Research on the Resilient Spatial Governance Configuration and Optimization of Resilient Rural Areas Based on Spatial Syntax Analysis

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Abstract: Combined with field investigations in agricultural villages in northern Hebei, the current rural human disasters, natural disasters, and public health disaster risk environment under the epidemic situation are analyzed, and the spatial syntax method is used to analyze the rural spatial relationship and the utilization rate of the flow of people. Try to establish a rural resilience configuration. In this way, measures and optimization strategies to deal with multi-scenario disasters or single-scenario disaster risks in the governance of rural resilience space are proposed.

1. Introduce

The development of rural space currently faces many challenges and problems. At present, in the process of rural space governance, human disasters, natural disasters, and the current epidemic and public health disasters are affecting the normal development of rural areas. In the human disaster, the traditional rural space is undergoing a process of spatial reconstruction, and the traditional rural settlements that have evolved naturally from top to bottom are gradually disappearing. The main economic structure industries in the countryside have declined, and the economic income level is low. The rural population has gradually developed from "agglomeration" to "extraversion", and rural areas are showing an aging and juvenile trend. In natural disasters, mountainous villages are faced with disaster risks such as flash floods, mudslides, and landslides, and the rural ecological environment is fragmented. Especially in the face of epidemic public health disasters, there is a lack of certain emergency management measures for the prevention and control of rural spaces. The village lacks its corresponding medical space. For the prevention and control of the epidemic, the form of closure of villages and households has been adopted. It has an excellent effect on the prevention and control of the epidemic in a short time. However, in the long-term rural space governance process, there is a lack of durable prevention and control measures and effective rural space governance strategies.

The term "resilience" originated from the concept of resilience in the engineering field, and its meaning is to regard "resilience" as a system with a certain degree of resilience when the system is damaged [5]. Resilience space refers to debugging and optimizing measures and capabilities made under the interference or influence of external disasters, and certain planning and intervention measures for its space to mitigate and reduce disaster risks. The research on the development of resilience theory has gone through three stages, from engineering resilience to ecological resilience to evolution of resilience. From a single field perspective, research has gradually expanded to multiple perspectives such as economics, society, ecology, and engineering. The theory of resilience is more applied to the system of urban space governance.

At present, the research on the governance of resilient space is mostly applied at the level of urban and community governance. Domestic scholars' research on rural resilience space is still in its infancy. Wei Yi uses an agricultural village in southwestern Shandong as an empirical case to reveal the internal reasons for the resilience imbalance in rural communities, and proposes reconstruction from a variety of spatial forms such as housing and cultural leisure. Strategy [1]. Wang Qiao pointed out that a framework for linking environmental elements and their sub-elements with resilience of public space in mountainous cities should be established, and strategies should be put forward from the aspects of land optimization, landscape ecological protection, green transportation, and ecological disaster prevention [2]. Liu Shanchong proposed to introduce the concept of resilience into rural planning, explore it, and propose strategies for the development and development of mountainous rural areas [3]. From the perspective of resilience, Li Hongbo seeks an adaptive transformation path coupled with disturbance shock for rural development from the adaptive transformation and internal mechanism of rural settlements [4]. Li Chi discusses the use of resilience theory for the spatial development of the Yellow River beach area to achieve the balance of its ecosystem [5]. Liu Gang used the cumulative distance model analysis to build an ecological water network, strengthen the stability of the water ecology, and build a resilient space for the water ecology [6].

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There are nearly 2.6 million natural villages in China, and the number of villages is huge. There are unstable and dynamic factors in the development of rural space. With the acceleration of urbanization, the traditional self-cultivation and self-farming natural rural space center of rural space gradually decreases [7]. Facing the disaster risk mechanism of fragmentation of rural ecological space, weakening of rural space, loss of rural population, and reconstruction of rural production and living space, the disaster risk prevention and early warning mechanisms of various factors in rural space are relatively weak, especially in the face of epidemic disaster scenarios [8-11]. In terms of the resilient governance of the public health environment, the risks of facing multi-scenario disasters in rural areas urgently need to be addressed. The research focus of relevant scholars at home and abroad is mostly focused on the prevention and control of resilience spaces in cities and communities [12-15]. However, few predecessors have put forward the research on the resilience space governance in rural areas under multi-scenario disasters. Therefore, this article attempts to study the governance of rural resilience space to provide a new perspective on the governance of rural space, which is of reference significance.

