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Identification and Hierarchy of Traditional Village Characteristics Based on Concentrated Contiguous Development—Taking 206 Traditional Villages in Hubei Province as an Example

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Abstract: Public policy for the preservation and development of traditional villages in China has witnessed a shift. That is from the equal distribution of finances to officially recognised traditional villages to the prioritisation of the development of more potential traditional villages that stimulate the development of surrounding villages and regions. This study takes 206 traditional villages in Hubei Province as an example and proposes a method framework for 'Feature identification, Hierarchical classification (FIHC) that combines field research, spatial geography and spatial network methods. The results of spatial geography show that traditional villages in Hubei province are unevenly distributed, mainly along the mountain ranges in the east and west, with scattered distribution in the central plains. The kernel density result reveals "3 + 2 high-density hotspot zones" (A, B, and C are high-density areas, whereas D and E are low-density areas). Furthermore, the results of the spatial network appear that the traditional villages' ecological situation in Zone A is better than in other areas, but their transportation accessibility and economy are poor; Zone B villages' transportation accessibility is better than in other areas; Zone C has the best economy; and three conditions of traditional villages in the D and E zones are poor. FIHC can identify villages with more development potential and stratify these villages in a multidimensional way. It is innovative and an important contribution to policymakers and planners in developing 'phased and focused' public policies and rural planning.

Keywords: traditional villages; networks analysis; spatial distribution characteristics; hierarchical classification; concentrated and continuous development

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1. Introduction

In the context of global industrialisation, the imbalance between urban and rural development has changed dramatically in the relationship between rural people and land. The rural recession and depopulation have become global problems that need to be solved [1,2]. The proportion of the rural population in the total population is decreasing from 53.3% in 2000 to 43.8% in 2020 https://data.worldbank.org/ (accessed on 2 May 2022). A series of problems have emerged in the United States, Sweden, Japan and South Korea since the 1950s [1,3,4]. The sustainable development of rural areas has been severely constrained by the rural labour shortage, economic decline, the disappearance of traditional culture and ecosystem destruction. In the 1970s, many rich countries pioneered the rural renaissance movement [5,6], intending to achieve rural revitalisation, which promoted rural economic development and population growth [7] from the implementation of land consolidation, agricultural subsidy policy, revamped infrastructure, and other rural revitalisation

policies [8–10]. As in these countries, in 1978, China experienced unprecedented urbanisation [11,12] and made tremendous progress [13]. The rapid urbanisation rate is expected to continue until 2030 [14]. The urban population increased from 17.9% in 1978 to 60.6% in 2019 (NBS, 2020). In 2019, about 173 million peasant workers left their homes to work in cities (NBS, 2019), which has led to a labour shortage, a declining economic trend [15,16] and hollowing problems [17,18].

Unlike rural areas in general, China's traditional villages are of great interest to society due to their high historical, cultural [19], aesthetic, and tourism [20] values. However, they are also inevitably decaying or even disappearing in rapid urbanisation [21–23]. The ancient dwellings of traditional villages have been replaced by large-scale modern steel and concrete dwellings, and the historical character of traditional villages has been destroyed. Even though traditional villages experienced several challenges, they should not have perished. Given this, the central government of China began to realise the severity of these problems and has issued a series of policies to preserve and restore traditional villages. In 2012, traditional villages began officially being identified and archived across the country (MOHURD, MCL and MOF, 2012). By 2019 China had conducted five rounds of work, identifying and archiving 6819 traditional villages http://www.gov.cn/index.htm (accessed on 3 May 2022). Each identified and archived traditional village could receive a financial subsidy of RMB 3 million to restore the ancient traditional vernacular dwellings and the surrounding environment and build roads. In 2017, the 19th CPC National Congress first proposed the rural revitalisation strategy. Its core task is to build rural areas with prosperous businesses, ecological livability, civilised countryside, effective administration and well-off living [24,25]. However, traditional villages' preservation and development rely on government financial subsidies. Funds are distributed equally to each identified traditional village. The public policy has resulted in limited financial subsidies for each village. 2022 after ten years of policy promotion. Through field research, we found that the overall effect of the preservation and development of traditional villages in Hubei has not met expectations. Traditional village areas are rife with serious hollowing out, poverty, the absence of traditional culture and ancient houses that are uninhabitable due to a lack of funds to repair them. Fortunately, the government has realised the drawbacks of the policy of equal distribution and has introduced a new policy of centralised preservation and demonstration (CPD). The policy was intended to explore effective methods that stimulate the revitalisation of traditional villages areas. How to pick examples of counties and cities, how to define concentrated contiguous regions, and how to allocate development funding and resources is a rigorous and scientific task.

Studies on rural settlements can contribute to the development of rural areas. Related research mainly includes settlements tourism [26–30], heritage value assessment [31], rural landscape [32], the reconstruction of settlement [33–35], spatial evolution [36,37] and distribution characteristics [38,39]. Yifei Pei was based on a literature review, field research, qualitative analysis, and quantitative analysis to analyse the layout forms and characteristics of Nine inter-village spaces in the Hongguan village group [40]. Song Lu employed questionnaires, in-depth interviews and image records to analyse the influence of tourism development on the linguistic landscape in Hongcun [41]. Ren Yang, Sun Yat-sen University, used the Average Nearest Neighbour Distance (R) index and the geographical detector method to analyse the distribution characteristics of rural settlements and their implications for rural reconstruction. This study has profound implications for subsequent related research. Jianbin Xu used a principal component analysis (PCA) to analyse the spatial pattern and impact of settlement isolation and land use changes on poverty in Guizhou [42]. Jing Chen measured village development potential, identified future development direction and classified villages [43]. Haoran Su adopted a series of spatial analysis methods to investigate the characteristics of the traditional village distribution in China by using the watershed as the research unit. They also revealed the complex and various characteristics of the traditional village distribution and its influence mechanism and offered scientific advice for traditional villages' future protection and development [44]. In general, the

research on rural settlement space varies from simple to comprehensive, from qualitative descriptions to quantitative analysis.

Network analysis, derived from graph theory, attempts to describe the structure of relations (links) between given entities (nodes) and to study the characteristics of a whole network and the position of individuals in the network structure [45]. It has long been the subject of many studies in mathematics, mathematical sociology, computer science and quantitative geography [46]. It is a theoretical approach that integrates integrity, stochasticity, and complexity to reveal the whole function and evolutionary characteristics of complex systems from the topology of networks and the connectivity behaviour between nodes [47,48]. Although networks have contributed significantly to the sustainable development of rural areas in several existing studies, there is limited research in this field. Hsin-Yu Shih investigates the network characteristics driving tourism in 16 tourist destinations in Taiwan with the help of network analysis methods [45,49]. Jizhe Zhou interpreted the complex system of rural settlements based on the complicated social network in Qin and Han New City [50].

