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Research on Quantitative Evaluation Method for Morphological Resilience of Historical Blocks —Taking the Historical and Cultural Blocks in the Xinanyu and Dongnanyu Subdistricts of Luoyang City as an Example

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ABSTRACT: At present, the research on the resilience of historical blocks is mainly focused on the theoretical interpretation, and lacks the scientific and complete practical approach to quantify the resilience. For the purpose of protecting the morphology of historical blocks, the resistance of morphology is the main body of quantitative evaluation of the morphological resilience. On the basis of analyzing the feasibility of combining Conzen's morphological framework with the resilience theory, a quantitative evaluation method for the morphological resilience of historical districts was constructed, which took the division of "morphological resilience regions" as the core. Four morphological resilience indexes including road system connectivity, block modularity, land use function diversity and building texture robustness were used in the evaluation. Finally, weighted overlay was used to obtain the regional map of historical blocks' morphological resilience, which was used to reflect the resilience of different morphological types. On this basis, five types of morphological resilience management units are further divided according to the style type and the strength of resilience. The ultimate goal is to realize the meticulous protection and management of the morphology of the historic district.

KEY WORDS: historical block; quantification of morphological resilience; evaluation method; morphological resilience region; management units

1 Introduction

Historical blocks are concentrated areas of urban traditional style and local characteristics. Under the impact of incessant natural and social changes, the protection and continuation of material forms have always faced severe tests. In the field of urban morphology, Conzenian urban morphology can decompose the complex urban form into multiple single elements, which makes it possible quantify the urban form. Resilience is a multi-dimensional and multi-level concept, the application of which into the morphological protection of historical blocks furnishes a new perspective. However, the current research on the resilience of historical blocks focuses on the interpretation of the conceptual connotation, and it is urgent to supplement practical operation methods. Therefore, this paper combines the Conzenian urban morphological analysis framework with the resilience theory, proposes a path for quantitative evaluation of the morphological resilience of his-

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torical blocks, and conducts empirical research on the historical and cultural blocks in the east, west and south corners of Luoyang.

2 Morphological resilience of historical blocks and its quantitative evaluation

2.1 Resilience and urban morphological resilience

"Resilience" comes from the Latin word "resilio", which means "to restore to the original state". Although different international organizations have different ways of expressing the definition of urban resilience, they all contain typical characteristics such as diversity and variety, redundancy and modularity, multi-scale network connections, adaptive development and innovative learning [1]. At present, there is a basic consensus on the concept and evolution of resilience, but without a unified conclusion on the construction of a quantitative framework for urban resilience and the selection of evaluation indices, how to implement the concept of resilience in spatial operations has become a new issue [2].

The concept of resilience was introduced into the field of urban research in the 1990s, and it focused on the study of urban ecological environmental resilience. It was not until after 2010 that scholars such as Jack Ahern, Graeme Cumming and Ayyoob Sharifi began to apply resilience to urban design practice and initially established the relationship between resilience and macro-, meso- and micro-scale urban morphological elements [3]. In 2018, Feliciotti and Fusco proposed the concept of morphological resilience. Urban morphology resilience is based on the complex adaptive system (CAS) in resilience theory and also involves the two core concepts of adaptive cycle and "panarchy" proposed by Holling. In resilience theory, urban morphology is conceptualized as an organic system, in which each element has its own independent adaptive cycle. Small-scale elements usually tend to "revolt", while large-scale elements tend to "remember". They interact with each other and affect the renewal and evolution of urban morphology [4].

Urban morphology resilience belongs to the physical dimension of urban resilience, focusing on the physical properties of different morphological components (such as street networks, blocks, plots and buildings), and how to enhance their resilience potential through design [5]. Based on existing research, this paper defines urban morphology resilience as: the ability of its constituent elements to resist, adapt and transform in the face of urban changes, that is, the characteristics of maintaining stability or completing renewal without large-scale spatial destruction and heavy reconstruction operations [6].

