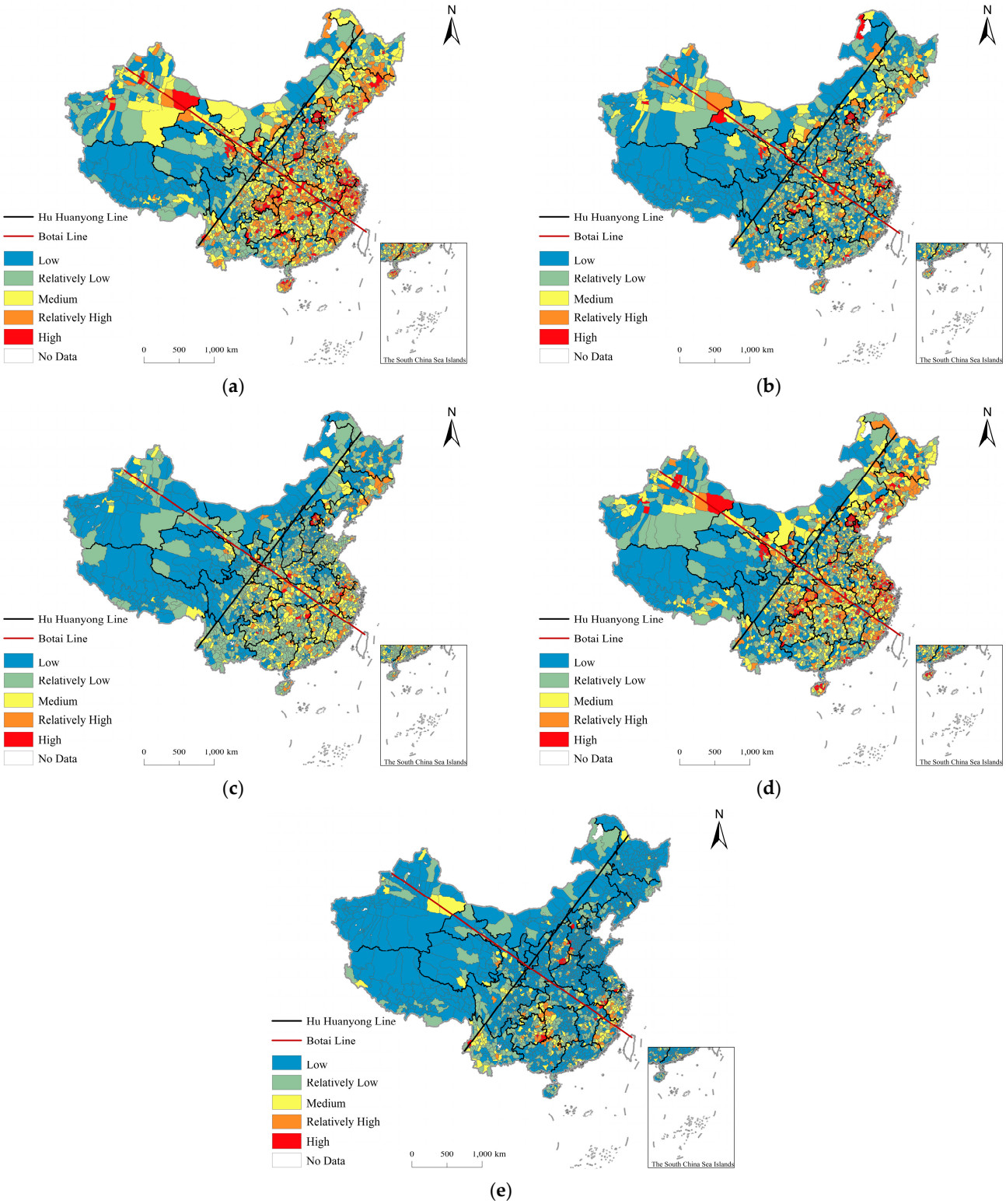


Figure 4. Spatial differentiation of the rural development level at the county scale in China ((**a**) Spatial Heterogeneity of Rural Development Level; (**b**) Spatial Heterogeneity of Economic Level; (**c**) Spatial Heterogeneity of Environmental Level; (**d**) Spatial Heterogeneity of Social Level; (**e**) Spatial Heterogeneity of Cultural Level).