Very little literature currently uses spatial networks to identify traditional villages' distribution characteristics and hierarchies. The key to CPD is identifying critical and model villages and the hierarchy of villages. There are 6819 traditional villages in China, and regional differences have led to significant differences in architectural style, culture and economy, and targeted policies and planning are essential. This paper proposes a multi-method research framework (FIHC) for analysing the characteristics and hierarchy of 206 villages in Hubei, using Hubei Province as an example (Figure 1). This framework is efficient and scientific in identifying the characteristics of network structures and classifying nodes. It is innovative and outstanding in that the approach of stratifying a large number of traditional villages helps governments and planners to develop 'phased and focused' policies and planning. It is crucial for policymakers and planners.

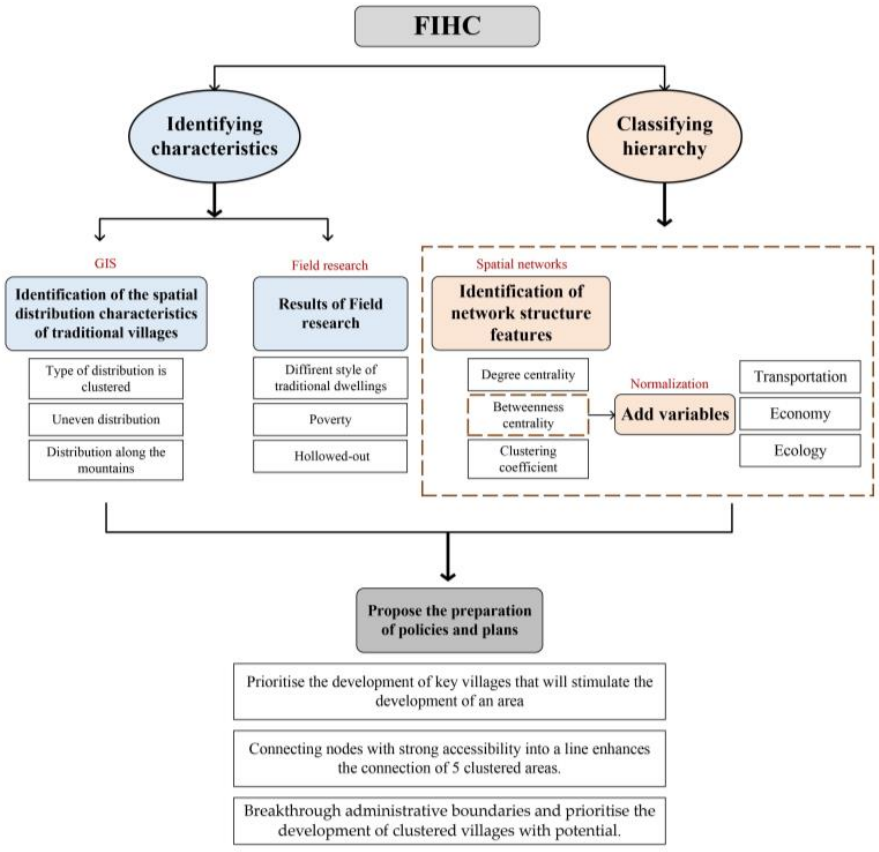


Figure 1. The method framework for Feature identification, Hierarchical classification (FIHC).

To overcome the long-term difficulties in slowly developing traditional villages and formulating policies that do not in line with the actual situation in Hubei. The specific objectives of this paper are as follows: (1) to propose a method framework (FIHC) identifying characteristics of traditional villages in Hubei (Figure 1); (2) to identify the characteristics of traditional villages in Hubei and classify the hierarchy; and (3) to propose scientific policies that are in line with the preservation and development of traditional villages in Hubei. The overall objective of this study is to provide recommendations and scientific references for formulating policies on the conservation and development of traditional villages in Hubei Province. The innovation of this paper is the addition of three variables affecting the development of traditional villages and data from field research. It makes the identification of the distribution characteristics more realistic.

2. Materials and Methods

2.1. Study Area

Hubei Province is located in central China (108°21′42″ E~116°07′50″ E, 29°01′53″ N~33°6′47″ N) (Figure 2). The province has a land area of 185,900 square kilometres, with mountains accounting for 56%, hills for 24%, and lakes for 20%. The topography of Hubei Province is complex and diverse, with the province surrounded by mountains on three sides, such as the Dabie Mountains in eastern Hubei, The Wuling Mountains and the Wushan Mountains in western Hubei, the Wudang Mountains and the Dahong Mountains in northern Hubei, and the Mubu Mountains in southeastern Hubei. The central part is Jianghan Plain, which is rich in lake resources.