2.2 Morphological resilience of historical blocks with protection as the goal

Historical blocks are a type of meso-micro-scale urban morphological area that has received widespread attention. The morphological resilience of historical blocks can be regarded as a combination of three resilience capabilities: "resistance", "recovery" and "adaptability" [7]. Among these three capabilities, resistance refers to the ability of the material form of historical blocks to resist and absorb disturbances and prevent structural changes, which is directly related to the maintenance and continuation of the morphology of historical blocks. In the protection of historical blocks, if the context and traditional atmosphere are to be continued, the protection of the material space form is the basis. Starting from the purpose of urban morphological protection of historical blocks, this paper takes resistance resilience as the main body of quantitative evaluation of urban morphological resilience. Resistance reflects the "rigidity" of urban morphology in the face of environmental changes and is also the "safety bottom line" of urban morphology against disturbances brought about by the "robustness" of urban morphology [8].

2.3 Necessity of quantitative evaluation of morphological resilience of historical blocks

Currently, domestic research on the resilience of historical blocks has mostlyapproached the resilience recovery mechanism from economic, social, and political perspectives [9]. Material spatial form belongs to the category of technical resilience in urban structural resilience [10], is the carrier of the above-mentioned "soft resilience", and is also the prerequisite for the "soft resilience" of historical blocks to take effect. After 2010, special research on urban morphological resilience appeared internationally. In 2021, Zhai Guofang and other scholars proposed the theoretical framework of "spatial resilience" [11], emphasizing the necessity of spatial resilience research. Quantification is the way to translate morphological resilience from theory to practice. Kang Zeen proposed a qualitative understanding of the stability of urban morphological elements. In order to connect resilience theory with spatial operations and transform the abstract concept of resilience into a morphological protection strategy for historical blocks, it is also necessary to connect morphological resilience research with planning and design and translate it into spatial operations.

The spatial scale of the quantified object of urban morphological resilience covers multiple levels such as region, city, community, and single building. Existing meso-micro research at home and abroad includes the study of the Gobers area in Glasgow, UK by foreign scholar Feliciotti [12] and the quantitative evaluation of the urban morphological adaptive transformation process of Shenzhen Shekou Industrial Zone by Chinese scholar Chen Bilin [13]. The quantitative study of the resilience of historical block morphology not only expands the scope of the quantification of urban morphology resilience at the micro-scale but also has the social value and practical significance of protecting the traditional urban texture and inheriting the historical context.

2.4 Feasibility of quantitative assessment of the resilience of historical block morphology

After comparing theburgage cycle proposed by Conzen and the resilience cycle proposed by Holling et al., it is found that both summarize the evolution of the system as a dynamic cycle from growth, decline to reorganization. The Burgage cycle divides the evolution process of buildings in the plot into four stages: repletive, climax, recessive, and fallow. In the field of resilience, Holling summarized the adaptive cycle in order to distinguish the differences in the persistence and variability of elements at different scales [14], including four stages: exploitation, conservation, release and reorganization.

Urban morphology can be conceptualized as a multilayered spatiotemporal system that evolves continuously in an adaptive cycle. In other words, urban morphology exhibits four basic characteristics that match the complex adaptive system identified by Holling et al., including: (1) Inter-system interaction: urban morphology can be decomposed into a series of components that belong to the same or cross-level scale categories and are characterized by interaction with each other; (2) Historical succession: urban morphology is a dynamic entity that undergoes multiple cycles of change and is affected by historical development and status; (3) Spatial connection: urban morphology is not only passive, but also has its own inertia to resist social, economic, political and other factors, and morphological evolution is spatially interrelated; (4) Nonlinear structure: The morphological evolution process can be fast or slow, and the interaction between them produces two types of changes, bottom-up and top-down, corresponding to small-scale internal adaptive updates and the promotion of major external events, respectively. This shows that urban morphology research is adaptable to resilience theory, providing the possibility of integrating the two research frameworks and forming a morphological resilience research framework (Figure 1).