(5) Cultural level: The percentages of counties with low to high levels account for 73.41%, 18.44%, 6.21%, 1.52%, and 0.42%, respectively. The average cultural level of the counties in the second quadrant is higher than in the other quadrants, and the lowest level is in the fourth quadrant. The average cultural levels of most counties are at a relatively low level or below, and only in some counties in the eastern coastal area, the southern coastal area, and Southwest China are the average cultural level high or relatively high; the northern coastal area, the middle region of the Yellow River, Northwest China, and Northeast China are merely at a low level. At the provincial level, the average cultural levels of all provinces are low or relatively low, but there are obvious internal disparities within certain provinces. For example, the average cultural level of southern Zhejiang, southern Anhui, southern Jiangsu, southern Fujian, western Hunan, southeastern Guizhou, and northwestern Yunnan is significantly higher than that of other regions in the province. The reasons for these results are as follows: first, the developed economy and high urbanization rate have spurred the emergence of rural modern civilization; second, the natural environment and ethnic characteristics have nurtured rural traditional culture (Figure 4e).

4. Influencing Factors

4.1. Model Test

The OLS model was applied for collinearity and significance testing. The results indicate that 11 independent variables meet the required criteria, including 3 independent variables for the natural environment, 2 independent variables for economic production, 4 independent variables for resource endowment, and 2 independent variables for social services. These variables are as follows: X1 average elevation, X4 river density, X6 forest coverage, X7 per capita GDP, X11 per capita general public budget expenditure, X12 population density, X13 number of cultural resources, X14 proportion of cultivated land area, X17 net primary productivity, X19 number of transportation stations, and X20 road network density. The GWR model was used for calculations, the kernel type was FIXED, and the bandwidth method was AICc. A comparison of the GWR model with the OLS model reveals that the R2adj value of the GWR model is significantly greater than that of the OLS model, whereas the AICc value is significantly lower. The results indicate that the GWR model has better explanatory power for the rural development level than the OLS model (Table 3).

Table 3. Comparison of the OLS model and GWR model.

Independent Variable	OLS				GWR			
	Coefficient	StdError	Probability	VIF [c]	The Average Value of Coefficients	Median	Percentage of Negative Values	Percentage of Positive Values
X4	0.0333	0.0000	0.0000	1.6392	0.0177	0.0199	0.2067	0.7933
X11	0.0077	0.0012	0.0000	2.2533	0.0146	0.0165	0.2549	0.7451
X13	0.0031	0.0002	0.0000	2.1167	0.0031	0.0032	0.0296	0.9704
X7	0.0008	0.0004	0.0229	6.2528	−0.0001	0.0002	0.4227	0.5773
X19	0.0006	0.0001	0.0000	1.3523	0.0007	0.0005	0.0019	0.9981
X14	0.0005	0.0001	0.0000	2.1167	0.0000	0.0000	0.4654	0.5346
X17	0.0005	0.0001	0.0009	2.2504	0.0000	0.0000	0.5372	0.4628
X6	0.0000	0.0000	0.0235	1.3798	0.0000	0.0000	0.7410	0.2590
X1	0.0000	0.0000	0.0000	4.0670	0.0000	0.0000	0.6406	0.3594
X20	−0.0039	0.0015	0.0074	3.7970	−0.0057	−0.0070	0.8718	0.1282
X12	−2.8399	0.4775	0.0000	2.1167	−4.0042	−2.8448	0.9704	0.0296
R2adj	0.1900	AICc	−9287.0091		R2adj	0.3517	AICc	−10,030.4474

4.2. Model Results

According to the GWR model, the average coefficients of the influencing factors in descending order are as follows: the natural environment, economic production, social services, and resource endowment. The average coefficients of the natural environment and economic production are significantly greater than those of the other two, indicating that the natural environment and economic production have greater comprehensive promotional effects on the level of rural development. The 11 independent variables also have different effects on the level of rural development. The average coefficients in descending order are as follows: X4, X11, X13, X19, X14, X17, X6, X1, X7, X20, and X12. Through exploratory analysis, four independent variables are selected to characterize the spatial variability of influencing factors at the rural development level in China's counties.

