

Article

Spatial Patterns and Influencing Factors of People's Commune Sites: A Case Study of Henan Province, China

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Abstract: The people's commune was a social practice for achieving a communist society after the establishment of New China, but they were dismantled in the early 1980s, along with their legacy. This paper analyzes people's commune sites, offering guidance for their protection and development. This study used the historical place names of the communes recorded in the *Overview of People's Commune*, compiled a comprehensive database of people's commune sites, and mathematically analyzed the quantity and type of communes. The spatial pattern of people's commune sites was described via average nearest neighbors, spatial variability, kernel density analysis, and spatial correlation. Moreover, the driving mechanism was measured using the geodetector model. The survey results revealed 327 points related to people's communes, which were categorized into three main types: agriculture-oriented, industry-oriented, and integrated. Agriculture-oriented communes are the most significant type of people's commune, accounting for 87.0%. Communes in the northern region of Henan Province are more densely clustered, whereas those in the southeastern region are less concentrated. Moreover, precipitation is the most critical factor affecting the spatial pattern of people's commune sites, followed by railroad accessibility. A comprehensive literature analysis revealed that water conservancy projects limited the development of communes during the people's commune period. This paper analyzes the spatial distribution patterns of the sites that have existed historically according to historical gazetteers, revealing the factors that influenced the development of this particular political system. It enriches the spatial scope of the study of people's communes and provides theoretical references for the future preservation of communal heritage from the perspective of regional heritage.

Keywords: people's commune sites; spatial pattern; influencing factors; regional heritage; Henan Province



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1. Introduction

People's communes (1958–1983), which lasted for approximately 25 years, were a primary unit in rural areas and played a dual political and economic role in socialist society. They were also a testing ground for many architects and geographic planners who worked with local villagers to build a rural environment [1]. After the founding of the new PRC in 1949, the Communist Party carried out large-scale nationalization in agriculture, industry, and commerce to achieve industrialization and modernization. During nationalization, by the end of the 1950s, the development of agricultural cooperation between the state and the peasants introduced a new social institution called the people's commune [2]. The planning of people's communes was considered a socialist utopian idea, in which there was no private ownership but only public hospitals, welfare, compulsory education, and old-age homes for the general public; the inherent model of the family was abolished, and women emancipated themselves from the home [3]. While the communes stressed equality to the extent that they had to present sufficient incentives for commune members to be productive, farming efficiency lagged severely. The system had to be dismantled and replaced by

individual household farming under the household production responsibility scheme in the early 1980s [4]. Nonetheless, the construction activities of this period significantly impacted the productive lives of the country's urban and rural residents and the built environment. However, this topic has yet to attract sufficient domestic and international academic attention.

Rapid urbanization has promoted the prosperity of urban economies and the growth of urban space, but it has also led to rural recessions. Rural China has been undergoing an unprecedented recession in recent decades. Several issues are increasingly serious, including the decline in vernacular culture and the hollowing out of rural areas. However, village construction during the people's commune period, as a form of vernacular heritage, has been politicized as controversial without widespread conservation recognition. In the 1950s, Henan Province took the lead in communalizing the countryside and building people's communes in cities [5]. During the people's commune period, numerous representative constructions were made in Henan Province, such as the *Weixing Commune* and *Red Flag Canal*. As a historical product, the people's commune evolved from pre-basic villages and towns. Since communes are mostly located in remote geographic locations and there are no official statistics, this paper provides a reference for heritage conservation surveys by studying the distribution of communities.

The people's commune, as a transient system, presents a unique challenge due to its extensive material remains, which lack specific information and are widely dispersed, with no publicly accessible resource data. Investigations have revealed that this distinctive vernacular heritage is at risk of disappearing, primarily due to the ongoing threat of hazardous house reconstruction [6]. This paper investigates the mechanisms influencing the spatial distribution of the people's commune aims to enhance the protection of this unique type of heritage at the regional level. The main challenge in studying commune heritage is the lack of understanding of their current distribution and the absence of digitized records. Investigating regional factors influencing this distribution can provide insights into the significant impacts on spatial patterns, leading to recommendations for heritage preservation. For example, if commune distribution is found to be strongly influenced by railway transport, with a higher concentration near major routes, it would be prudent for the government to focus on the excavation and documentation of commune heritage in urbanizing areas with developed transportation. Conversely, if communes are located in areas with minimal transportation infrastructure and no other contributing factors, concerns about the destruction of commune heritage may be reduced.

This paper seeks to establish a comprehensive and systematic database that will serve two key purposes: first, to provide foundational research and guidance for regional heritage preservation efforts and, second, to analyze the historical distribution patterns of the commune. This analysis will elucidate the relationship between the commune as an institutional construct and its geographical context, ultimately offering valuable insights for the future modernization of rural areas.

2. Literature Review

The study of people's communes was initially confined to the fields of sociology [7], history [8], and economics [9], with scholars in various fields conducting relevant research from multiple perspectives considering the characteristics of their disciplines. Most studies have explored the social characteristics, historical development, and economic development of people's communes, with less attention given to their physical and spatial forms.

In recent years, owing to their unique political spatial nature, they have attracted attention from the fields of architecture, planning, and other material spaces. Gui systematically analyzed the historical, artistic, scientific, and social values of architecture from the people's commune period, using the Shangsu People's Commune in Yunnan as a case study [10]. Cheng studied collective canteens and residential buildings to analyze the relationship between political power and spatial production, from the scale of village planning to individual buildings [11]. Tan explored the detailed planning of industrial

towns during China's Third Front construction period (1964–1980) by analyzing spatial patterns and the language of spatial design from a historical perspective [12]. Xiang analyzed the planning of people's commune settlements from 1958 to 1962 from a more macroscopic perspective, discussing production-oriented rural collectivized spaces mainly in terms of settlement layout, settlement functional division, spatial order, and public service facilities [13]. In people's commune heritage research, Ma was the first to use big data methods to analyze the spatiotemporal distribution and category evolution of socialist built heritage [14,15]. Current research on the people's commune within architecture and planning predominantly addresses architectural design, village planning, and town master planning. However, there is a notable lack of exploration at the regional level, and research on commune heritage remains limited. This deficiency is especially evident in theoretical discussions focused on the value of commune rural heritage, with insufficient data collection and field investigation. Furthermore, existing studies primarily address only the 'architectural' aspects of commune heritage, overlooking the broader scope of commune remains.

In the early years of the PRC, Chinese urban planning was influenced by the Soviet Union's idea of industrial rational planning, and the principle of production-oriented planning was clearly reflected in the planning of people's communes [16]. In the people's commune system, workers, peasants, merchants, academics, and soldiers are integrated, and the government and society are united. It forms a large-scale, comprehensive territorial production complex for the comprehensive development of agriculture, forestry, animal husbandry, byproducts, and fisheries [17]. It was also the prototype of the configuration of public facilities carried out by the early life circle [18]. Zhang noted that a people's commune is a small production team based in a natural village, with a specific cross-border natural town as the administrative and political center, recognizing the traditional settlement pattern [7]. In planning communes, it is necessary to identify the major public works in the county, including roads, rivers, and other factors, to ensure that each commune can benefit from them and to facilitate production management. Then, the boundaries of the commune must take care of the original production habits without interrupting production and try to adjust them according to the original township boundaries [19].

The natural factors to be considered in people's commune planning include geology, mineral deposits, landforms, climate, hydrology, soil, vegetation, and fauna [20]. Rationally arranging crop production according to the land was achieved by following the slogan "On the premise of realizing water conservancy, rice paddies will be realized on the flat land, terraced land will be realized on the transforming low-lying land, forest belts will be realized on the sloping land, and fruit trees will be realized on the mountainous land" [21]. This reflects the idea that the altitude and slope of the terrain were emphasized in selecting sites for the planning and layout so that production could be adapted to local conditions. Moreover, natural conditions, such as hydrology, climate, and rainfall, greatly impact communes' water conservancy construction [22]. Additionally, local vegetation preferences are considered when developing communal production to meet production needs [23]. In this study, elevation, slope, water systems, temperature, precipitation, and vegetation were selected as the natural factors affecting the distribution of communes.

The economic factors considered in people's commune planning include population, economy, industry, agriculture, and transportation [20]. People's communes were developed to be production-oriented, and industrial development further consolidated the commune system. In the industrial configuration, the emphasis is placed on balanced economic development, labor conservation and efficiency, and synergy between industrial sectors [24]. Commune development also focuses on transport links with neighboring communes [25]. The communes' focus is on an equilibrium between the costs of transport, the costs of migration, and the benefits of production, demonstrating the idea of multiple dimensions of transport accessibility. The regional distribution of communal industries has implemented the policy of "large-scale decentralization and small-scale centralization" [24]. The development of villages and small towns is also important, which is also a typical

characteristic of the distribution of settlements. As a result, the economy, road accessibility, railway accessibility, and distance from major cities were selected as the human factors affecting the distribution of communes in this study.