In addition, with the development of geospatial information science and technology, detailed and accurate analysis of spatial data with the help of digital technology has provided technical support for the quantification of urban morphological resilience. A series of new quantitative analysis tools in the field of urban morphology research, such as Space Syntax,sDNA, GIS platform and other morphological quantitative analysis methods based on multiple data sources, have made up for the shortcomings of classical urban morphology research that is prone to subjectivity and difficult to refine and deepen, and provided a technical basis for the numerical characteristic description of urban spatial morphology [15].

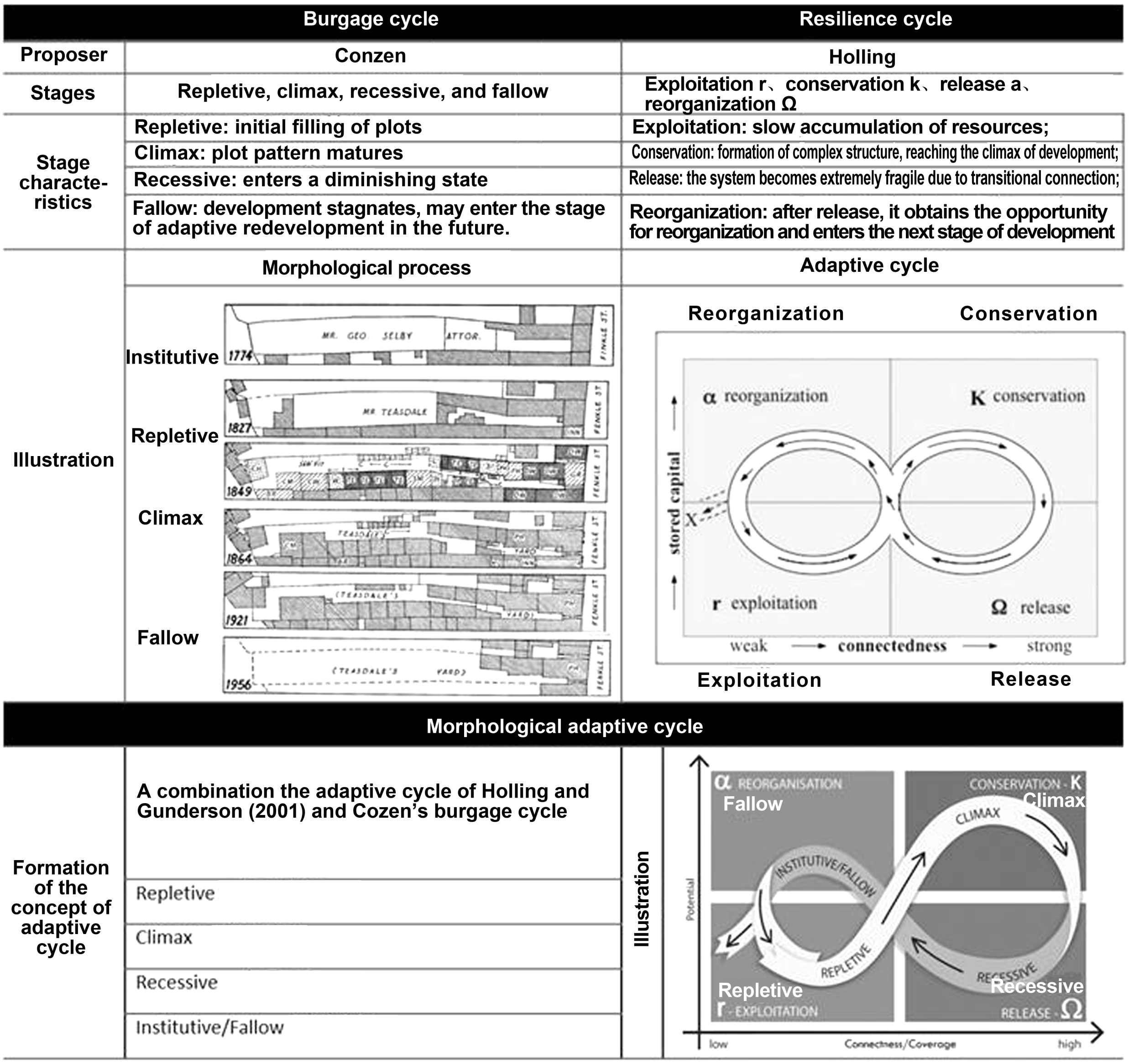


Figure 1 The Conzenianburgage cycle and the resilience cycle of Holling et al. are combined into an adaptive cycle