(1) Natural environmental factors: The average regression coefficient for X4 river density is 0.0177, with a proportion of positive values at 79.33%. These results suggest that river density exerts a positive influence on the rural development level in counties across the country. The regression coefficient value progressively increases from the central districts of Qinghai, northwestern Ningxia, and western Inner Mongolia in the western and eastern directions, with the maximum value occurring in northern Xinjiang and northwestern Tibet. In addition, the lowest value is observed in certain counties within western Xinjiang, indicating that river density has a greater impact on the rural development level in most counties in Northwest China, especially in northern Xinjiang. Given that the regions' characteristic agriculture and animal husbandry are well established and that rivers provide ample water for agricultural irrigation, these factors collectively promote agricultural development, they also exert a notable influence on the middle region of the Yangtze River and the middle region of the Yellow River, where the well-developed river network facilitates transportation. However, siltation poses challenges to both agricultural irrigation and ecological protection in these areas. River density has less of an impact on Southwest China and Northeast China. In Southwest China, topographical constraints result in rivers being predominantly confined to canyons and steep slopes, which hinders their utilization. Conversely, in the northeast, agricultural development mainly relies on large-scale mechanized farming, thereby diminishing the relative influence of river density on rural development (Figure 5a).

(2) Economic production factors: The average regression coefficient for X11 per capita general public budget expenditure is 0.0146, with a proportion of positive values of 74.51%. These results indicate that per capita general public budget expenditure has a significant positive effect on the rural development level in counties across the country. The regression coefficient forms a cluster centre in the Beijing–Tianjin–Hebei–Liaoning region, gradually decreasing towards the northeast and southwest, with the maximum value occurring in the northern coastal area and the middle of Northeast China and the minimum value occurring in Northwest China and Southwest China. These findings indicate that per capita general public budget expenditure has a substantial effect on the rural development level of counties within the northern coastal area, Northeast China, the eastern coastal area, the middle region of the Yellow River, and certain areas of the southern coastal area. In these regions, fiscal expenditures are allocated predominantly to infrastructure construction, such as transportation and water conservancy projects, which enhance agricultural production efficiency and the circulation of agricultural products, thereby promoting rural economic development. However, the influence is less pronounced in Northwest China and Southwest China, where economic development is relatively backwards, the area is extensive, and the population is sparsely distributed. Owing to the low population density, per capita fiscal expenditure is relatively high, but the actual available funds are limited, making it challenging to significantly improve the overall development level (Figure 5b).