Existing studies provide a rich and diverse body of knowledge on the spatial patterns of villages and heritage as well as the factors that influence them. However, research on the people's commune is currently limited to qualitative methods, and more quantitative analysis research using big data is needed. With respect to spatial pattern analysis, commonly used methods include the average nearest neighbor, spatial variability, kernel density estimation, standard deviation ellipses, the Gini coefficient, and spatial correlation indicators [26–28]. In terms of influencing factor analysis, commonly used research methods include geographic detectors, decision tree models, and spatial lag regression [29]. As research has progressed, some scholars have studied the factors influencing the spatial patterns of traditional villages or heritage sites, suggesting that they result from multiple effects, such as altitude, slope, water systems, population, transportation, and economic factors [30]. However, these quantitative analysis studies have focused mainly on contemporary urban and rural environments, while few studies have focused on settlement history. Therefore, this research selected people's communes as a unique research object using many quantitative analysis methods in contrast with the previous qualitative research on communes.

Although the people's commune system has been abolished, it has left behind a collective memory of a great deal of heritage, including tangible heritage, such as farmland and water conservancy infrastructures and *Gandalei houses* [31], and intangible heritage, such as the collective ownership system of rural land. Current research has focused on conservation at the architectural [14] or detailed planning scale and less on heritage conservation at the regional scale. Historic heritage conservation at the regional scale can effectively preserve the authenticity and integrity of heritage [32]. Recently, the perspective of heritage sites has transitioned from the traditional focus on individual historical and cultural resources to encompass regional historical and cultural spaces [33,34]. In 1992, at the 16th session of the World Heritage Committee of UNESCO, cultural landscapes were listed as a type of world heritage site. Since 2000, heritage canals and routes have been formally included in the scope of the *World Heritage List*. In 2008, the *Charter of Cultural Routes* by ICOMOS was adopted [35]. This shows that regional heritage conservation and the overall dynamic conservation of humanity and nature have become mainstream trends in international heritage conservation [36]. In existing studies, the objects of heritage area research are primarily traditional settlement spaces, such as heritage spaces along the Grand Canal [37], the Millennium Villages [38], the Loire Valley [39], etc. Research methods include field surveys [6], spatial and temporal evolution analyses [40], and text mining [41]. Regionalized governance strategies include constructing the heritage network of the historic city [42] and the clustered protection of villages and towns [43]. This paper selected the people's commune as a particular type of vernacular heritage and proposed a regionalized heritage conservation strategy.

3. Materials and Methods

As shown in Figure 1, this paper systematically organizes people's commune sites based on field research findings and site data. Additionally, it comprehensively analyzes the spatial patterns of people's commune sites via research methods such as average nearest neighbor, spatial variability, kernel density analysis, and spatial correlation. The geodetector method is employed to identify the driving factors influencing the spatial patterns of people's community sites. Finally, this paper provides corresponding suggestions to address the challenges faced in the protection and development of people's commune sites, serving as a scientific basis and reference for future endeavors in safeguarding and promoting the rich heritage of Henan Province.

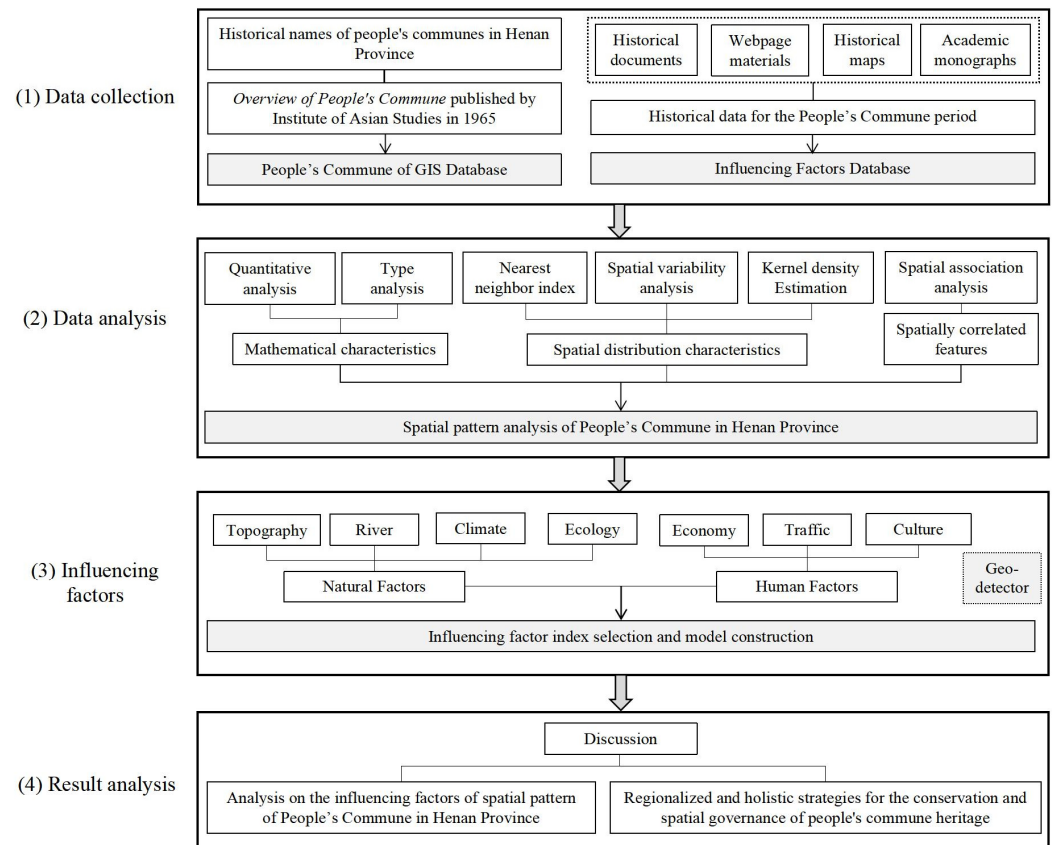


Figure 1. Research framework and methodology framework.

3.1. Data Resources

As shown in Figure 2, the data presented in this manuscript on people's commune sites in Henan were collected from various sources, including the *Overview of People's Commune* in 1965 and *Map of Henan Province* in 1970. Furthermore, we consulted the academic literature and relevant data to supplement the analysis. The database was constructed with the aid of field survey validation. The spatial coordinates of the people's commune were obtained via the Baidu coordinate picker, converted into WGS_1984 coordinates, and imported into ArcGIS for correction. Finally, the spatial point data were acquired.

This study utilized various sources to examine the spatial patterns and influencing factors of people's commune sites in Henan. Vector data of provincial and municipal administrative boundaries, the DEM, precipitation, temperature, and the Normalized Difference Vegetation Index (NDVI) were obtained from the Data Centre for Resources and Environmental Sciences of the Chinese Academy of Sciences. Additionally, vector data for railway, road, and water systems were plotted in ArcGIS 10.7 according to the *Map of Henan Province*. Nighttime light data used to characterize economic development were obtained from the Earth Resources Data Cloud. The data for major cities are available on the official website of the Henan Provincial Department of Civil Affairs. These data sources were used to examine the factors influencing the spatial patterns of people's commune sites in Henan Province. The selected factors and their data sources and formats are shown in Table 1.



Figure 2. History book covers from the People's Commune period: (a) *Overview of People's Commune*; (b) *Map of Henan Province*.

Table 1. Data list.

Data Name	Time	Data Source
People's commune data	1965	<i>Overview of People's Commune</i> , local chronicles, and field trips
DEM	2000 *	RESDC (http://www.resdc.cn , accessed on 1 May 2024)
River	1970	<i>Map of Henan Province</i>
Precipitation	1960	RESDC (http://www.resdc.cn)
Temperature	1960	RESDC (http://www.resdc.cn)
NDVI	1981	RESDC (http://www.resdc.cn)
Nighttime light data	1984 *	GRDC (http://www.gis5g.com/data/dgsj?id=247 , accessed on 15 May 2024)
Railway	1970	<i>Map of Henan Province</i>
Road	1970	<i>Map of Henan Province</i>
Major city	1965	https://mzt.henan.gov.cn/2009/08-06/942858.html , accessed on 1 May 2024

* Because DEM and economic data from the commune period are difficult to obtain, they were characterized with 2000 DEM and 1984 nighttime light data.