3 Evaluation method for morphological resilience of historical blocks

The original research goal of urban resilience was to resist and respond to sudden natural disasters. In fact, in addition to the natural impacts that have received widespread attention, the uncertain challenges of economic development and social changes have never stopped. These "hidden" disturbances often bring huge and sudden changes to urban morphology. Therefore, social disturbances are also an important source of impact for the urban system that cannot be ignored. The evaluation method for morphological resilience of historical blocks constructed in this study is mainly aimed at historical blocks and historical and cultural blocks that face human disturbances in the long term during social changes. In terms of the evaluation method, the concept of "morphological resilience region" is proposed. The idea of constructing the evaluation framework is to establish a clear correspondence between the three elements in Conzenian urban morphology and the resilience attributes, and after quantification of multi-indicator data, they are superimposed with the morphological area to form a morphological resilience region (Figure 2). The resulting graphic results are highly intuitive, which can be used as the basis for the division of spatial morphological management units of historical blocks in the preparatory stage of conservation efforts.

3.1 Selection of morphological resilienceindices

Connectivity, modularity, robustness, and diversity are selected as the resilience characteristic attributes of streets, plots, building textures, and land use in the micro-urban morphological analysis adopting the Conzenian theory, forming four first-level morphological resilience indices: street system connectivity, plot modularity, building texture robustness, and land use diversity. The four first-level indices contain qualitative and quantitative second-level indices that can be directly used for morphological analysis and quantification (Table 1). Second-level morphological indices can be expressed by function formulas, and data calculation and visualization can be performed on technical platforms such as GIS.

Table 1 Morphological resilience evaluationindices

Resilience characteristics	Concept analysis	Indices	Index connotation	Correlation
Diversity	Diversity refers to the ability of a system to contain multiple different functions that can be used simultaneously, which can be divided into richness and uniformity.	Facility diversity index FDIn	Number of public facilities per unit area (FDIn= Tn/Sn, where Tn is the number of facilities in plot n, Sn is the area of plot n)	+
		Facility mixedness index FMIn	Types of facilities per unit area ($FMIn = -\sum_{i=1}^{Nn}\left\{\left(\frac{Pi}{Pn}\right)\times\ln\left(\frac{Pi}{Pn}\right)\right\}$, where Nn is the sum of all types of facilities in plot n, Pi is the number of facility i in plot n, and Pn is the number of all facilities in plot n.	+
Connectivity	Connectivity refers to the ability of components in a system to connect to each other	Betweenness	Traffic flow model, reflecting the potential of people's cross-travel movement activities	-
		Closeness	The opposite of proximity, accessibility	-
Modularity	Modularity refers to the tendency of system components to be broken down into smaller units or aggregated into larger wholes	Plot Area	Reflecting the size and scale of the block	-
		Shape Index	Reflecting the degree of concavity and convexity of theblock (SI= shape length/4sqr (shape area, SI is shape index, shape length is the block perimeter, and shape area is the block area)	-
Robustness	Robustness refers to the solidity of buildings and other physical structures, reflecting the resistance of the morphological organization	Building Age	The initial construction year of the building (structure)	+
		Building Quality	The construction quality of the building (structure)	+
		Building Structure	The structural type of the building (structure)	/

3.2 Proposal of the concept of morphological resilience region

The morphological resilience region is based on the morphological region and can also reflect the resilience performance of the historical block morphology. To define a morphological resilience region, it is first necessary to determine the morphological region of the historical block and quantify the morphological resilience, which are then superimposed and integrated with each other [16]. The expression is: morphological resilience region = morphological region+ morphological resilience.