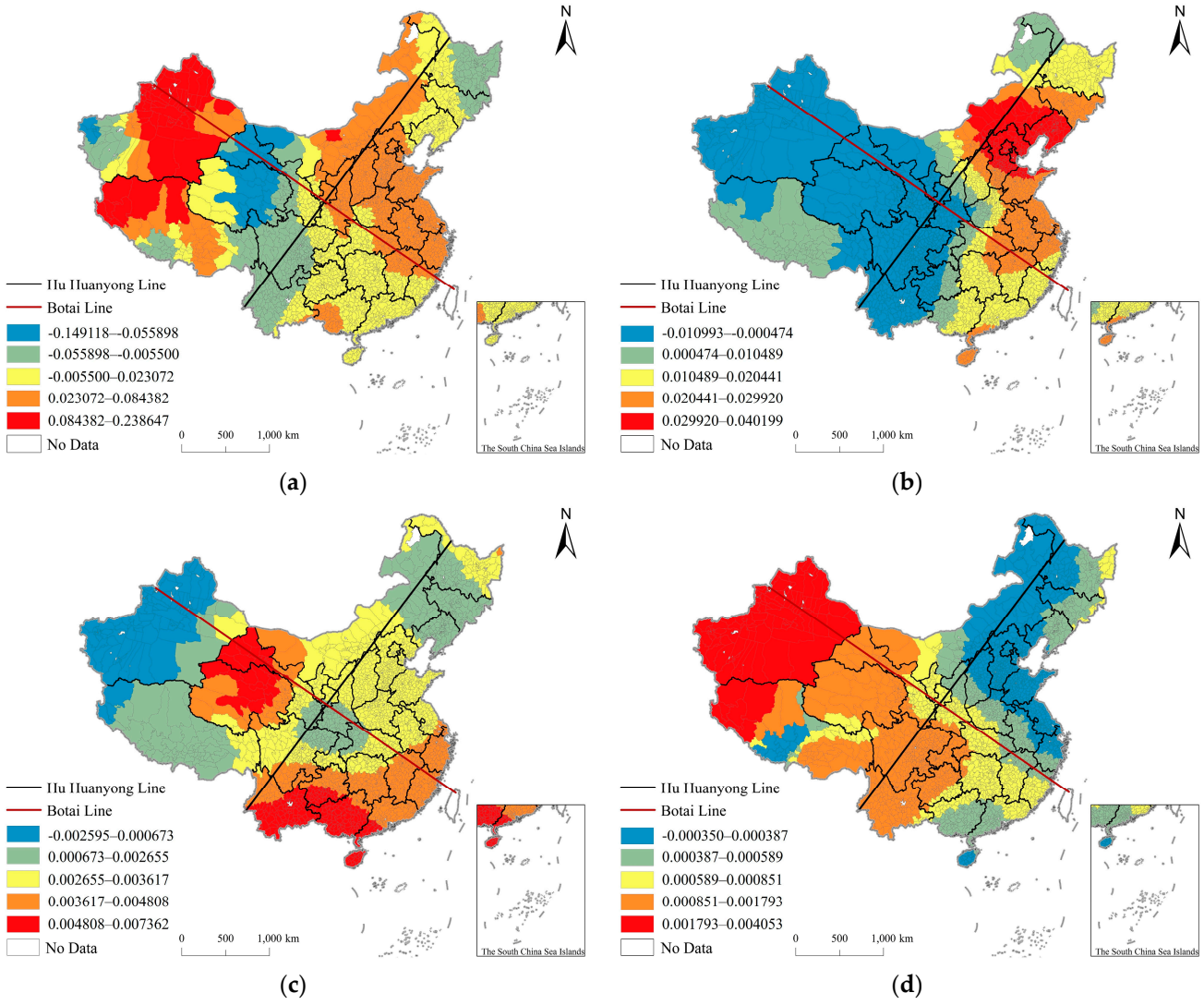


Figure 5. Spatial heterogeneity analysis of the independent variables of the rural development level in Chinese counties ((**a**) River density; (**b**) General public budget expenditure per capita; (**c**) The number of cultural resources; (**d**) The number of transportation stations).

(3) Resource endowment factors: The average regression coefficient of X14 for the number of cultural resources is 0.0031, with a proportion of positive values of 97.04%. These results indicate that the number of cultural resources has a positive effect on the rural development level in counties across the country. The regression coefficient gradually decreases from south to north, but a high-value regression coefficient cluster is observed in the central part of Northwest China, while the lowest value appears in the western part of Xinjiang. This situation suggests that the number of cultural resources has a greater impact on the rural development level of counties in the central part of Northwest China, the eastern coastal area, the southern coastal area, and most of Southwest China. The cultural resources in these areas are widely distributed and attractive, providing important support for the development of local tourism. The impacts on the Northeast China, the northern coastal area, the middle region of the Yellow River, and the western part of Northwest China are relatively small. The reason is that the cultural resources in these regions are relatively scarce, and the investment and development of cultural resources are relatively lagging (Figure 5c).

(4) Social service factors: The average regression coefficient of X19 for the number of transportation stations is 0.0007, with a proportion of positive values at 99.81%. These

results indicate that the number of transportation stations has a positive effect on the rural development level of counties across the country. The regression coefficient gradually decreases from west to east, with the maximum values occurring in Xinjiang and western Tibet and the lowest values occurring in Northeast China, the northern coastal area, and the eastern coastal area. In addition, the regression coefficient values in parts of Tibet and Hainan are notably modest. These results reveal that the number of transportation stations has a greater impact on the rural development level of counties in most of Northwest China and Southwest China, especially in Xinjiang. In these regions, the complex terrain conditions constrain the layout of the transportation network. Additionally, the relatively underdeveloped rural economy and the dispersed population directly affect the construction of transportation infrastructure, further exacerbating these challenges. However, the impact on Northeast China, the northern coastal area and the eastern coastal area is comparatively minor. As the underlying rationale for this phenomenon, these regions already boast a well-established transportation infrastructure and a robust foundation for rural development. As a result, the marginal benefits derived from the addition of further transportation stations are relatively low (Figure 5d).