3.2. Study Area

Henan Province (31°23'–36°22' N, 110°21'–116°39' E) is located in the central and eastern parts of China and the middle and lower reaches of the Yellow River. It has jurisdiction over 18 provincial cities, including Zhengzhou, Kaifeng, and Luoyang. The terrain is high in the west and low in the east, spanning four major river basins, including the Yangtze, Yellow, Huai, and Hai Rivers. Henan Province is the birthplace of Chinese civilization and has long served as China's political, economic, and cultural center. In the 1950s, Henan Province took the lead in communalizing the countryside and building people's communes in cities [5]. During the people's commune period, numerous representative constructions emerged in Henan, such as the *Red Flag Canal*. Notably, specific people's commune sites, such as *Weixing Commune*, have gained significant recognition as tourist destinations both locally and internationally.

3.3. Methods

On a regional geographical scale, all people's commune sites can be considered one-point elements whose geographical information and numbers constitute the basic analysis parameters. After the data were transformed in ArcGIS 10.7, built-in analysis techniques were applied to further explore the evolutionary features. This process involved the following three steps: (1) the application of mathematical analysis to investigate the number and

equality of the people's commune and various types of communes; (2) the comprehensive use of average-nearest-neighbor analysis, spatial variation analysis, kernel density analysis, and spatial association analysis to examine the spatial distribution characteristics of the communes; and (3) the utilization of geographic detectors to identify and assess the driving factors behind the distribution of commune locations.

3.3.1. Average Nearest Neighbor

The average nearest neighbor was applied to identify the distribution patterns of people's commune sites which can be determined as clustered, uniform and random, and their associated attributes across the region. The nearest-neighbor index R , z score, and p value were the main rubrics of the tool [29]. R is the ratio of the average nearest-neighbor distance to the expected nearest-neighbor distance, and the other two values are measures of statistical significance. When z and p were statistically significant, an R value less than 1.0 characterized clustering trends, a value greater than 1.0 characterized discrete trends, and a value of 0.0 characterized random trends, as calculated via Equations (1)–(3).

$$R = \frac{\overline{DO}}{\overline{DE}} \quad (1)$$

$$\overline{DO} = \frac{\sum_{i=1}^n d_i}{n} \quad (2)$$

$$\overline{DE} = \frac{0.5}{\sqrt{n/A}} \quad (3)$$

where R is the average nearest-neighbor index, $\overline{DO}$ is the average nearest-neighbor distance between each person's commune and its nearest-neighbor sites, $\overline{DE}$ is the expected nearest-neighbor distance between each site and its nearest neighbor, n is the total number of elements, d_i is the distance between the i -th person's commune and its nearest neighbor, and A is the total study area.

3.3.2. Spatial Variability

The coefficient of variation method was used to calculate the spatial variability of people's commune sites in Henan Province [44]. The formula is as follows:

$$SD = \sqrt{\frac{1}{n} \sum_{i=1}^n (X_i - \bar{X})^2} \quad (4)$$

$$CV = \frac{SD}{\bar{X}} \quad (5)$$

where CV is the coefficient of variation, SD is the standard deviation, n represents the number of administrative units, X_i represents the number of sites in administrative unit i ($i = 1, 2, \dots, n$), and $\bar{X}$ represents the mean value of the sites in each administrative unit. If the variation coefficient is large, it indicates a significant spatial difference between people's commune sites in Henan.

3.3.3. Kernel Density

Kernel density analysis is a nonparametric statistical method for estimating density in a given dataset. It assigns higher densities to central point elements within a specific bandwidth range, whereas peripheral density values are lower [45]. This methodology enables analyzing spatial agglomeration characteristics of heritage resources. The equation for calculating the kernel density is as follows:

$$f(s) = \sum_{i=1}^n \frac{1}{nh^2} K\left(\frac{d_{is}}{h}\right) \quad (6)$$

where $f(s)$ is the kernel density value at s , h represents the bandwidth, and n represents the number of heritage resources within the region. d_{is} is the distance from i to s and the K function represents the kernel function. The larger the $f(s)$, the richer the people's commune sites, and the density value of resources decreases with increasing distance (d_{is}).

3.3.4. Spatial Correlation Indicators

1. Global indicators of spatial correlation

In this work, the global Moran's I index is used to analyze the global spatial association of people's commune sites in Henan to obtain the global correlation of the sites [46]. The expression is as follows:

$$\text{Global Moran's } I = \frac{n}{\sum_{i=1}^n \sum_{j=1}^n \omega_{ij}} \frac{\sum_{i=1}^n \sum_{j=1}^n \omega_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_{i=1}^n (X_i - \bar{X})^2} \quad (7)$$

where *Global Moran's I* denotes the association coefficient, n denotes the number of administrative units at the county level, X_i and X_j represent the number of sites of the i -th and j -th administrative units, respectively, $\bar{X}$ represents the mean value, and ω_{ij} represents the spatial weight. The Moran's I index value is $[-1, 1]$; if the result is greater than zero, it indicates a global positive correlation and that the sites are in a spatial agglomeration state. If it is negative, it indicates a global negative correlation, and the spatial difference in heritage resources is large. The closer the result is to 0, the more it indicates that people's commune sites tend to be distributed randomly.

2. Local indicators of spatial association (LISA)

The local association can describe the local aggregation state of people's commune sites in Henan, which includes four cases in total—H-H cluster, H-L outlier, L-H outlier, and L-L cluster [46]—expressed as follows:

$$\text{Local Moran's } I = \frac{X_i - \bar{X}}{S_i^2} \sum_{j=1, j \neq i}^n \omega_{ij} (X_j - \bar{X}) \quad (8)$$

where S_i^2 represents the variance in sites in different administrative units throughout Henan, and the rest are consistent with those in Equation (7). Two cases of high-high or low-low clusters occur when the value exceeds zero. The former indicates many sites in the administrative and surrounding administrative units. In contrast, the latter indicates that the number of sites is low. When the value is less than zero, two cases of high-low outliers and low-high outliers occur; the former indicates a significant number of sites in the region, while the number of surrounding areas is small, while the latter indicates the opposite.

3.3.5. Geodetector

This paper comprehensively analyzes the factors impacting the spatial distribution of people's commune sites in Henan. An index system considering the natural and social environmental factors influencing their distribution was proposed. Moreover, this study employed the geodetector factor detector to assess the explanatory power of various factors on the spatial distribution of sites, as measured by the q value [47]. The formula used for this calculation is as follows:

$$q = 1 - \frac{\sum_{h=1}^L \sigma_h^2 N_h}{N \sigma^2} \quad (9)$$

where N and σ^2 represent the variance in the number of units and Y in the study area, respectively. The population Y consists of L layers ($h = 1, 2, \dots, L$). q represents the explanatory ability of each influence factor to Y , and its value is strictly within $[0, 1]$. The larger the value of q , the stronger the explanatory ability of the independent variable X of dependent variable Y , and vice versa.

4. Results

4.1. Mathematical Analysis of People's Commune Sites in Henan Province

In this study, a database of 327 commune sites in Henan was constructed. According to the labeling of the production status of each commune in the *Overview of People's Commune*, communes are categorized into three main types: agriculture-oriented, industry-oriented, and integrated communes. Of these, 261 have recorded industrial development. As shown in Figure 3, the sites are distributed across all 18 city-level administrative regions of Henan Province. However, their distribution is uneven. In this paper, the geographic concentration index is used to study the distribution concentration of the historical names of the people's communes in Henan Province. The total number of historical names of people's communes in the province is $T = 314$, and the number of cities is $n = 18$. The number of sites in each city is counted. According to the geographic concentration index model, the geographic concentration index of historical names of people's commune sites in Henan is $G = 26.554$. If the sites were evenly distributed in each city, the geographical concentration index would have been $G_0 = 23.570$. $G > G_0$ indicates that the distribution of sites is relatively concentrated at the municipal scale.