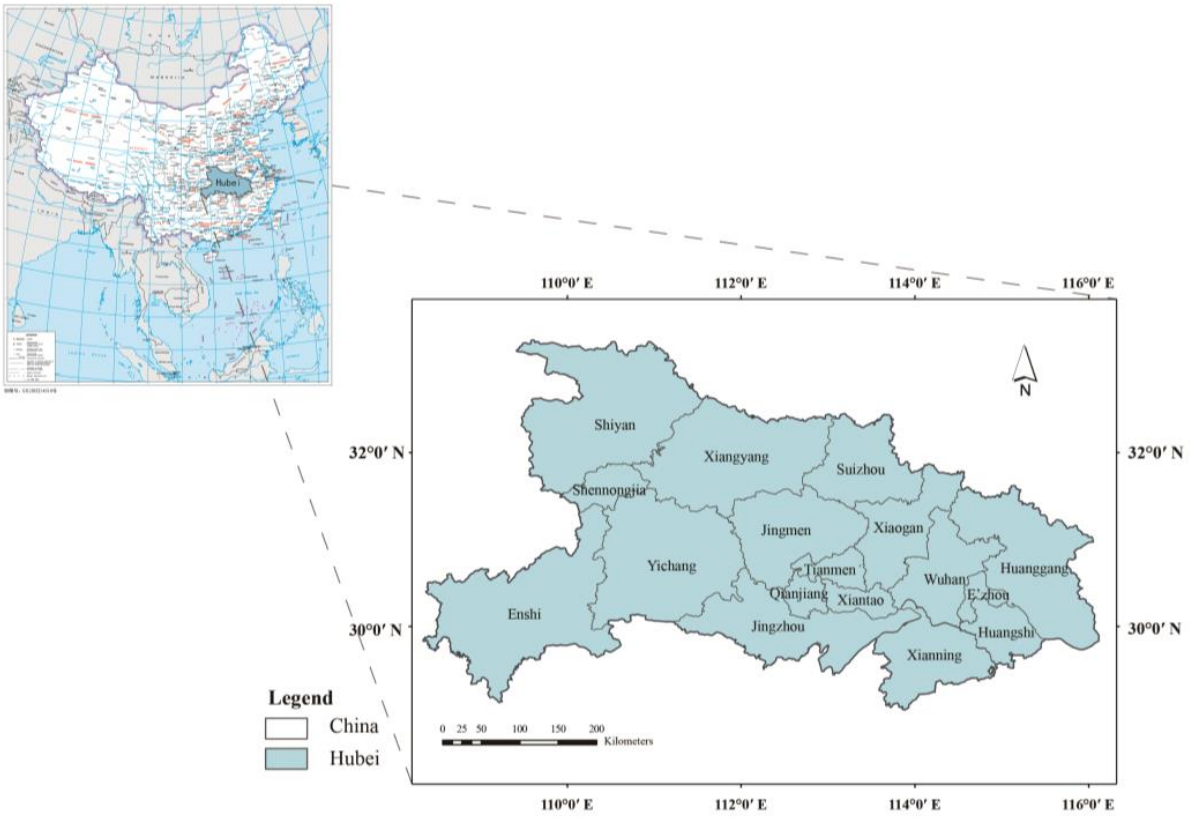


Figure 2. The location of the study area.

2.2. Data Sources and Processing

The data on 206 traditional villages in Hubei Province comes from the list of five batches of traditional villages published by the Ministry of Housing and Urban-Rural Development of the People's Republic of China http://www.mohurd.gov.cn (accessed on

3 May 2022). Village latitude and longitude information using LocaSpace Viewer (three-dimensional digital earth software) for the place name retrieval calibration and related data cleaning and entry. The digital elevation data of Hubei Province comes from the Geospatial Data Cloud website SRTM30 meter data information. The administrative division data of Hubei Province comes from the basic geographic information technology system of Hubei Province. Traffic data from Hubei province comes from OpenStreetMap www.openstreetmap.com (accessed on 2 November 2020). Nightscape light images from Hubei High-Resolution Center LuoJa No.1 http://59.175.109.173:8888/index.html (accessed on 15 November 2020). The satellite remote sensing data comes from landsat7-landsat8 satellite remote sensing band maps (the basic grid size unit is 30 × 30 m).

According to the list of 6819 traditional villages published by the Ministry of Housing and Construction of China, Hubei Province accounts for 206 villages, which is 3% of the national total. Among them, Enshi Autonomous Prefecture has the most distribution (81), Huanggang City (36), and some municipalities have one or no distribution within their boundaries (Table 1).

Table 1. The number of traditional villages in cities and prefectures in Hubei.

No.	City and State Name	Number
1	Enshi Tujia and Miao Autonomous Prefecture	81
2	Huanggang	36
3	Xianning	21
4	Huangshi	13
5	Shiyan	13
6	Yichang	12
7	Xiaogan	11
8	Xiangyang	6
9	Suizhou	4
10	Wuhan	4
11	Jingmen	3
12	Jingzhou	1
13	Xiantao	1
14	Ezhou	0
15	Tianmen	0
16	Shennongjia Forestry District	0
17	Qianjiang	0

2.3. Methods

2.3.1. Geospatial Analysis Method

1. The Nearest Neighbour Index

The spatial structure characteristics of traditional villages present the villages in the form of point elements on the map and use geographic information technology to process the data. The spatial distribution of 206 points was identified by the nearest neighbour index method and kernel density analysis. The proximity index method characterises the degree of mutual proximity of traditional villages in geographical space. The calculation formula is:

$$R = \frac{r_1}{r_E} = 2\sqrt{r_1 D} \quad (1)$$

Among them, R represents the nearest point index; r_1 represents the average value of the actual distance between each point and the nearest point; r_E is the theoretical nearest distance; d is the point density. $R = 1$, the distribution type of point elements is random; $r > 1$, the distribution type of point elements is uniform; $r < 1$, the point distribution is condensed type.

2. Kernel Density Estimation

The kernel density analysis method can analyse the equilibrium degree (balance level) of the density of each point element in a certain range around and visualise the spatial distribution density characteristics of traditional villages through QGIS software [51]. The formula is:

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} k(\frac{x - x_i}{h}) \quad (2)$$

where $f(x)$ represents the kernel density function; x_i represents the position coordinate of the ith traditional village, h is the bandwidth; n represents the number of all traditional villages; the k function represents the distance relationship between each point element x and the core x_i [52].

2.3.2. Methods of Spatial Networks

1. Methods for Constructing Networks

(1) Voronoi

Voronoi tessellations are interesting for spatial networks because they provide a natural null model to which one can compare a real-world network. A Voronoi diagram is determined by distances to a specified discrete set of points. Each site has a Voronoi cell *V (s)* consisting of all points closer to s than any other site. The segments of the Voronoi diagram are all the points in the plane that are equidistant to the two nearest sites. The formula is:

$$p_n = \frac{c}{4\pi^2}\frac{(8\pi^2)^n}{(2n)!}[1 + \vartheta(\frac{1}{\sqrt{n}})] \quad (3)$$

which at the dominant order behaves as $pn \approx n{-}2n$.

(2) Delaunay Triangulation

Delaunay triangulation is good at solving the problem of spatial proximity in computation and geometry. It is a dual spatial relationship with the Thiessen polygon, which is a set of adjacent and non-overlapping triangles in space. In a traditional village, the village that has the most significant effect on a particular village is the one that is close to it. The construction of Delaunay triangulation is the concrete representation of the interaction between traditional villages.

Data Normalised Treatment (Table 2)

Table 2. Data normalisation formula.

Name	Equation	Equation Interpretation	No.
Radiance Formula of Luojia No. 1	$L = DN^{3/2} \cdot 10^{-10}$	Where L is the absolute radiation correction after the radiation brightness value. The unit is $W/(m^2 \cdot sr \cdot \mu m)$, DN is the grey value of images.	(4)
NDVI Vegetation Index	$NDVI = (band5\ band4)/(band5 + band4)$	Where *band5* and *band4* refer to the spectral reflectance in the near-infrared and red bands, respectively [53].	(5)
Normalised Equation	$X_{non} = \frac{X - X_{min}}{X_{max} - X_{min}}$	Where the normalised equation performs a linear operator of the raw data to achieve an isometric scaling of the original data. The different kinds of data are grouped into one dimension. X is the original data.	(6)

3. Spatial Networks Indicators

Spatial networks are derived from graph theory. It constructs a given entity (node) as a network system, studies the structural relationships between nodes within the network and

derives relevant metrics and results [45,54]. Three centrality indices (i.e., Degree centrality, Betweenness centrality, and Clustering coefficient) are chosen for the network construction method of this study to analyse the villages (Table 3).