5. Discussion and Conclusions

5.1. Discussion

(1) Suggestions for the implementation of rural development zoning and classification

On the basis of the spatial differences in rural development levels, the clustering method is used to divide the rural regional system of the country into the following 10 types of zones: Sichuan Basin region with moderate level of comprehensive development (I), Middle Yangtze River region with moderate level of comprehensive development (II), North China region with higher level of comprehensive development (III), Southeast coastal region with high level of comprehensive development (IV), Yunnan–Guizhou Plateau region with socio-cultural advantages and a lower level of comprehensive development (V), northeast region with socio-economic advantages and a relatively low level of comprehensive development (VI), Middle Yellow River region with socio-economic advantages and a relatively low level of comprehensive development (VII), Northwest region with socio-economic advantages and moderate level of comprehensive development (VIII), Southern coastal region with environmental advantages and a moderate level of comprehensive development (IX), and the Qinghai–Tibet Plateau region with a dominant absence model and a low level of comprehensive development (X) (Figure 6). Drawing on the spatial differentiation characteristics of rural development levels and the influencing factors, and in conjunction with the basic conditions of different types of zones, the following targeted development suggestions are proposed: on the one hand, focus on backwards areas, tap potential, address deficiencies, and expeditiously elevate the standard of rural development; on the other hand, target advanced areas, where the emphasis is on optimizing industrial structures, fostering urban–rural integration, enhancing quality and efficiency, and realizing holistic sustainable development. For example:

- The southeast coastal region with a high level of comprehensive development should build on its location advantages, good urbanization level, and economic development foundation to strengthen urban–rural integration, promote the construction of urban agglomeration agricultural industrial chains, explore comprehensive and multi-dimensional development paths for rural areas, achieve high-quality rural development, and build modern, ecological, and smart villages.
- The southern coastal region with environmental advantages and a moderate level of comprehensive development should rely on the advantages of opening up in the Pearl River Delta and Hainan Free Trade Zone, as well as its superior ecological environment

and coastal advantages, to strengthen the radiation and driving effect of the Pearl River Delta urban agglomeration on rural areas, develop rural eco-tourism and the large health industry, and explore the path of modernization and internationalization of agriculture and rural areas.

- The Qinghai–Tibet Plateau region, which has a dominant absence model and a low level of comprehensive development should rely on its plateau agricultural and pastoral bases and rich cultural resources to implement an "ecology + culture + industry" development path, develop plateau green agriculture and animal husbandry and eco-tourism, strengthen the construction of infrastructure and public service facilities, and improve the rural living environment.