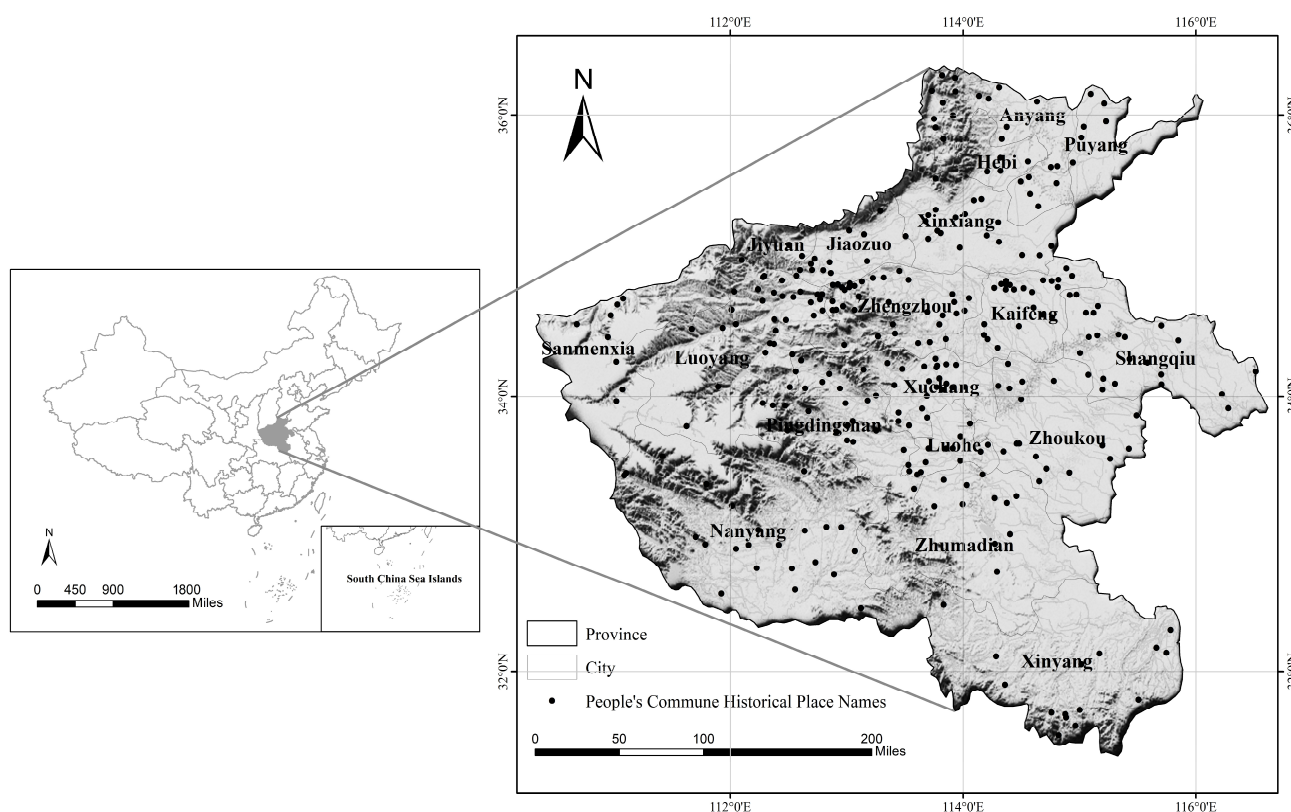


Figure 3. The location of Henan Province.

The imbalance index was used to study the distribution balance of people's commune sites in Henan. The imbalance index of $S = 0.313$ indicates that the distribution of sites is uneven in 18 cities. As shown in Figure 4, using the Lorenz curve of the distribution of sites in various cities reveals an upward convex trend and that they are mainly distributed in the areas of Zhengzhou, Luoyang, Kaifeng, and Anyang in Henan province.

As shown in Figure 5, according to the production development of each commune recorded in the *Overview of People's Commune*, the sites were categorized into agriculture-oriented, industrial-oriented, and comprehensive communes. In agriculture-oriented communes, the main business developed was growing crops such as wheat, maize, and sorghum and livestock such as pigs and cattle. Most communes focused on agriculture, such as the Longhai People's Commune in Zhengzhou, which grew mainly millet and sweet

potatoes. Among the industry-oriented communes, more water conservancy, agricultural machinery, and iron ore mining industries were developed. Some communes in Zhengzhou had a distinctive textile industry, and water conservancy facilities were better developed in Anyang Linxian. Comprehensive communes, such as the Zhaohe People's Commune in Xinxiang, have a well-developed industrial system, combining agriculture and industry. Owing to the better conditions for economic development, the integrated communes are located primarily in the northern part of Henan Province. All types of people's communes and the total number of them in each city in Henan Province have been counted in Table 2.

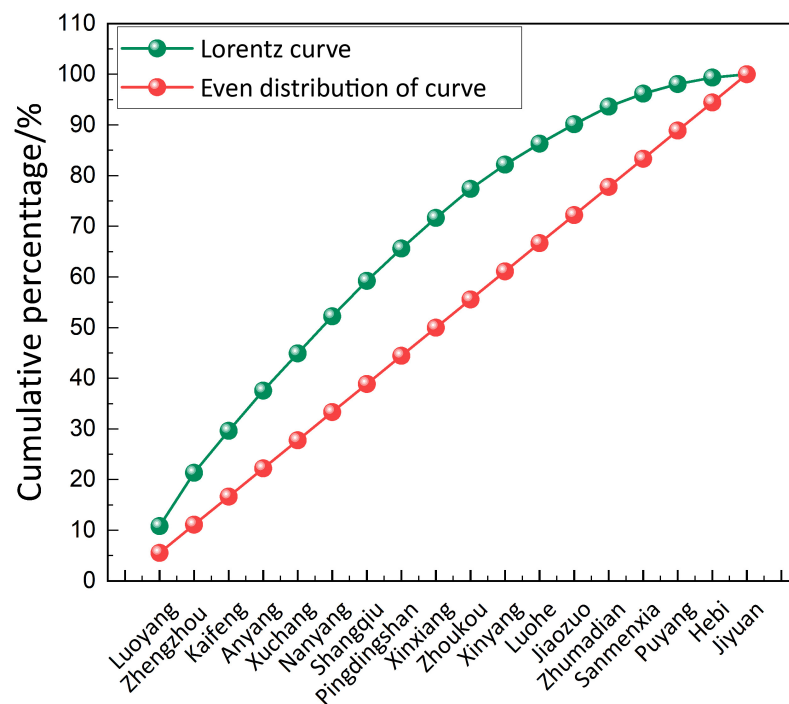


Figure 4. Distribution of people's communes in Henan at the municipal scale.

Table 2. Data list.

Number	City Name	Total Number ¹	Agriculture-Oriented Communes	Industry-Oriented Communes	Integrated Communes
1	Luoyang	37	26	2	3
2	Zhengzhou	36	21	2	1
3	Kaifeng	27	18	4	0
4	Xuchang	25	18	2	1
5	Anyang	25	16	0	3
6	Shangqiu	23	16	1	0
7	Nanyang	23	15	2	1
8	Pingdingshan	20	14	0	2
9	Xinxiang	19	14	3	0
10	Zhoukou	18	14	0	1
11	Xinyang	16	13	1	1
12	Luohe	13	7	0	2
13	Jiaozuo	13	10	0	2
14	Zhumadian	11	8	0	0
15	Sanmenxia	9	7	0	0
16	Puyang	6	6	0	0
17	Hebi	4	2	0	0
18	Jiyuan	2	2		

¹ In addition to the above three classic types, there are some communes in the *Overview of People's Commune* that are not documented in detail. There is therefore a mismatch between the sum of the three types and the total number.

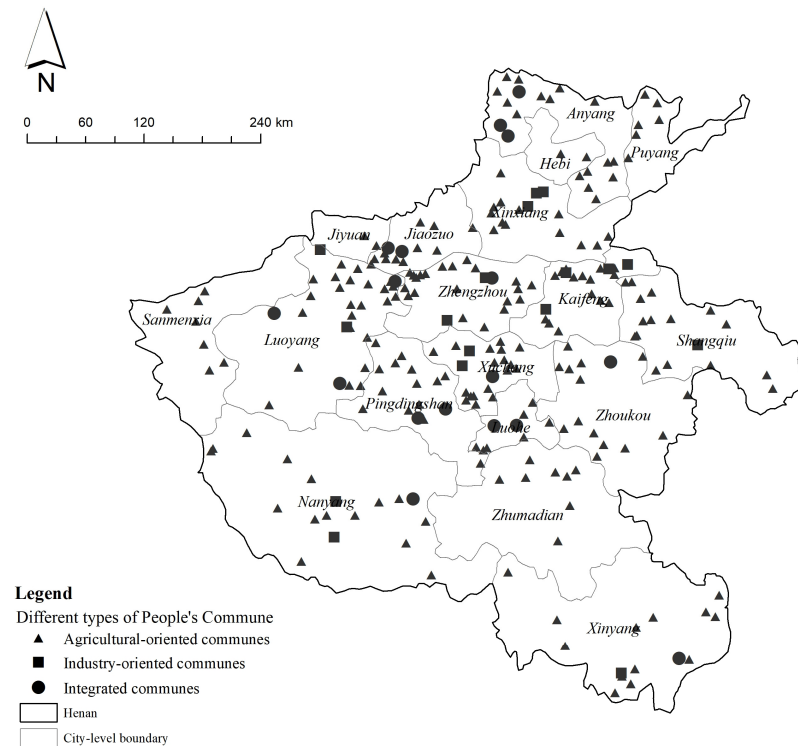


Figure 5. Distribution of different types of people's communes in Henan.