Table 3. Spatial networks indicator formula and interpretation.

Name	Formula	Formula Interpretation	No.
Degree centrality (DC)	$C_{DC}(i) = \sum_{I=1}^{n} x_{io}(n-1)$	***CDc*** is the degree of centrality of a single village, *i* represents the ith traditional village node within the network, *n* is the total number of traditional villages. *xij* is the degree of connectivity between the ith and the other village [55].	(7)
Betweenness centrality (BC)	$C_{\mathrm{BC}}(i) = \sum \frac{d_{io}(n)}{d_{io}}$	$\boldsymbol{C_{BC}}$ is the intermediary centrality of a single rural area. ***dij*** denotes the number of shortest paths from *i* to *o*. *Dio (n)* is the number of nodes that pass through in the shortest path from *i* to *o*.	(8)
Clustering coefficient centrality (CC)	$C_{CO}(i) = \frac{2L_i}{k_i(k_i-1)}$	$\boldsymbol{L_i}$ denotes the number of links between the $\boldsymbol{k_i}$ neighbours of node *i*. The higher the degree of connectivity between nodes, the more conducive to forming a stable network structure [45,46].	(9)

3. Results and Analysis

3.1. Geospatial Distribution Characteristics of Traditional Villages in Hubei Province

To get an overall understanding of these 206 villages, we need to analyse the spatial distribution of these villages before applying the network approach to village analysis. Using Formula (1), we can measure the distribution attributes of the villages. Formulas (2) and (3) are used to visualise the spatial distribution characteristics.

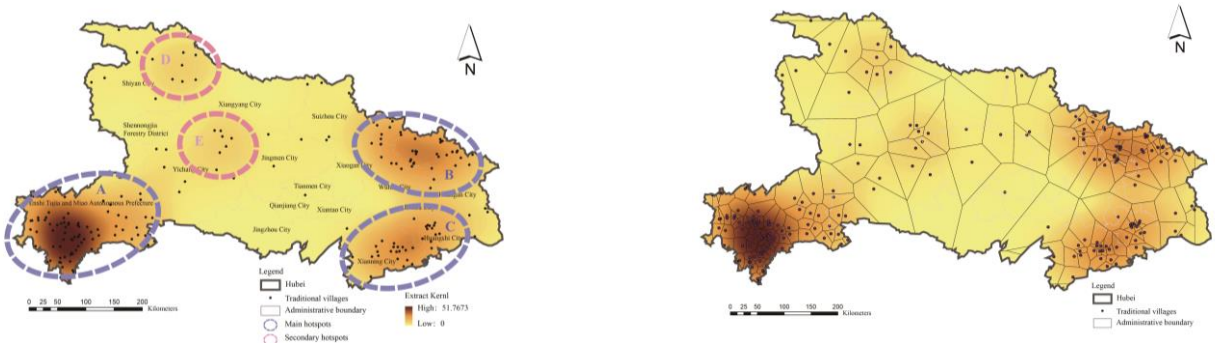
3.1.1. The Distribution Type of 206 Traditional Villages Is Clustered

Individual traditional villages are points in space. There are three main types of the spatial distribution of point-like elements: clustered, random and dispersed. The closest proximity index is $R = 0.584 < 1$, and the closest proximity distance is 11.38 km. The results show that the distribution type of traditional villages in Hubei Province is clustered.

To further determine the clustering areas and the degree of clustering of traditional villages in Hubei Province at the spatial level, a kernel density hotspot map of traditional villages in Hubei Province was generated by Formula (2) (Figure 3a). The spatial distribution of traditional villages in Hubei Province shows a "3 + 2 high-density zones" pattern. That is three high-density areas, Zone A, B and C, and two secondary high-density areas, Zone D and E. Moreover, Zone A has the highest density.

3.1.2. Traditional Villages Are Extremely Unevenly Distributed

Although the distribution type of traditional villages in Hubei Province is clustered, only a few scattered villages are distributed in the Jianghan Plain. It is a "clustered distribution in the east and west and a dispersed distribution in the middle" Features. To analyze their neighbour relationship more precisely, we obtained the Voronoi diagram using Formula (3) (Figure 3b).



(**a**) (**b**)

Figure 3. (**a**) Kernel density distribution of traditional villages; (**b**) Voronoi diagram of traditional villages.

3.1.3. Distribution of Traditional Villages along Mountain Ranges

Figure 4 shows that the elevation of Hubei Province ranges from −138 m to 3088 m, with a topographic pattern of high in the west and low in the east. The 206 traditional villages in Hubei province are characterised by their distribution along mountain ranges, ranging from 20 m to 1420 m above sea level. Moreover, they are mainly distributed along hills and mountains above 200 m. More specifically, the traditional villages in Zone A are mainly located along the Wuling Mountains and the Ta-pa Mountains, while those in Area B are mainly located in the remaining Ta-pieh Mountains and those in Area C are mainly located along the Mu-fu Mountains. Moreover, Zones D and E villages are mainly located along the Ta-pa Mountains.

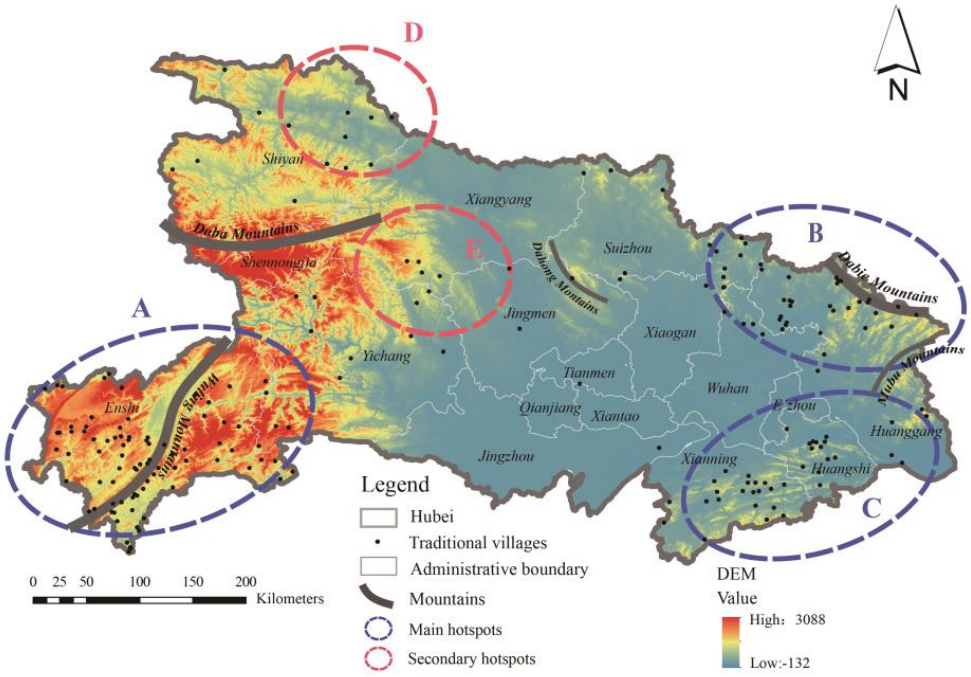


Figure 4. The DEM map and major mountains of Hubei province.