2. Research area

This study takes Wangzhuang Village in the northern Hebei region as the case site. Wangzhuang Village is an administrative village under the jurisdiction of Duzhuang Town, Haigang District, Qinhuangdao City, Hebei Province (Figure 1). Located in the Liujiang National Geological Park, it is a geological heritage site in the Liujiang Basin. The terrain is high in the northwest and low in the southeast. There are 241 households in the village with a total population of 733 people. Wangzhuang Village is rich in mineral resources, and the mountain texture has been destroyed by artificial reclamation. As shown in Figure 1, the transitional reclamation has left "giant pits". With the collection of rainwater and groundwater, a lake with a better landscape is formed. Today, it has been transformed into a place for tourists to rest and play. The economic industry of Wangzhuang Village is mainly based on fish farming. Most of them are based on individual contracting or collective operation (Figure 2,3).

The selection of Wangzhuang Village as a social case is based on the following considerations:(1) Uniqueness of rural space. It is a popular rural space driven by society and an artificially self-repairing rural space. Wangzhuang Village was formerly a village dominated by small farmers. Since the discovery of abundant mineral resources since the last century, it has gradually become a village with resource-based consumption capacity. However, with the continuous collection of resources, the limitless limit of mankind will be Exhausted resources, it has become a natural tourism development type village. Repair and form a natural artificial lake with a unique "artificial lake". (2) Wangzhuang Village is a natural village located in Yanshan Scenic Area, Hebei Province. The surrounding natural villages are relatively scenic spots, so studying the surrounding areas of Wangzhuang Village Country Park is of universal significance for the study of other villages.

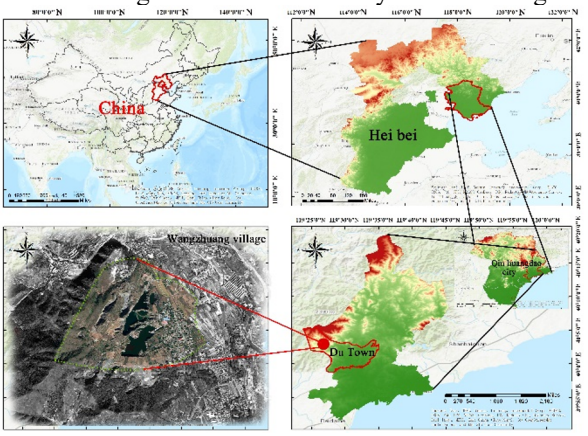

Figure 1 location analysis map of wangzhuang village

2.1. Research methods and data sources

In the syntactic model, for the analysis and elaboration of the rural settlement space, several different models are usually used to explain and analyze the morphology between the spaces. Space syntax theory is a theory about architecture and urban space [16]. It is a series of theories and techniques of spatial graphic analysis, and at the same time, it provides a model for systematic quantitative analysis of the influence of spatial forms of different scales on social and economic behavior [17]. Study the relationship between human activities and space through the space between buildings, cities, and settlements. The structure of space is the core concept of its space syntax. This article attempts to use a syntactic model to analyze the relationship between the scope of the research population and the rural space, so as to establish a resilient rural space configuration [18]. To deal with disasters in single-scenario and multi-scenario environments.

Figure 2 Wangzhuang Village spatial layout

Figure 3 Street layout of Wangzhuang Village

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2.2. Spatial analysis of rural resilience

2.2.1 Spatial characteristics of Wangzhuang Village

The resilience of space has different attributes and characteristics. On the one hand, it is a resilient space that does not rely on the intervention of external factors. On the other hand, it is necessary to use external means to cope with the interference and impact of the disaster risk environment that is currently or in the future. After reasonable optimization and adjustment, the ability to withstand the disaster risk is called resilience.

The ecological resilience space of Wangzhuang Village is self-repairing. When the mountain body of Wangzhuang Village is disturbed and impacted by outsiders, it causes the mountain to form "giant pits" and its own ecosystem is destroyed. Because of its rich underground water resources. The underground water gushes to form a natural lake surface. Use the potential advantages of nature to reconstruct and renew the ecological space of Wangzhuang Village. To buffer and reduce the risk of natural disasters caused by man-made destruction of the ecological space of Wangzhuang Village. And use its advantages to develop its economy. When the production-living space and the public health space for responding to sudden emergencies in Wangzhuang Village are subject to external disturbances, they currently do not have the “repairing power”. Effective optimization paths need to be taken to establish a rural resilient spatial configuration to deal with Rural spatial governance strategies in the face of sudden public health disaster risks and multi-scenario disasters.