The results of this study demonstrated variability in the number of types of people's communes, as referred to in Figure 3. Notably, the number of agriculture-oriented communes was significantly greater, accounting for 227 of all people's communes. Conversely, there were 17 industry-oriented and 17 integrated communes. Agriculture is the primary industry of most of the communes in Henan, which are evenly distributed throughout the province. In contrast, industry-oriented and integrated communes tend to be located in the northern part of Henan Province.

4.2. Spatial Pattern Analysis of People's Commune Sites in Henan Province

4.2.1. Average Nearest Neighbor Analysis

The point elements on a map [29] represent the spatial structural characteristics of people's commune sites. There are three main types of spatial distributions for point elements: clustered, random, and uniform. The ArcGIS 10.7 nearest-neighbor index method (Formulas (1)–(3)) was used, and the distribution of sites was calculated with $R = 0.733 < 1$. The average observed distance (observed mean distance) was 10.1 km; the expected (expected mean distance) distance was 13.8 km; and the absolute value of the Z score, -9.22 , was significant. The results indicate considerable deviation from a random distribution. The results demonstrated a clustered spatial distribution of people's commune sites in Henan.

4.2.2. Spatial Variability Analysis

Since the definition criteria of the nearest-neighbor index in determining the type of spatial distribution of point elements are still in a developmental stage, this paper conducts further research on the spatial distribution of people's commune sites in Henan by measuring the coefficient of variation. ArcGIS 10.7 software generates Tyson polygons of the sites. The CV value of the Tyson polygon area variance in the West Tree is measured to be 101.48%, which is greater than 64%, indicating that a clustered spatial distribution of the people's commune sites in Henan Province. This further verifies the results of the analysis of the nearest-neighbor index.

4.2.3. Kernel Density Analysis

The kernel density tool in Spatial Analyst of ArcGIS 10.7 was utilized for kernel density estimation to generate a kernel density map of the spatial distribution of people's commune sites in Henan. The map shows that the sites have a spatial distribution pattern of “large dispersion, small agglomeration” and are dense in the north and sparse in the south. The high-density area is located in the *Yellow River basin*, where the Luoyang, Zhengzhou, and Jiaozuo border areas and Kaifeng and its surrounding areas are the most concentrated. The Yellow River basin is rich in history and culture, has distinctive regional characteristics, and has flat terrain, making it conducive for constructing people's communes. The medium-density zone is located in the *Huaihe* and *Haihe River basins*, mainly in Xuchang City and Anyang City. In contrast, the low-density zone is distributed along the *Yangtze River basin*, mainly in the cities of Nanyang, Zhumadian, and Xinyang in the southern region of Henan Province. The distribution characteristics of agriculture-oriented communes are generally similar to those of the overall kernel density distribution of communes, with a notable concentration near the Yellow River basin. Industry-oriented communes are primarily concentrated in the northeastern region of Henan Province and in the Nanyang area. Meanwhile, integrated communes are densely distributed in central Henan (refer to Figure 6).

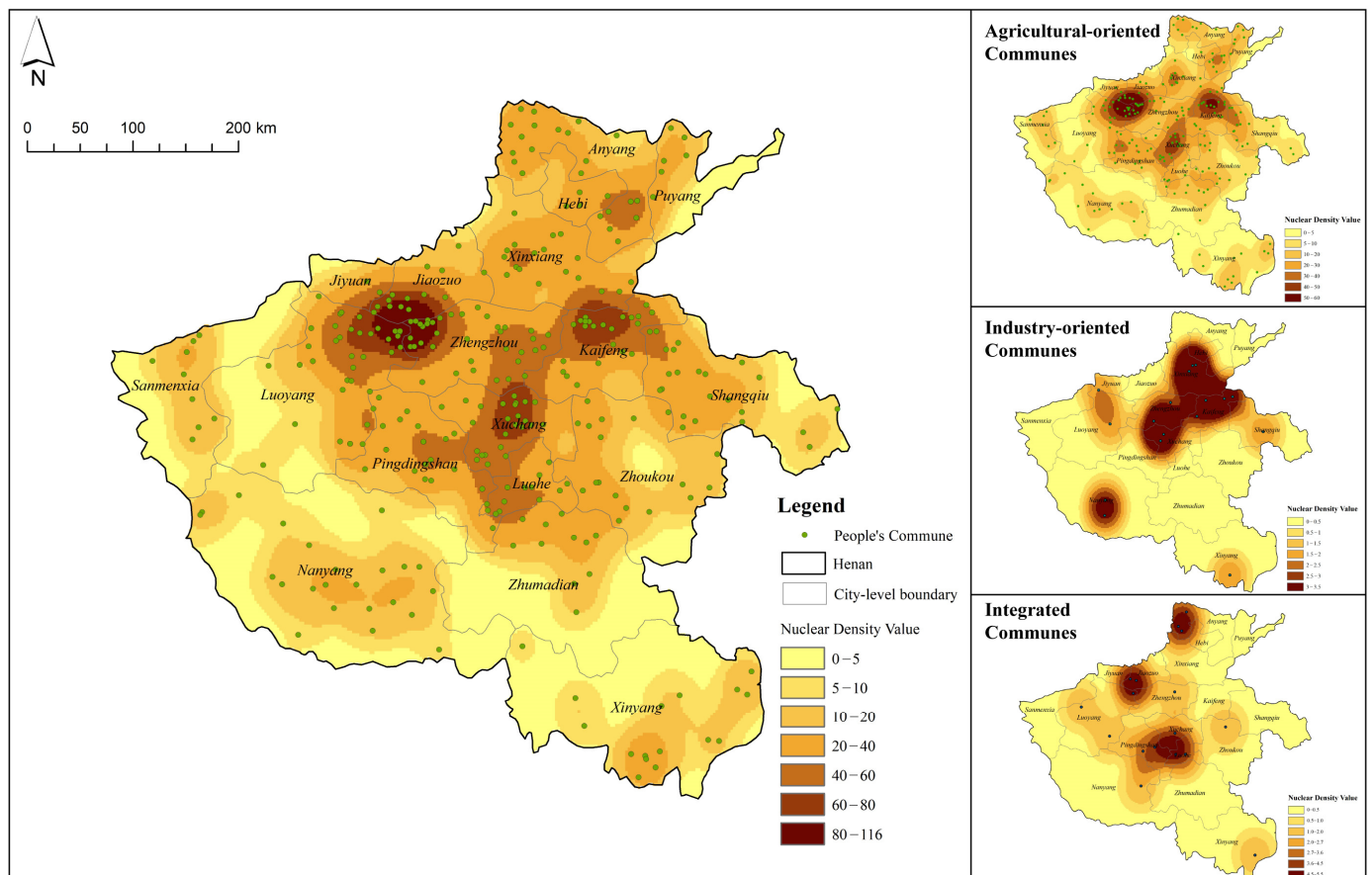


Figure 6. Kernel density of people's communes in Henan.

4.2.4. Spatial Correlation Analysis

Regarding spatial distribution, the global Moran's I index was calculated for the people's communes in Henan. The result was 0.2987, which reached the 0.01 level of significance, indicating that the people's commune sites were clustered and distributed.

Regarding local distribution, high–high clusters of sites were identified primarily in Luoyang, Zhengzhou, and Kaifeng, while low–low clusters were predominantly located

in the southeastern region of Henan, specifically in Xinyang and Zhumadian. Low-high outliers were found in Xuchang and Xinxiang. Notably, Zhoukou, Zhumadian, and Puyang displayed an overall high-low outlier pattern for the people's commune sites in the local area. Based on the results of the local Moran's I for each type of commune, the distribution of agriculture-oriented communes is similar to that of the overall communes. Industry-oriented communes are primarily distributed in the eastern part of Henan Province, particularly within the Yellow River basin, while integrated communes exhibit an irregular local distribution pattern (refer to Figure 7).