The morphological region comes from the urban morphological research established by M. R. G. Conzen. Conzen's urban morphological analysis decomposes the urban morphology into three typical elements: town plan (composed of street system, plot, building base), building fabric and land utilization. By identifying the "urban landscape units" with different morphological structures and then interpreting the complex urban built-up areas, the divided morphological regions can truly reflect the morphological characteristics of the historical city [17]. In this study, morphological resilience represents the comprehensive resilience performance of the "three elements" of morphology. Specifically, it selects the associated resilience attributes and quantifiable indices based on the characteristics of a single morphological element, quantifies the resilience data respectively, and then superimposes them with different weights to obtain the morphological resilience of the research object.

The morphological resilience region is a way to evaluate and manage the complex morphological regions and morphological resilience of historical blocks. Each morphological resilience zone contains a certain morphological type and corresponding morphological resilience information.Regions of different morphological types or those of the same morphological type with different resilience strengths need to be divided into different morphological resilience regions and adopt different protection and management methods. Corresponding morphological resilience management units and guidelines can be further formed in the future.

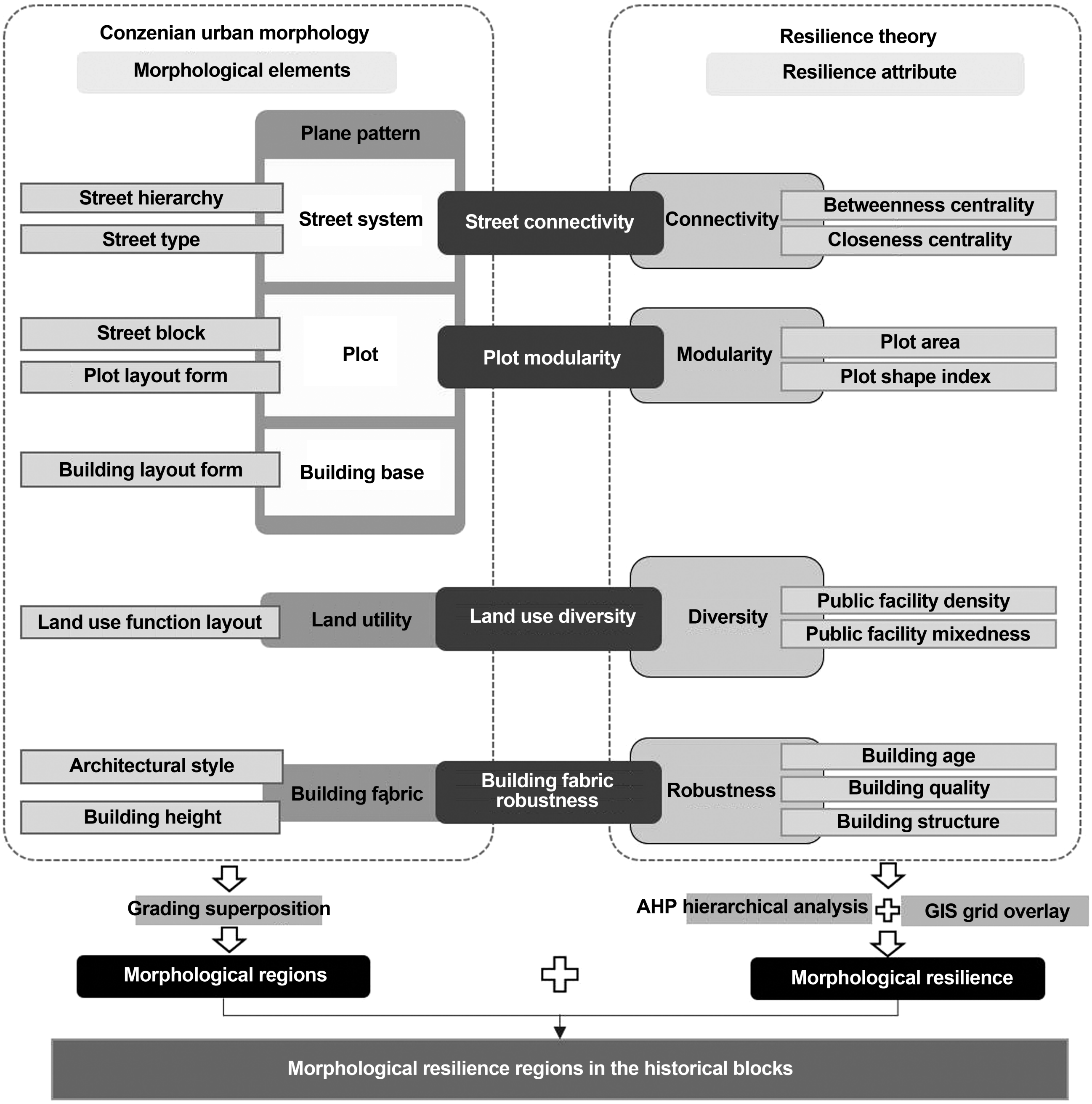


Figure 2 Outline of the analysis and quantification of historical block morphological resilience

4 Empirical study: Morphological resilienceregion of the historical and cultural blocks in the Dongnanyu and Xinanyu subdistricts of Luoyang

4.1 Research object