2.2.2 Syntax analysis

The parameter value of the syntax model is set to distinguish the high and low values according to the shade of the axis color, and the color dark red-dark blue color gradient value is successively decreased from high to low, and then marked. It can be seen from the axis model that in the integration diagram: the highest parameter value of the axis integration degree of Wangzhuang Village is 0.6223, which is located in the core block of Wangzhuang Village and connects the villagers’ living space. It is the most accessible area for people flow. There are 6 axes with dark red color, and their parameter values from high to low are: 0.6223, 0.6173, 0.6092, 0.6081, 0.5969, 0.5953. The dark red axis area is the area with the highest traffic accessibility in the entire rural space. According to the field survey, these areas are important street nodes and traffic arteries in Wangzhuang Village, connecting the village committee and important public spaces of the villagers. The lowest value of axis integration is 0.2437. The axis area is located in the farmland of Wangzhuang Village, and the flow rate of people is relatively low. Villagers rarely move around except when they are farming (Figure 4).

The degree of axis selection is usually a measure of the potential of an element to attract cross traffic. In a village, the axis with the highest degree of selection indicates that this axis has a strong potential to attract traffic between spaces. There are two axes with higher selectivity, and the axis numbers are 1 and 2. The parameter values are 26730 and 23549. It shows that this axis has a high degree of selectivity and a high degree of spatial freedom. The axis of its area connects the roads leading to the various villages. It is the distribution center of the transportation hub. The region with low selectivity is between 0-128 parameter values. The degree of freedom of space is poor, and it is often the living space leading to the row block. The global depth value is inversely proportional to the selectivity. The lower the global depth value, the higher its potential to reach traffic (Figure 5,6).

Figure 4 integration degree analysis of wangzhuang village

Figure 5 Analysis diagram of axis selection degree of Wangzhuang Village

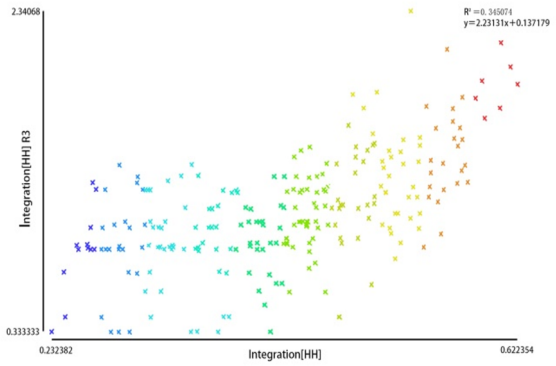

Figure 6 Analysis of the degree of fit of Wangzhuang Village

Figure 7 Rural toughness configuration diagram of wangzhuang village

3. Optimization research

3.1. Transformation of the Spatial Risk Paradigm of Rural Resilience

3.1.1 Resilience governance under public health disasters

In the current governance of rural public health space, the measures of "closing the village" and "not leaving the house" have made great progress in a short period of time. However, the effect of long-term resilience governance of public space is very small. In order to deal with the governance of rural space under public disasters, the above-mentioned analysis of rural space parameter values are evaluated for risk warning. According to the syntactic analysis, the axis parameter value decreases from the highest value to the lowest value through the dark red-dark blue color in the figure. The depth of its color is to determine the degree of the utilization rate of the flow of people, the accessibility of traffic, and the potential of space traffic in the axis space. The red and orange axis is a highly integrated axis area, with high traffic accessibility, and high utilization and flow rate of people to the space. The contact rate between people or between people and space is correspondingly higher, and the public health risk is greater.

Therefore, an early warning mechanism for rural spatial risk is established, and the red and orange areas of the axis integration are set as high-risk areas, the yellow axis area is the medium-high risk area, the green axis area is the medium-risk area, and the blue, blue, and purple axis areas are the low-risk areas. In the occurrence of sudden public health disasters and the prevention and control of epidemic disasters, the high-risk areas should be displayed to the villagers, and governance strategies should be adopted to prevent people from gathering in areas with dense populations. Divert the flow of people to reduce the risk of contact with public health spaces. Set up open-air health centers in low-risk areas. Select low-risk areas in the village and abandoned houses of villagers for renovation to improve the public health level of Wangzhuang Village (Figure 7).

3.1.2 Resilience governance under natural disasters

Most of the natural disasters are the ecological spaces in their villages, and the self-repairing natural space of Wangzhuang Village "re-greens" the broken mountain environment. Regenerate the landscape of broken mountains and increase slope consolidation measures. The Wangzhuang village clay waste is mixed with green waste compost to form a nutrient-rich fertilizer. For the current epidemic environment, reserve a buffer zone in the green space. To increase the ecological space environment. Through syntactic analysis, increase forest protection vegetation in areas with relatively low integration and areas with low utilization rate of pedestrian flow. Because areas with low integration levels are less crowded.