3.1.4. One of the Most Basic Principles in Choosing a Residential Site Is "By the Mountain and the Water"

The topography obviously influences the distribution and layout of traditional villages in Hubei Province. As there are many mountains and water in Hubei, the influence of mountains and water systems on the layout of village sites is often decisive. No matter

the mountain villages in the south and northwest of Hubei or the waterfront villages in Jianghan Plain, one of the most basic principles to choosing a home base is to rely on the mountains and water as the source of life. Without water, people cannot survive. Contour lines mainly determine the layout of mountainous villages in Southwest and Northwest Hubei, and there are spatial forms such as parallel contour layout, terrace layout and scattered layout according to the topography of villages. The water system and traffic influence the layout of villages in Jianghan Plain. Even in places without hillocks, villages are backed by low hills as much as possible, and the spatial form of villages is developed along roads or perpendicular to water banks. The garrison villages in northwestern and northeastern Hubei are mostly in the ravines. Walls and gates are set up around the villages according to the terrain and passages. The buildings in the villages are scattered and staggered due to the constraints of the terrain.

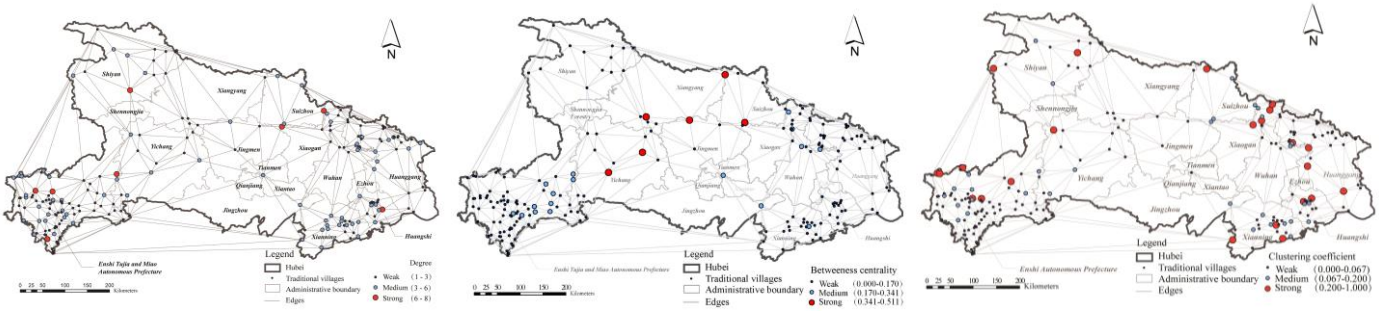
3.2. Spatial Network Characteristics of Traditional Villages in Hubei

The previous section analysed the spatial distribution characteristics of traditional villages in Hubei Province from a macro level. This section uses the method of the spatial network to identify traditional villages' structural features and classify them. First, three network centrality indicators (Formulas (7)–(9)) were chosen to analyse the structural features of these villages. Nevertheless, the evolution and development of traditional villages are affected by many factors, such as transportation, economy, policy, history and ecology [56]. Consequently, three main influencing factors were selected to adjust the network structure, adding traffic data, nightscape light images and NDVI data to betweenness centrality. Then, comparing the adjusted results with the raw results is necessary to assess the impact of these data on the network. Consequently, the structural characteristics of traditional villages can be obtained more accurately.

3.2.1. Original Spatial Network Results

1. Low Connectivity of Villages

The more connections a node has with its neighbours, the higher value of DC, which is more important in the network. Figure 5a illustrates that there are only four nodes with the highest value of 8 out of 206. The classification results show that there are only eight nodes in the Strong class, 72 in the medium class and as many as 126 nodes in the Weak class. It indicates that only 8 of the 206 traditional villages in Hubei are most connected to other villages and have the most significant effect on others. It is worth noting that up to 62% of the villages are weakly connected and have little effect on other villages. The eight most influential villages should be the focus of attention when formulating future conservation measures and development planning.



(**a**) (**b**) (**c**)

Figure 5. (**a**) Result of degree; (**b**) Result of betweenness centrality; (**c**) Result of clustering coefficient.

2. Poor Accessibility in Traditional Villages

The number of links between individual villages and neighbouring villages is not the only indicator of the importance of villages in the network structure. It is also essential to determine which villages are located on the shortest path between two villages, which reflects the accessibility of these villages. BC can be used as a metric to measure. According to its results (Figure 5b), the classes of the Strong and Medium have 6 and 32 nodes, respectively. Remarkably, there are 168 nodes with a value $\leq$0.170 in the Weak class, of which 25 have a value of 0. 38 villages in the province have good accessibility. 82% of the villages are located in areas with poor accessibility.

3. High Extent of Clustering in Traditional Villages

Figure 5c shows that CC can be used to describe the extent to which network vertices are clustered with each other. Larger nodes indicate a greater extent of the chain with surrounding nodes. As a result, surrounding nodes tend to cluster more towards the nodes. It indicates that there are 22 nodes with a Strong class, 39 with a Medium class and 145 with a Weak class. The nodes in the Strong and Medium classes are more advantageous than the Weak class in implementing concentrated conservation and development in clusters in the future. Therefore, priority should be given to these nodes in the class of Strong and Medium.

3.2.2. Adjusted Spatial Network Characteristics

1. Traditional Villages have poor Accessibility

Figure 6b shows the network structure affected by the traffic data. As shown in the figure, the network structure does not change significantly due to the effect of road weights. There are ten nodes in the Strong and Medium classes, respectively. As many as 186 nodes fall into the Weak class, with 90% of nodes in poor traffic conditions. This result is not significantly changed from the original result. Furthermore, the road weight has weakly affected the network. There were four more nodes in the Strong class, seven fewer nodes in the Medium class and three more nodes in the Weak class (Table 4).