The historical and cultural blocks in the Dongnanyu and Xinanyu subdistricts of Luoyang (research area of about 94 hectares) are in the old city of Luoyang, Henan Province. They are in the protection area of the Luoyang City blocks in the Sui and Tang Dynasties and the ruins of the ancient city of Jin and Yuan Dynasties. They have retained the original city pattern and framework structure since the first year of Dazheng in the Jin dynasty and are an important carrier of Luoyang's traditional folk customs, history and culture. The plane morphological element information of the historical blocks in the Dongnanyu and Xinanyu subdistricts of Luoyang was sorted and entered into GIS, including roads, street frames (4), secondary street frames (47), property plots (1,300), building bases (7,524), rivers, etc. as the basis for morphological quantification.

4.2 Conzenian urban morphological region of the historical and cultural blocks in the Dongnanyu and Xinanyu subdistricts

4.2.1 The "three elements" of Conzenian plane morphology

The historical blocks inthe Dongnanyu and Xinanyu subdistricts of Luoyang have kept the street and lane pattern since the Ming and Qing Dynasties and the Republic of China, the most stable structures in the block morphology. According to the level and importance of streets and lanes, they can be classified into four categories: urban main roads, main pedestrian roads, important streets and lanes, and general streets and lanes (Figure 3a).

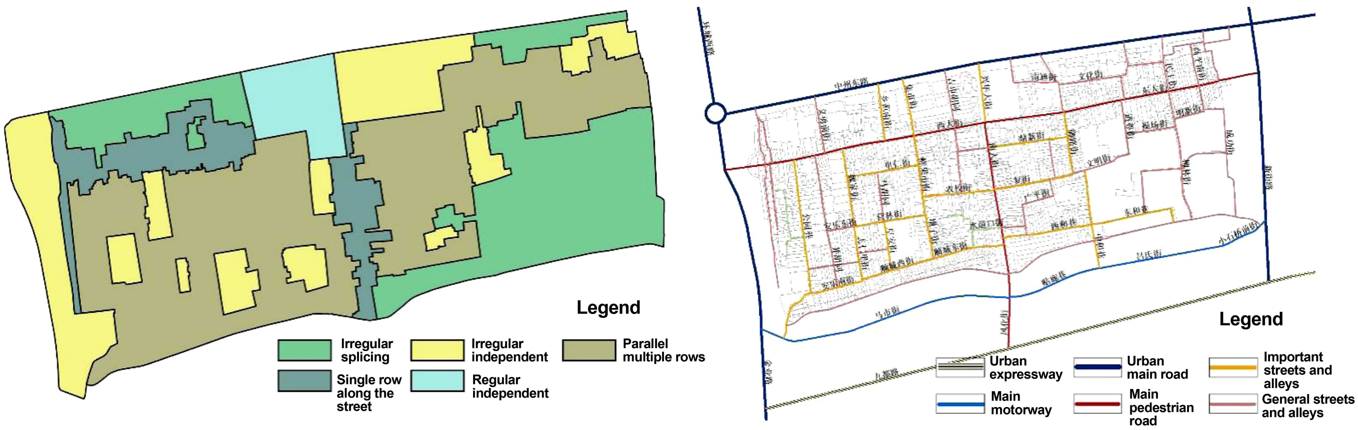
Plots are the basic components of the urban space system.Conzen defined it as a plot of land surrounded by four boundaries. One or more adjacent property plots can form a plot sequence [18]. The plots within the research scope can be divided into five types according to their arrangement methods: single row along the street, parallel multi-row, regular independent, irregular independent, and irregular splicing. The plot combination division of the historical and cultural blocks in the Dongnanyu and Xinanyu subdistricts of Luoyang is shown in Figure 3b.