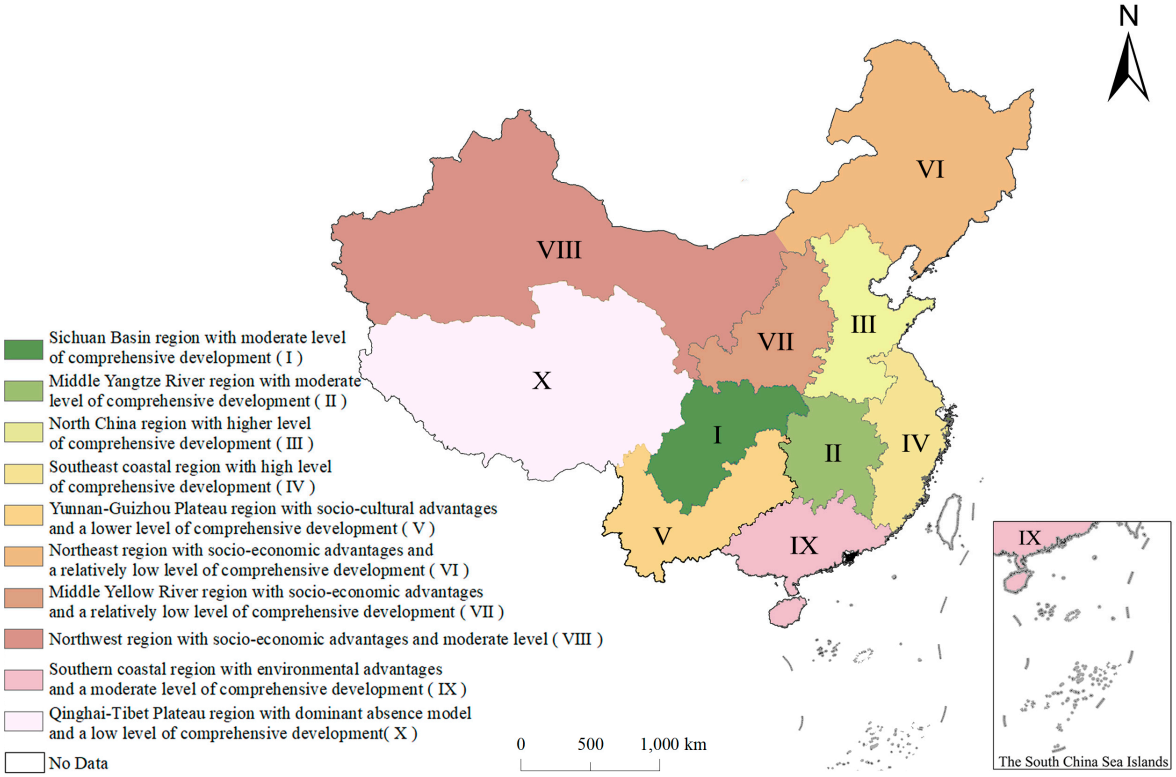


Figure 6. Types of Rural Revitalization in Chinese Counties.

(2) Comparative analysis with existing studies

Point data can successfully be used to analyse rural development levels. The point data used in this study are generated through a competitive evaluation process. This evaluation practice is commonly used and has Chinese characteristics. It features a characteristic blend of top–down and bottom–up characteristics. Its rationality can be inferred from its stated purpose and from the point data generation process. ① The demonstration village evaluation projects launched by central ministries and commissions have a top–down incentive mechanism and manifest centralization. First, to reflect their intentions and achieve effective governance, the central ministries and commissions established evaluation criteria consistent with the fundamental requirements of all provinces in the country. The objective of the evaluation is to facilitate national advancements in industrial development, environmental protection, social governance, and cultural inheritance in rural areas. Second, according to the population, land area, economy, and other factors of each province, the central ministries and commissions allocate evaluation quotas at varying amounts to each province from the top governance level to the bottom governance level. This allocation aims to reflect the differences between regions while also considering the balanced development

of all regions and provinces. For example, the "12th Batch of National 'One Village One Product' Demonstration Villages and Towns", issued by the Ministry of Agriculture and Rural Affairs supports the principle of quantity control (https://www.gov.cn/zhengce/zhengceku/2022-05/26/content_5692353.htm (accessed on 28 February 2025). Provinces with larger populations and greater land areas, such as Hebei, Shandong, Henan, and Sichuan, are allocated more quotas; provinces with lesser populations and smaller areas, such as Beijing, Tianjin, and Shanghai, are allocated fewer quotas; and provinces with relatively unsophisticated rural development, such as Inner Mongolia, Guangxi, and Guizhou, have special quotas for key assistance counties and designated support counties. ② The relevant government departments of each province conduct selections across the province from the bottom up, according to the evaluation criteria and quota indicators determined by the central ministries and commissions. Owing to the limited number of quota indicators, provincial government departments must conduct objective evaluations on the basis of the criteria determined by the central government departments and actual conditions such as the performance and typicality of the candidates. Otherwise, the selection results will not be convincing for the losing entities or incentivize the selected ones, nor will they meet the requirements of higher-level government departments. The various village lists formed through this process can provide data regarding rural development levels with Chinese characteristics. The selection process and results are in accordance with the principle of selecting the best; they represent excellent examples of rural development levels across the country. The point data are credible and usable.

Compared with area data (statistical data, remote sensing data, etc.) [9], point data have the following advantages: ① Point data can yield evaluation results similar to those of area data [9,30], making this method feasible. ② Village lists can provide sample points that directly reflect the development level of the village-level unit while preventing the characteristics of urban areas in the county from impacting the measurement results. In contrast, the area data represent the overall level of the county and thus the influence of urban areas cannot be eliminated. ③ The village lists correspond to the four dimensions proposed by the OECD for evaluating rural development levels and thus directly express the spatial characteristics of each dimension. Each list is the result of a comprehensive evaluation and selection of villages and is a comprehensive indicator with more complex connotations than are possible with a single indicator of area data. For example, the area data representing the economic level are mostly single indicators of agricultural production, whereas the "National 'One Village One Product' Demonstration Villages and Towns" list contains in-depth content closely related to rural economic development, such as dominant industry, industry integration, and characteristic products.