Table 4. Comparison of original and adjusted network results.

Class	Number of Nodes with Original betweenness Centrality	Number of Nodes with Added Weights		
		Road	Light	NDVI
Strong	6	10	10	19
Medium	17	10	31	76
Weak	183	186	165	111

Regarding "3 + 2 High-density hotspots zones", B, A and C Zones have 3, 2 and 1 nodes in the Strong nodes, respectively. Zone B has better traffic conditions than the other zones. Although villages in Hubei Province are clustered, 90% of the villages are in mountainous areas with poor access, especially in Zone A, where the Wuling and Wushan Mountains block the interconnection between them. In order to enhance the entire network structure and promote the sustainable development of the 206 villages, it is necessary to focus on 20 villages with high traffic accessibility to strengthen the connection between villages.

2. Traditional Villages have a poor Economic Condition

Nightscape light images can reflect the economic vitality and GDP of an area. Figure 6c shows the adjusted network affected by it in Hubei Province. It shows that ten nodes are in a Strong class, 31 in the Medium, and 165 in the Weak class. Compared with the results of the original network, the adjusted network has more nodes with higher classes (Strong and Medium), but 80% of the nodes are weakly affected by nightscape light images. It shows that The overall economic level of traditional villages in Hubei Province is poor and hollowed out [57].

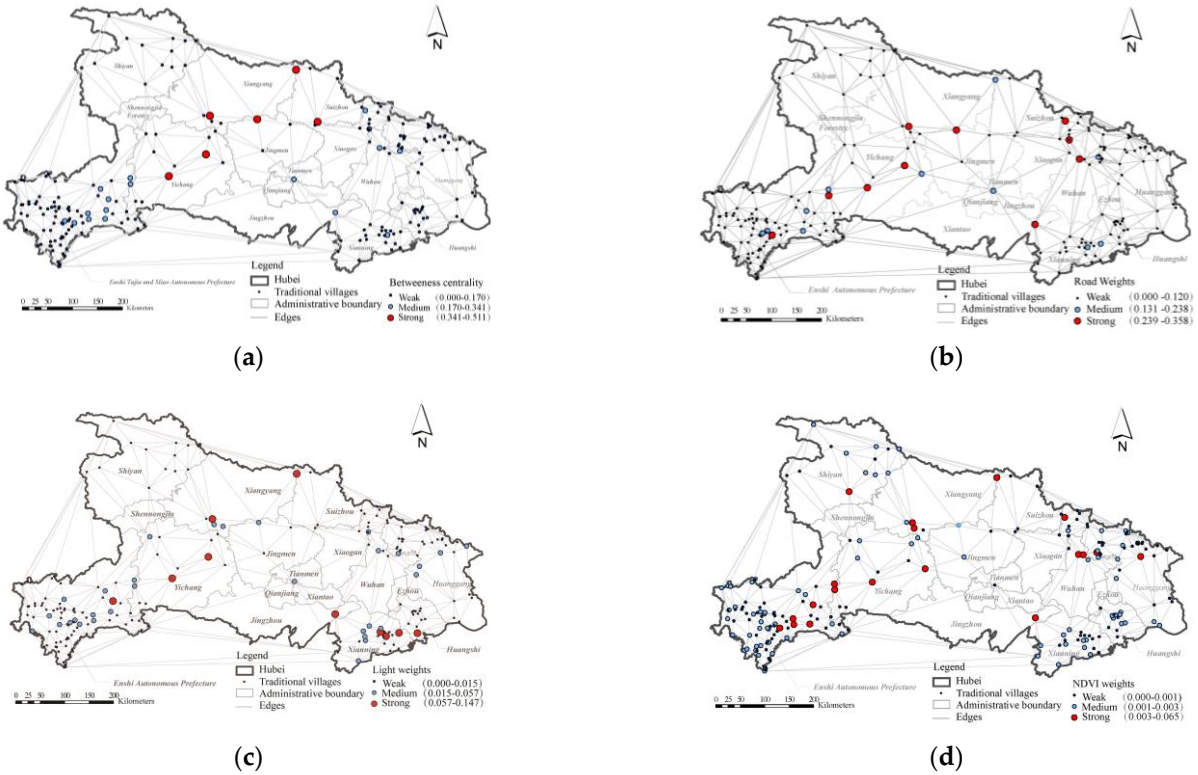


Figure 6. Adjusted network results. (**a**) Original network; (**b**) Results of road weights; (**c**) Results of light weights; (**d**) Results of NDVI weights.

In terms of "3 + 2 High-density hotspots zones", the nodes in Zone C are most obviously affected by the Wuhan economy, while those in Zones A and B are mainly unaffected. More specifically, among the 40 nodes in Zone C, there are up to 5 nodes in the Strong class and 6 in the Medium class. Zone A has one strong-class node and 13 medium-class nodes, while Zone B has only six medium-class nodes, none belonging to the Strong class. Several factors have contributed to the result. Firstly, there is hot spring tourism in Xianning, the central city in Area C. Many tourists from Wuhan are attracted by tourism, which stimulates the local economy [58,59]. Secondly, due to poor transportation and mountain barriers, the main cities of Enshi and Huanggang city in Zone A and Zone B were included in 14 destitute areas in China. The two cities in poor economic situations were not lifted out of poverty until 2019 [60].

3. The Ecological Conditions of Traditional Villages in Hubei Province are Good

Figure 6d shows the network as influenced by the NDVI weights, with larger nodes indicating better ecological conditions than the smaller ones. Compared to the original network, this adjusted network is significantly influenced. There are 19 nodes in the Strong class, 76 in the Medium, and 111 in the Weak class. In addition, 46% of the 206 traditional villages have good ecological resources. Compared to the original network results, the adjusted network is more solid, with 13 more nodes in the Strong class, 59 more in the Medium class, and 72 fewer nodes in the Weak class (Table 4).

In terms of "3 + 2 High-density hotspots zones", A zone has the best ecological environment because of mountain barriers and poor transportation. This area is not heavily urbanised and not industrialised. Therefore, the ecological resources are better protected than in other Zones. There are seven strong-class nodes and 33 Medium class nodes out of 40 nodes in the Zone. The worst ecological environment is in Area C. Thanks to the development of spa tourism in this area, promising economic development has been achieved, but the ecology has been damaged. There is only one node in the Strong class, 19 nodes in the Medium class and 20 nodes in the Weak class. This adjusted network

suggests that economic development should not be the only goal in further conserving and developing traditional villages. The conservation of the ecological environment is also an essential factor in the sustainable development of these villages.