The building base refers to the layout of buildings in the built-up area, which is defined by the projection of its enclosed exterior walls on the ground. It is usually calleda "building". According to the different filling methods of the building base in the plot, a total of five types of building base types were extracted in the the Dongnanyu and Xinanyu historical and cultural blocks: full paving, independent, row, courtyard, and open space. The division is shown in Figure 4a.

Compared with the street system and plots, the buildingfabric is less stable, but it can directly reflect the urban style. The architectural style (Figure 4b) and the number of building floors are selected as the indices for building fabric (Figure 5a). Land utilization is closely related to the decomposition and merger of plots in the city and the replacement of building types. The current land utilization division of the historic blocks in the Dongnanyu and Xinanyu subdistricts is shown in Figure 5b.

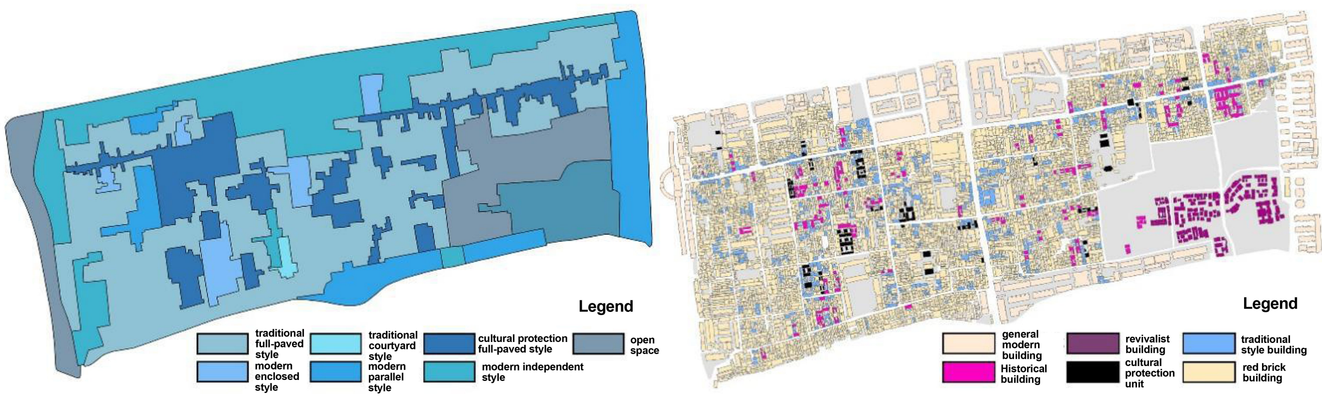
4.2.2 Division of morphological regions

The unit division of the three elements of Conzenian urban morphology is superimposed to form the morphological regions of the Dongnanyu and Xinanyu subdistricts of Luoyang. The morphological regions are divided according to three levels of boundaries (Figure 6). The first level is based on the three elements of the most macroscopic and most significant differences in morphology, the street, the combination of plots, and the type of building base plane, as the dividing criteria, forming 13 first-level morphological regions. Since the proportion of courtyard-style dwellings in the Dongnanyu and Xinanyu historical and cultural blocks is large and has historical protection value, the second level is based on the architectural style and the number of floors as the dividing standard, resulting in traditional red brick dwellings, traditional historical dwellings, traditional cultural dwellings and other regions. The third level is based on the least stable building use function as the basis for division.