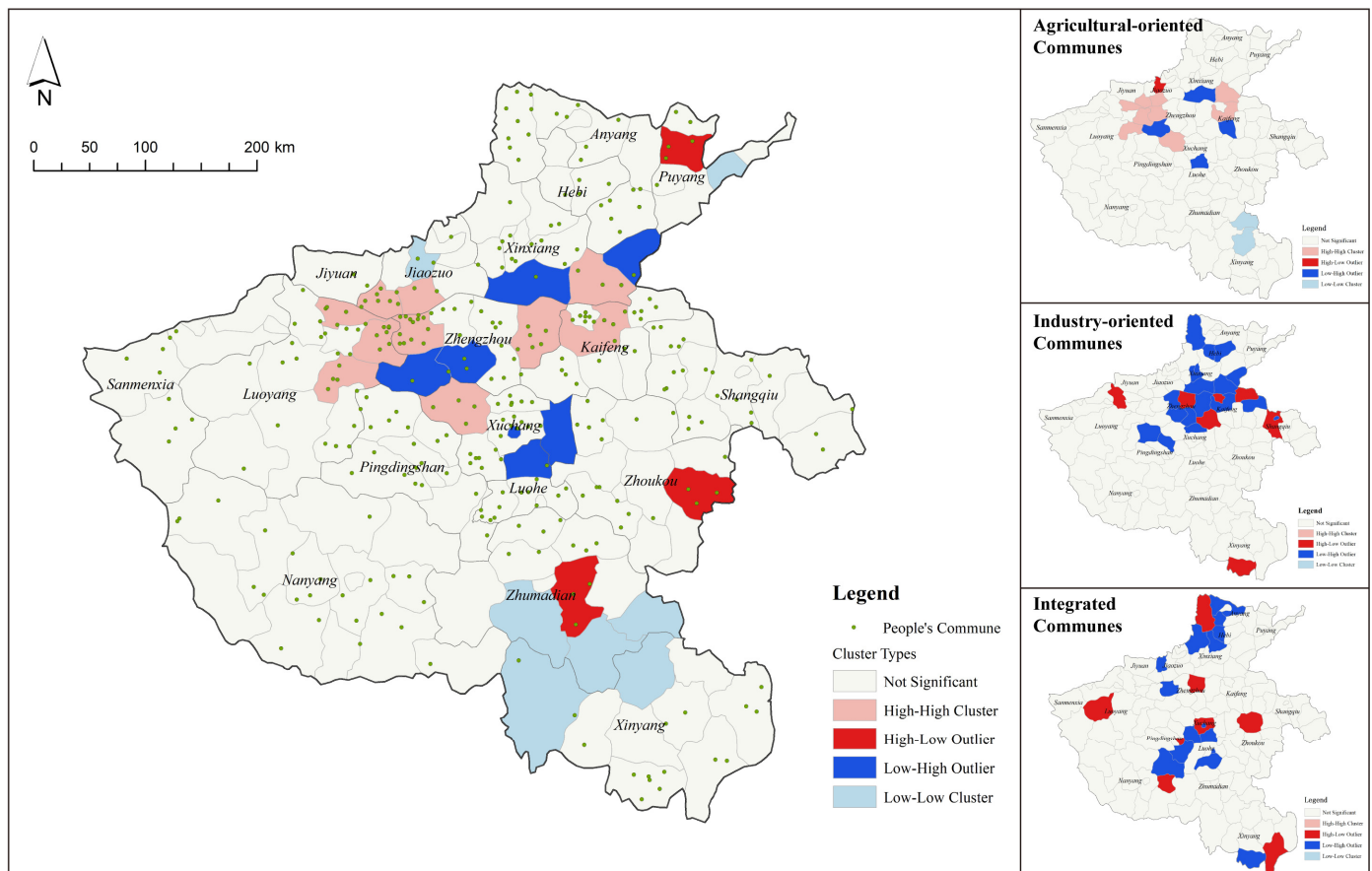


Figure 7. Local spatial correlation of people's communes in Henan.

Our findings indicated that people's commune sites were mainly concentrated in regions with advantageous geographical locations, rich historical and cultural heritage, and frequent military conflicts. The northern part of Henan, such as Luoyang, Zhengzhou, and Kaifeng, has the highest concentration of communes, while the southern part has the lowest concentration.

4.3. Influencing Factors of People's Commune Sites in Henan Province

The relationship between origin and development is closely intertwined with a region's natural and socioeconomic environment. The spatial distribution of people's commune sites results from various factors. By utilizing previous research and expert opinions, this study developed an index system incorporating the impacts on the sites' spatial patterns. As shown in Table 3, the factors affecting the spatial patterns of the sites are explored from the perspectives of the natural and socioeconomic environments. Due to the small number of people's communes in each subtype, the results of geographic probing are not significant, so this paper only discusses the factors affecting the full range of people's communes.

Table 3. Index system of influencing factors.

Indicators	Detection Factors	Explanation of Indicators
Natural factors	X1 Altitude	The altitude of people’s commune (m)
	X2 Slope	The slope of a people’s commune (°)
	X3 Water system distribution	Distance from a water system (m)
	X4 Temperature	The temperature of a people’s commune (°C)
	X5 Precipitation	The precipitation of a people’s commune (mm)
	X6 NDVI	Vegetation index
Human factors	X7 Economy	Nighttime Lighting Index
	X8 Railway accessibility	Distance from a railway (m)
	X9 Road accessibility	Distance from a road (m)
	X10 Distance from major cities	Distance from a main administrative unit (m)

4.3.1. Natural Factors

In this study, the natural geographical factors selected include altitude, slope, water systems, temperature, precipitation, and the NDVI index. Altitude and slope are analyzed using digital elevation model (DEM) data, while water systems are assessed based on the distribution of significant rivers. Temperature, precipitation, and NDVI data are derived from the 1960 dataset of the Institute of Geography, Chinese Academy of Sciences. All of the above data can be observed in Figure 8.

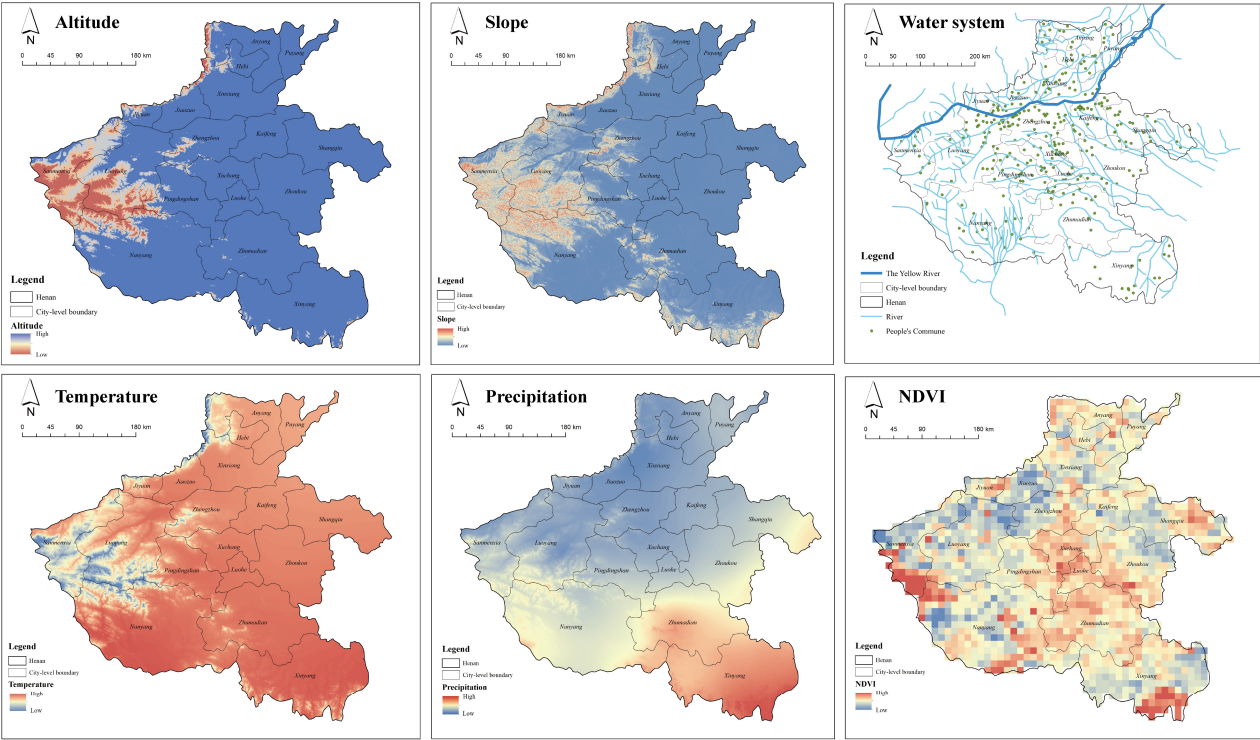


Figure 8. Natural factors in Henan.

1. Altitude and slope

Altitude (X1) is a critical factor affecting the regional climate, hydrology, geomorphology, and habitability. As a result, it influences the origin and development of heritage resources, particularly material cultural heritage. Slope (X2) also significantly affects population habitation and building construction. Plains or basins with lower slopes are optimal for living, whereas mountainous areas with steeper slopes are unsuitable for construction and habitation [48].