3.3. Field Research Results

The spatial distribution and network structural characteristics of 206 traditional villages have been identified in the previous two sections. However, the development of traditional villages is multi-factorial. The spatial networks method cannot fully identify these influencing factors, such as the conservation situation of traditional dwellings, the survival of intangible cultural heritage, and historical culture. These influencing factors can be obtained by utilising field research. The method framework for 'Feature identification, Hierarchical classification(FIHC) 'can be used to combine the three methods to comprehensively identify the distribution characteristics of traditional villages in Hubei Province. We selected 36 villages in three counties and cities distributed in three high-density hotspot zones (12 in Area A, 16 in Area B, and 6 in Area C) to conduct field research work. The results of the field research are as follows.

1. Traditional Dwellings have Different Styles

Most of the 36 traditional villages were built during the Ming and Qing and the Ming Dynasties. Apart from a few traditional dwellings damaged by age, all are well preserved. They have high historical and cultural value and are worthy of further research and conservation. The three have formed distinctive styles of dwellings. Zone A has formed wooden frame-based stilted dwellings with a minority style, while Zones B and C have formed Jingchu-style dwellings made of masonry. Moreover, the layout of the traditional dwellings in Hubei was under the strong effect of the so-called geomantic omen, which said that the house's site selection should obey the rule of 'gathering mountains and rivers all together, holding breeze and getting water' [61]. Based on the photographs (Figure 7) from the field research, we find that most of these traditional dwellings conform to this rule.

2. Traditional Villages have sound Ecology

According to the results of the field research, the ecological condition of Hubei Province matches the adjusted network with NDVI (Figure 6d) and the DEM map (Figure 5). Twelve villages in Xuanen County have better ecological conditions than villages in Machen and Thongshan. Because Xuanen County is in the Wuling Mountain, one of the largest mountainous areas in Hubei Province, it is less disturbed by the outside world and has better preserved deep forest resources. It fully indicates that the adjusted network can reasonably identify the characteristics of traditional villages.

3. Traditional Villages are Seriously Hollowed Out and Lack Vitality

During the field research, We interviewed local leaders and villagers. We found that most of these traditional villages have problems with hollowing out. Very few young people live there; it is mostly older people and children. The villages are not vibrant enough. The economic development of these villages is lagging due to some factors (such as mountainous barriers, labour outflow and a single economic structure) [18,57,62]. To achieve the goal of sustainable development of traditional villages, Planners should consider adjusting the industrial structure of traditional villages to attract more young labour. Traditional villages differ from common villages and possess unique historical and cultural values. It is well suited to increased tourism and agro-processing industries.

4. The Imbalance Between Conservation and Development

Traditional villages have historical, cultural, ethnic and aesthetic values, unlike ordinary villages. Excessive development is bound to lead to the destruction of these values. In our field research, we found that most of the villages with better-preserved traditional villages suffer from economic lag and severe hollowing out. Some traditional villages with

better economic development have suffered damage to their historical culture, customs, traditional dwellings and layout. For example, the villages of Shiqiaowan and Fuxingwian in Macheng are close to town, so the village economy has developed well. However, only two or three ancient houses have been conserved in the two villages. The rest of the traditional houses have been replaced by new ones. The historical appearance of the two villages has been damaged seriously and has lost its historical character as a traditional village (Figure 7). Thus, the sustainable development of traditional villages must be based on the preservation of traditional culture. If the traditional culture is destroyed or even lost, then it cannot be called a traditional village in China. Scholars, experts, builders, and policymakers need to consider how to balance the protection and development of traditional villages.



Figure 7. Results of the field research.

4. Discussion

Rural revitalisation is an area of research focus around the world. Many developed countries have taken many measures to achieve a rural renaissance [6]. The same is true for China. As a rural area carrying history, traditional villages have received significant attention in revitalising rural areas in China [63–66]. The traditional villages in Hubei have undergone ten years of top-down preservation and development. Overall, some experience and results have been achieved in preservation and restoration, but the problems of poverty, hollowing out, and lack of funding in the region are still severe. Scientific and rational public policies and village planning are crucial.

4.1. Obstacles to Revitalizing Traditional Villages in Hubei

4.1.1. Limited Development Funding and Over-Reliance on Government

In summary, the conservation and development of traditional villages in Hubei Province have been conducted for ten years. After the field research, we found that the development situation of 36 villages is not ideal. Thirty-six villages have a different extent of hollowing out, and the villages have no vitality. Because of this, although each village has been allocated funds. The funds are limited to achieve sustainable development. The development of traditional villages cannot rely entirely on top-down support, but should also mobilise the power of villagers and society to build them together from the bottom up.

4.1.2. Mountainous Terrain and Poor Transportation Hindered the Development of the Village with the Outside World

Most of the 206 villages in Hubei Province are located in mountainous areas above 200 m, and 82% of the villages are inaccessible. These barriers affect the ability of traditional villages to connect with surrounding towns, sell agricultural products, and introduce new technologies. Many villages are still subsistence smallholder economies.

4.2. Strengths of FIHC Framework in Rural Revitalisation

4.2.1. The FIHC Helps Make Policymakers Implement the Work of Concentrated and Continuous Demonstration Counties

China's rural revitalisation strategy has provided policy assistance and guidance for the sustainable development of rural areas. As a rural area with history and culture, the development of traditional villages in Hubei Province has attracted much attention. Since 2012, China began to pay attention to the value of traditional villages and has introduced many top-down policies and given a lot of financial, human and material support in the past ten years. However, the overall development effect has not been satisfactory. Due to many problems, it is difficult for traditional villages in Hubei Province to achieve self-sustainable development. Policymakers were also adjusting their policies. In 2012, each region was given the same policy; by 2022, two to three concentrated demonstration counties were selected in each province. The Ministry of Finance has changed the way it allocates funds—from the original allocation of RMB 3 million per traditional village to RMB 30 to 50 million per demonstration county in 2022. The limited funds will be allocated to demonstration counties with a high number of traditional villages. The purpose of the policy change is first to support the development of this part of the demonstration counties; then it is to activate the development of the surrounding areas. Finally, successful and replicable conservation and development experiences are summarised and offered to the whole country. However, how to select the demonstration counties and how to delineate the contiguous development areas within the demonstration counties becomes another challenge. Our proposed FIHC framework will guide policymakers to select model counties and help model county leaders to delineate concentrated contiguous areas for traditional villages.

4.2.2. The FIHC Helps Village Builders Implement "Hierarchical and Key Nodes" of Traditional Village Planning

With the national emphasis on traditional village areas, the advantages of traditional village areas have gradually come to the fore, attracting the attention of all sectors of society. The rise and development of ancient village tourism have brought opportunities to these areas. Traditional village protection and tourism development planning have been prepared all over Hubei Province. However, practical planning cannot be accomplished without scientific and effective methods. FIHC effectively identifies traditional villages' development advantages and potentials and classifies 206 villages into different classes according to their advantages and potentials. It helps village builders to implement the "hierarchical and key nodes" planning of traditional villages, which is of great significance to the sustainable development of traditional villages.