However, the limitations of the point data method are also obvious: ① Because this method is based on point data from rural lists, the measurement results of the rural development level can express only the relative level and are suitable for analysing only spatial disparities. The economic and sociological significance of the measurement value itself is not sufficient and cannot convey the absolute level. ② These point data usually appear in centralized countries and lack global comparability. For most democratic countries, following a bottom–up path, citizens express individual opinions through ballots, and there is no such top–down evaluation. However, the "World's Best Tourist Village" selected by the United Nations World Tourism Organization [58] and the "World Cultural Heritage List" selected by UNESCO [59] are also based on an evaluation method similar to that of the Chinese Rural Lists, and the relevant content is all in the category of effective point data. The United Nations and other countries may benefit from adopting China's village evaluation model, which not only allows for a further exploration of the potential and value of villages but also facilitates the performance of various types of village list selection work.

By enhancing the popularity and influence of selected villages, it is possible to attract more financial investment. In turn, this study provides a demonstration and reference for other villages, thereby promoting rural diversification and sustainable development overall.

5.2. Conclusions

The conclusions of this study are as follows:

(1) Distribution pattern of characteristic points: The characteristic points of rural development present a "polarized" pattern along the Hu Huanyong Line, with the majority distributed on its southeast side. The following four major aggregation cores are identified: Shanghai, Zhejiang, southern Jiangsu, and southern Anhui; Beijing, Tianjin, and the surrounding areas; the border areas of Hebei, Henan, and Shanxi; and southeastern Guizhou and the border areas of Guizhou, Hunan, and Guangxi. In terms of dimensions, the economic, environmental, and social points cluster in Beijing–Tianjin and Shanghai–Jiangsu–Zhejiang, while the cultural dimension forms three agglomeration centres in eastern Guizhou–western Hunan–northeastern Guangxi, southern Anhui-Zhejiang–northern Fujian, and southeastern Shanxi–northern Henan. Additionally, economic points form small-scale agglomerations in the Chengdu–Chongqing urban agglomeration, Xi'an, Zhengzhou, and Xining; the environmental points form several secondary agglomeration centres in Changsha, and Xi'an; and the social points are concentrated in the middle Yellow River region and the eastern coastal area.

(2) Spatial differentiation of counties: There are significant spatial disparities in the rural development levels of national counties among the large regions and socioeconomic zones and within the provinces. At the overall level, the counties with relatively high rural development levels are mainly located in the first and second quadrants, divided by the Hu Huanyong Line and the Botai Line. The eastern coastal area and northern coastal area exhibit the highest average rural development levels among all the socioeconomic zones, while Beijing, Shanghai, and Tianjin lead among all the provinces, while Jiangsu, Sichuan, Gansu, and Xinjiang have obvious internal differences. At the dimensional level, the first quadrant has the highest economic and social levels, the second quadrant has the highest environmental and cultural levels, and the third and fourth quadrants have relatively low levels of the four dimensions. Among the socioeconomic zones, the eastern coastal area ranks highest across all dimensions, with relatively high social and cultural levels, and moderate economic and environmental levels. The remaining socioeconomic zones have medium or lower levels of the four dimensions. Beijing, Tianjin, and Shanghai have the highest or second highest levels in the economic, environment, and social dimensions among all provinces, whereas Tibet ranks the lowest. Additionally, the average cultural levels of most counties are relatively low.

(3) Influencing factors: The natural environment and economic production are the main factors affecting the rural development level of counties. The impact of river density on the rural development level in counties in Northwest China is significantly greater than that in Southwest China and Northeast China; general public expenditure per capita has a greater impact on the northern coastal area and the central part of Northeast China; the number of cultural resources has a greater impact on the central part of Northwest China, the eastern coastal area, the southern coastal area, and most of Southwest China; and the number of transportation stations has a significantly greater impact on Northwest China and Southwest China than on Northeast China, the northern coastal area, and the eastern coastal area.

This study innovatively adopts the "point-to-area" approach to reveal the rural development level and its regional disparities in China. However, owing to the limitations of the types and number of rural lists, some dimensions (such as economic dimensions)

and some lists (such as National Eco-villages) have fewer sample points, which may affect the evaluation results. In subsequent studies, multisource data such as point and area data should be integrated to build a more comprehensive indicator system and conduct rural development level evaluations at different spatial scales to better serve the global rural sustainable development goals. This method can also be applied to evaluation and measurement research on the basis of point data such as in world heritage sites.

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