Using ArcGIS 10.7 software and DEM data, the elevations of the historical place names of each people's commune were extracted and statistically analyzed. The results show that the average elevation of people's communes in Henan Province is 156 m. With increasing elevation, the number of people's communes tends to increase and then decrease. A total of 96.1% of the historical names of people's communes are located in hilly and plain areas, which have suitable climatic environments, relatively few natural disasters, and superior conditions for agricultural development, which are conducive to the production and development of the people's communes.

2. Water systems

Proximity to water systems is closely linked to human activities. This study calculated the shortest distance between people's communes and water systems to determine their influence. On the one hand, rivers provide basic material security for human life and production [49]. In ancient times, people in China paid attention to Feng Shui, mostly preferring to build on the side of the mountains, and water and rivers were essential transportation corridors, playing an important role in transporting materials and cultural exchanges. Using ArcGIS 10.7 software to overlay and analyze the two layers of people's communes and significant rivers in Henan Province, the historical names of people's communes tend to be distributed along the rivers, which is especially significant in the Yellow River and Haihe River basins. Using this software to analyze the buffer zones of significant rivers in the province, it was found that people's communes were distributed within the buffer zones of 5, 10, and 15 km rivers, accounting for 63.7%, 91.1%, and 96.5%, respectively.

3. Temperature and precipitation

The climatic environment significantly influences the selection of sites for people's communes, where humans work and reside. Climatic factors must be considered in the selection of sites for commune construction, whose design and construction must align with local climate characteristics; these factors are crucial for ensuring and enhancing living conditions [50]. The annual average temperature in Henan Province exhibits an east-west gradient, whereas annual precipitation predominantly occurs in the southern, western, and northern mountainous and hilly regions. The distribution of traditional villages in Henan Province is uniform within the annual average temperature range of 4.1–16.0 °C. Excessively high or low temperatures impose certain constraints on agricultural production. There are comparatively fewer traditional villages in regions with extreme precipitation levels. Insufficient precipitation may result in water scarcity, adversely affecting agricultural production, whereas excessive precipitation increases the risk of natural disasters such as floods.

4. Ecological environment

As a direct participant in and responder to environmental changes, vegetation profoundly affects the energy balance of the Earth-atmosphere system and the ecological environment. The growth state of vegetation is the most direct response to changes in the climate, the environment, and other factors [51]. The normalized difference vegetation index (NDVI) was greater in the western and southern regions of Henan Province and lower in the central and northern regions. In this work, we use 1961 NDVI data to calculate the greening rate of Henan Province during the commune period.

4.3.2. Socioeconomic Factors

In this study, the human geographical factors selected for analysis include the economy, railway accessibility, road accessibility, and distance to central cities. Economic data are represented by nighttime light imagery from the 1980s, while railway and road data are derived from *Maps of Henan Province* from the 1970s. Central cities are defined based on the central counties of various regions from the 1965 administrative divisions. All of the above data can be observed in Figure 9.

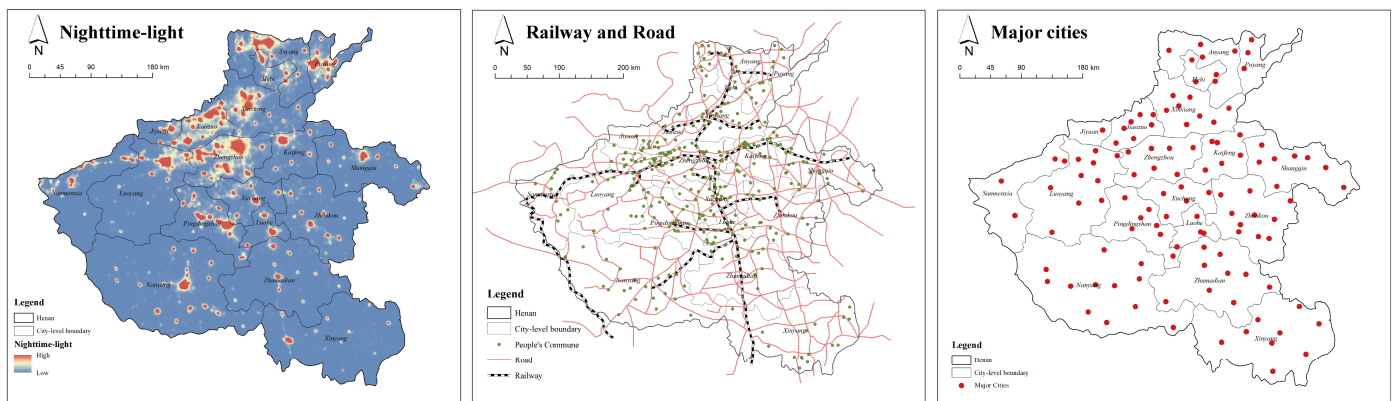


Figure 9. Socioeconomic factors in Henan.

1. Economic development

As seen from the literature review on people's commune planning, commune site layouts are influenced by local economic conditions; thus, this paper selects economic development as an influencing factor. Owing to the lack of data from the people's commune period, this study uses 1984 nighttime light data for Henan Province to represent the level of economic development. The results show Henan's economic development is characterized by a spatial pattern of "one horizontal, one vertical, and one core". This distribution is similar to the kernel density distribution of people's commune. The greater the level of economic development, the greater the distribution of people's communes.

2. Transportation conditions

To facilitate transportation, accessibility in commune planning was very important, in which roads and railroads were also key projects developed during the Great Leap Forward. In particular, there was a construction boom of earthen railroads in Henan. Roads and railways connect villages and are the main information channels. As shown in Figure 9, railroad and highway data were mapped via ArcGIS 10.7 on *Map of Henan Province*. The results show that most communes are located in places with good transportation accessibility.

3. Major cities

According to location theory, villages similar to people's communes show a clustered distribution around the central city; therefore, the distance from the central city was considered in this study. The center of each county administrative unit was selected, and the distance of the people's commune from each county administrative unit was calculated and assigned weights.

5. Discussion

5.1. Analysis of the Influencing Factors of People's Commune Sites Spatial Patterns in Henan Province

5.1.1. Main Influencing Factors on the Distribution of People's Commune Sites

This study revealed that the influencing factors on the spatial pattern of people's commune sites in Henan have varying explanatory power (refer to Figure 10a). All the factors passed the p value test at the 0.05 level of significance. Various factors influenced the spatial patterns of the sites, with precipitation being the dominant factor, indicating that the sites relied significantly on rainfall. The more abundant the precipitation, the greater the number of people's communes that will spread out. The primary industry of most people's communes is agriculture; therefore, the communes rely significantly on rainfall for cultivation. Given the limited level of economic and technological development in China at that time, agricultural development depended on the advantages and disadvantages of the natural conditions. Altitude and slope were among the natural factors significantly affecting the distribution of people's communes and communal production. The NDVI

has the least explanatory power, indicating the influence of the vegetation index on the people's commune sites is relatively weak.

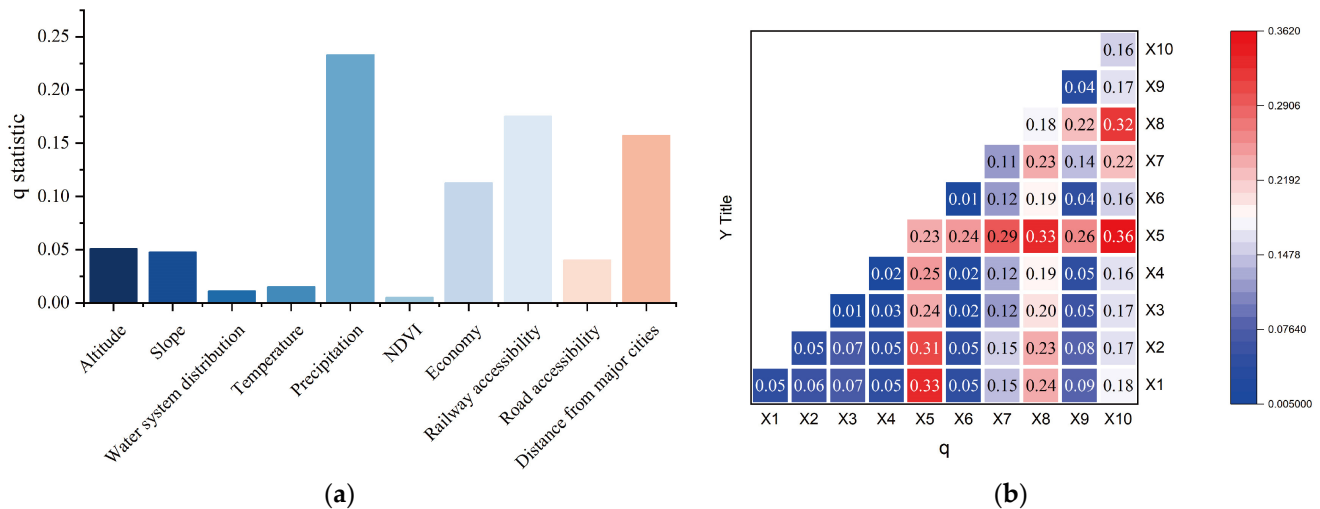


Figure 10. Results of geodetector analysis for people's commune site distribution: (a) results of single-factor analysis; (b) results of interaction factor analysis.