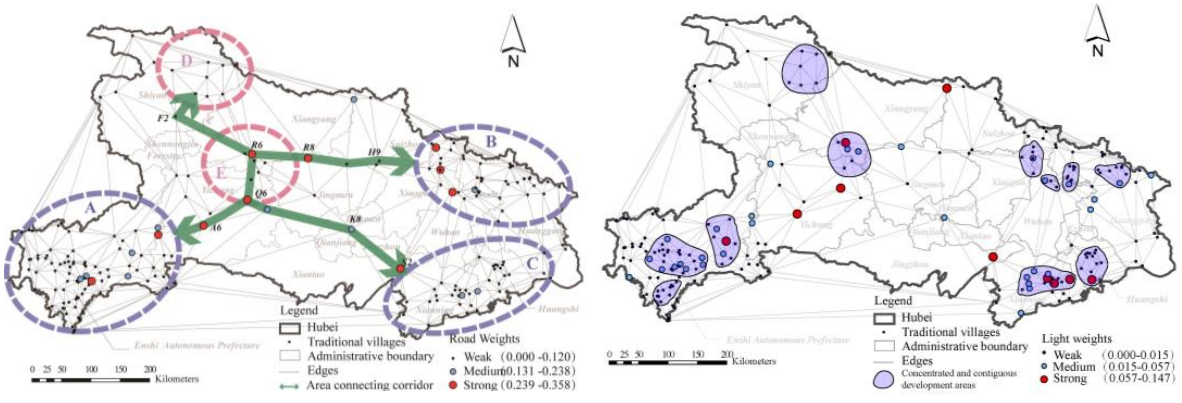
4.3. Policy Suggestions

4.3.1. Prioritise the Development of Key Villages That Will Stimulate the Development of an Area

The development of traditional villages has always been dependent on national policies. However, the government has limited finances, staff and energy. The rational allocation of these resources requires a 'hierarchical and phased' approach to developing these villages. In allocating resources, consideration should be given to focusing on the Strong and Medium class nodes with the degree, betweenness centrality, and Road weights. These villages have a strong connection with neighbouring ones, which can stimulate the development of the surrounding villages.

4.3.2. Connecting Villages with Strong Accessibility into a Line Enhances the Connection of 5 Clustered Areas

Traditional villages in Hubei Province are distributed according to mountain ranges showing "small clusters and large dispersions". The eastern and western ends are densely distributed, while the middle of Hubei is scattered. The current linkage between these five clusters is weak, and how to strengthen the linkage between these five clusters. It is possible to select villages with higher traffic accessibility (A6, Q6, R6, R8, H9, K8, S2, F2) and play the role of a hub for these nodes (Figure 8a). These villages are linked into a line as a corridor connecting the five clusters, enhancing circulation and development between the five clusters.



(**a**) (**b**)

Figure 8. Diagram of the policy and planning proposals. (**a**) A diagram to improve the accessibility of 5 clusters; (**b**) A planning for the concentrated development of traditional villages.

The development of traditional villages is not entirely restricted by administrative boundaries and needs to follow the spontaneous links between villages. Its development

should break through administrative boundaries and identify areas of concentrated development through the clustering coefficient and kernel density of nodes. The border cities and states should consider the connection with neighbouring provinces (Figure 8b). Combined with the above results, in terms of the five high-density areas, (1) the village in Zone A has the highest NDVI value despite poor accessibility, and the traditional culture of the Tujia minority is well preserved. When developing future policy and rural planning, Zone A should pay more attention to conserving these villages and appropriately develop tourism related to ecology and minority culture; (2) The villages in Zone B have the best transport accessibility. During our fieldwork, we found that these villages are severely hollowed out and lagging in economic development. In future development, the transportation advantage should be exploited to develop processing industries for agricultural products and weekend holiday tours to attract resources from the surrounding big cities such as Wuhan; (3) The traditional villages in Zone C have unsatisfactory values of weights, except for the highest value of the nightscape light images. Zone C should continue to rely on Wuhan and vigorously develop hot-spring tourism while improving the ecological and transportation conditions of the deficiencies; and (4) All data for traditional villages in areas D and E are unsatisfactory. In the future development, efforts should be concentrated on developing villages with a high value of the DC and road weights. Priority should be given to the development of key villages to stimulate the development of the surrounding villages.

4.4. Contributions to Research, Limitations and Future Work

The contributions of this paper include the addition of three factors affecting the development of traditional villages as weights in the network, such as roads, economy, and NDVI; and it proposes a model: 'feature identification-network adjustment'. The model can hierarchize 206 villages by location advantage, traffic accessibility, economic vitality, and ecological resource endowments. It can help guide the hierarchical implementation of traditional village planning. We can solve the problem of inadequate traditional villages in Hubei with more pertinence only by scientifically identifying the grade of these villages using limited financial and material resources where they are really needed.

The limitations of this study are that only 36 villages were studied in the field, and only three factors affecting village development were added as weights. In the forthcoming study on the influencing mechanism of the distribution characteristics of 206 traditional villages, more factors will be added, and a more extensive study of traditional villages will be conducted.

5. Conclusions

In existing studies on identification and stratification in rural areas, there is no systematic approach applied to traditional village areas. Nor has the method of the spatial network been sufficiently considered to add factors affecting the development of traditional villages as weights in the study of traditional villages. This study innovatively proposes a systematic model for identifying the spatial distribution characteristics of 206 villages in Hubei Province. The model combines three methods and adds three weights affecting village development to the network structure to make the model more accurate in identification and classification. The identification results show that the traditional villages in Hubei Province are clustered along the mountain ranges and are "dense in the east and west and sporadic in the central plains". The network characteristics show that the traditional villages in Hubei Province are characterised by poor accessibility, poor economic development, and an excellent ecological environment. More specifically, Zone A has the best ecological resources and the worst transport conditions, Zone B has the best transport conditions, Zone C has the highest level of economic development, and all data for Zones D and E are unsatisfactory. The current situation shows that traditional villages in Hubei province are seriously hollowed out, with an exodus of labour and a lack of vitality.

In this paper, we used the FIHC to identify the characteristics and hierarchy of traditional villages. It is not only a concept of concentration and continuous development

but also sustainability. It will help policymakers to allocate limited development resources to traditional villages that need them, as well as help village builders to implement a " hierarchical and key nodes " village planning.

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