3.1.3 Resilience governance under man-made disasters

Rural issues under man-made disasters mainly deal with risk issues such as the loss of rural population, the transformation of spatial structure, and the unitary economic and industrial structure [11]. Wangzhuang Village currently mainly focuses on traditional agriculture and fish farming under individual contract. The single economic and industrial structure, the low income level of farmers, and the absence of redundant economic sources can easily lead to the outflow of rural population. The industrial structure should be diversified, the tourism industry should be introduced, and a characteristic homestay industry should be created. Focus on building "Peach Blossom Island". Open the agricultural product network sales platform and establish picking orchards and vegetable gardens. Establish a health care center for direct fruit supply.

3.2. Establish a "multi-dimensional unity" resilience space

The living space, production space, ecological space, cultural space and tourism space are multi-dimensionally integrated, and the development is coordinated. Optimize the spatial structure of its rural settlements, establish a new mechanism for the development of rural settlements, form a cultural-tourism-residential space dominated by the five official residences, create a regional culture, and continue

the cultural map. The surrounding mountains, forests, water bodies and green areas of the village are coordinated to form a production-ecology-tourism space. Planting a fruit picking garden dominated by persimmons, developing a flower industry along the west bank of the Pingjiang River, integrating ecological space with tourism space, expanding the scope of its landscape leisure space, and establishing a new commercial-residential-leisure complex tourism space. The space construction of small cities and towns is integrated with the construction of villages. It constitutes a coupling resilience space of urban-rural-human settlements. Promote the coupling of urbanization and ecological space.

3.3. Combination of rigid space and elastic space

Establish the bottom line thinking of rural villages, evaluate and prevent the risks of tourismization and commercialization of their villages, and prevent the destruction of the spatial texture of the village caused by over-tourism. Improve the adaptability and transformation ability of Wangzhuang Village in coping with spatial restructuring and evolution. Solve the prevention and control measures in the face of rapid tourism and response to small-probability events such as disasters and epidemics. Stabilize the risk prevention and control mechanism driven by sudden tourism, improve the spatial pattern governance system, implement protective development of the old buildings in Wangzhuang Village, and become a cultural space open to the public. Appropriate development of modern buildings can be used to develop the homestay industry. Relying on the "Peach Blossom Island" scenic spot. Enhance the vitality of the village and improve the modernization of the space governance system. The lost population can be traced back to the old village. Currently, the tourism development of Wangzhuang Village is dominated by villagers' spontaneous management. However, with the continuous deepening of tourism development, external capital will surely intervene, plan the path of tourism development in the village, and improve tourism quality standards through co-construction and co-governance. The ecological space on the periphery of the island is the center, which will continue to spread and expand, develop its high-end homestay industry, and enhance the level of tourist population. Promote the long-term and stable development of space governance in Wangzhuang Village.

4. Discussion

This study focuses on Wangzhuang Village as a case study. Employing spatial syntax analysis, it elucidates the relationships underpinning rural spatial governance across multiple hazard scenarios and, based on these insights, proposes optimization strategies to mitigate risk-related disasters. Compared with existing work, our research introduces two key innovations. First, it deepens our understanding of rural resilience governance in the spatial dimension: previous studies on urban or community resilience have largely emphasized individual-level or macro-system scales, with relatively little attention paid to the spatial-structural characteristics of rural settings. Second, methodologically, we pioneer the integration of spatial syntax analysis into spatial governance research. Unlike traditional qualitative interviews or single-model simulations, spatial syntax analysis more comprehensively captures the logical connections and structural patterns among spatial elements, thereby revealing latent pathways of risk propagation and identifying critical governance nodes.

In summary, this investigation of rural resilience spatial governance under a multi-hazard framework not only enriches the theoretical intersection of resilience governance and spatial planning but also offers practical optimization pathways—providing valuable guidance for future research and disaster-prevention efforts within China's Rural Revitalization initiative. Nonetheless, our study has certain limitations. As a single-village case study, Wangzhuang's spatial characteristics and socio-economic context are region-specific. Future research should validate these findings across a broader set of cases, expand the sample size, and leverage multi-source real-time data to continuously refine the rural resilience spatial governance framework.

5. Conclusion

This research is based on the preliminary exploration of rural resilience spatial governance under multi-hazard scenarios, and in-depth discussion of spatial governance relationships in today's disaster-prone villages. Through syntactic analysis, quantitative analysis of the spatial characteristics and spatial relationships of Wangzhuang Village, in order to establish a resilient configuration and propose optimization strategies to deal with the disturbance factors and risk disasters that appear in the village. It enables us to lay a theoretical foundation for the future spatial governance of Wangzhuang Village, and propose response strategies for spatial governance in response to the current epidemic. Many rural resilience space governance provide a reference basis.

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