Social factors influence the distribution of people's commune sites more than natural factors. Among them, railway accessibility has a more significant influence on the spatial distribution of people's communes. At the same time, distance from major cities and the level of economic development also play a role in the spatial distribution of people's communes. During the people's commune period, to prepare for war and famine, important railway lines, such as the Jiao Liu Line, were constructed, constituting major transport arteries in the west that ran north-south and supported the construction of a strategic rear area; thus, railway accessibility had a more significant socioeconomic impact on the construction of communes. Moreover, cities are starting points for regional development and possess rich historical and cultural heritage, traditional architecture, and other resources that attract tourists. As a result, they have become core high-density areas where people's communes areas are located.

5.1.2. Interaction of Factors Influencing the Spatial Distribution of People's Commune Sites

The distribution pattern of people's commune sites in Henan is often influenced by individual factors and somewhat by the combined effects of multiple factors. After examining the main influencing factors of the distribution of people's commune sites, this study utilized the factor interaction detector module of geodetector to analyze the interactions among various influencing factors (Figure 10b).

According to the dual-factor detection results, the interaction between various influencing factors is greater than the sum of the influence of individual factors. The results (Figure 10b) indicate that the dual-factor explanatory power of the distance to major cities and precipitation is as high as 0.36, indicating that the interaction between these two factors is significant. The outcome highlights the crucial impact of precipitation on establishing people's communes, which relies not only on the influence of natural factors but also significantly on humanistic factors. Through the dual-factor interaction analysis, it is evident that the interaction with precipitation significantly enhances the influence of various factors. It also shows the enhanced effect of the primary influence of a single factor under certain conditions. Comparative observations revealed that the interaction results for each factor exhibited simultaneous increases or decreases, indicating that a complete promoting or weakening relationship was absent. In other words, due to the non-uniform geographical distribution of the driving factors, multiple influences emerged that either reinforced or limited one another when addressing the same distribution of people's commune sites.

Consequently, the distribution of sites within the study area was not determined by a single factor but resulted from a multifactorial approach.

5.2. Regionalized and Holistic Strategies for the Conservation and Spatial Governance of People's Commune Heritage

The people's commune was a form of economic organization during a particular period of Chinese history. The preservation of heritage within the commune contributed to conserving the historical memory and providing an essential source of information for this study and understanding of this specific period of history. At the same time, the commune also involves the cultural memories and traditions of a particular region, and preserving this collective heritage helps strengthen the cultural identity of residents, passing on and promoting regional cultural characteristics. The people's communes are a unique cultural resource, and their rational development and utilization can catalyze and drive the development of local cultural tourism. Finally, preserving this unique heritage can also strengthen the internal cohesion and sense of belonging within the collective and enhance social harmony and community building.

Having a certain number or proportion of authentic, historically accessible villages and essential elements that reflect the traditional style and sense of historical vicissitudes is a critical primary condition [52]. However, to protect traditional villages and towns, the old and new often coexist in the old streets or ancient villages, and they are all repaired using traditional colors. The few historical relics in the villages are submerged in the antique-style new vernacular style. Therefore, to preserve the built heritage of people's communes, it is necessary to first preserve the original materials of the buildings and then retain their original form. In addition to preserving historical buildings with high conservation value, such as the Great Hall, attention should be given to their vernacular environment. In addition to local material heritage, attention should also be given to intangible cultural heritage, such as the unique collective system of the people's commune period.

Yu proposed a strategic proposal to establish a network of vernacular heritage landscapes to protect the foundation of Chinese folk beliefs [53]. People's commune heritage landscapes should be systematically and wholly protected to form a continuous and complete landscape network, which also serves as a permanent space for the education of future generations, for recreation and integrating with bicycles and permanent network recreation systems that will be spread across the country in the future. To determine the scope of people's commune heritage, it is essential to focus on critical areas and important nodes of commune heritage protection, pay attention to cross-regional coordination, and formulate a holistic protection strategy. The *Weixing People's Commune* site in Henan Province, the *Red Flag Canal*, and the *Zhengzhou Cotton Spinning Mill* are all important nodes of the commune's heritage. Developing a strategy for conserving the heritage of people's communes aligns with today's buildings and landscapes.

The continuity of life implies recognizing the value of living heritage and focusing on the living atmosphere of many traditional dwellings and local inhabitants. Historical heritage, which is based on traditional residential functions, is rich not only in material and intangible elements but also in the long-term accumulation and merging of the two in space and time, constituting a society's spatial structure, spirit of place, and cultural identity [54]. Therefore, in preserving the heritage of people, maintaining a certain proportion of the original inhabitants to continue their lives, inheriting their cultural traditions, improving their infrastructure and living environment, and maintaining the vitality of the commune are appropriate. Moreover, as a unique product of the collectivization era, continuing life in the local community is maintained in contemporary collective construction by increasing the frequency of government–society interactions, combining governmentled and resident participation mechanisms, and improving the relationship between residents and the government while facilitating governance of the unit and its heritage.

Regarding the heritage of each type of people's commune, agriculture-oriented communes must emphasize the inheritance and education of vernacular culture. This is ex-

emplified by the establishment of agricultural museums that preserve knowledge related to agricultural production and the communal way of life during the commune period. In contrast, industry-oriented communes prioritize the protection and reuse of industrial heritage, focusing on the theme of collective memory. Villages with historical and cultural significance are selected for renovation and transformed into creative industrial parks to stimulate economic development. For the protection of integrated commune heritage, well-known representative sites should be identified for preservation. An example is the Hongqi People's Commune in Zhengzhou, which has chosen to preserve and transform significant structures, such as National Cotton Factory No. 2, as part of its heritage conservation efforts.

6. Conclusions

This study revealed that people's commune sites in Henan were concentrated in specific regions. Natural and social factors influenced the spatial distribution pattern. Natural factors such as precipitation significantly impacted the site distribution of people's communes, whereas social factors such as railway accessibility and distance from major cities also played essential roles. These findings are crucial for policy-making and planning decisions related to regionalized and holistic strategies for the conservation and spatial governance of people's commune heritage. They provided valuable insights into the factors that shaped their distribution in Henan.

This paper proposes recommendations for optimizing, conserving, and exploiting the vernacular-built heritage of people's communes in this particular period in terms of authenticity, integrity, and continuity. First, Henan Province is a famous agricultural province in China and a pioneering place of people's commune practices, with a rich and unique culture during the collectivization period. However, the economies and poor infrastructure of less developed regions limit the regional preservation of this type of vernacular heritage. The government should increase its investment in this type of heritage to improve the efficiency of resource utilization and its economic benefits and to protect the balance between development and conservation. Second, the transport infrastructure in rural areas of Henan Province should be strengthened, cultural cooperation and exchanges with neighboring regions should be explored, and collectivist spiritual tourism routes should be gradually opened in conjunction with famous revolutionary areas such as the Shanxi region. The government should also strengthen efforts excavating and protecting people's commune heritage. In addition, the transmission and preservation of intangible cultural heritage during the commune period should be promoted. These recommendations are concrete steps for promoting the sustainable development of people's commune heritage in Henan and China. By adopting an integrated approach to infrastructure development, cultural exchange, and heritage conservation, policy-makers can tap into the potential of this cultural heritage while ensuring its long-term sustainability.

Due to the limited availability of relevant data and field research time constraints, a significant need remains to supplement the database of people's commune sites in Henan that was constructed in this paper. Additionally, the index system of influencing factors requires further refinement. Subsequent research can use data from roads and comprehensive water systems for a deeper analysis, resulting in increased scientific rigor of the analysis. It is also worth studying how to measure the applicability of the current development strategy to the sustainable development of the heritage of people's communes and how to determine the degree of exploitation of this exceptional heritage. Focusing on the sustainability of people's commune heritage development and conducting quantitative research will contribute to preserving and promoting heritage in these regions. It will also help formulate evidence-based policies and strategies for the long-term sustainability of the heritage of people's communes. Specific heritage preservation efforts will require extensive field investigations and foundational surveys in the future. This paper provides a preliminary framework, reflected in a basic database and an analysis of influencing factors.

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