(a) (b)

Figure 3 （a）Division ofplot combination units（b）Division of street levels



(a) (b)

Figure 4 （a）Division of building base units（b）Architectural features

(a) (b)

Figure 5 （a）Buildingfabric unit division（b）Land use unit division

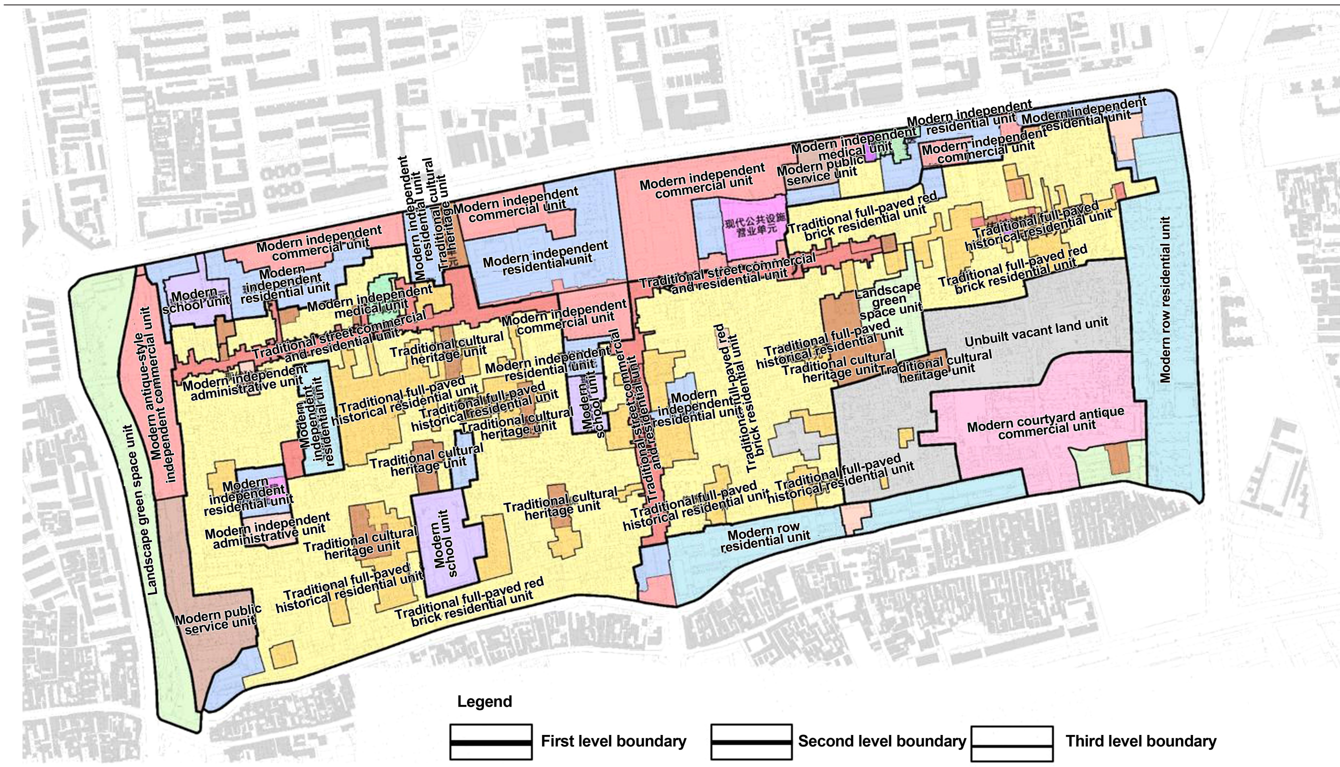


Figure 6 Morphological regions of the Dongnanyu and Xinanyu historical and cultural blocks

4.3 Morphological resilience of the historical and cultural blocks in the Dongnanyu and Xinanyu subdistricts

The morphological resilience of the historical and cultural blocks in the Dongnanyu and Xinanyu subdistricts will be quantified from four dimensions: the connectivity of the street system, the modularity of the plots, the robustness of the building fabric and the diversity of land utility. 2-3 secondary indicators are selected from each dimension, and the data are quantified separately, and then weighted and superimposed to form a comprehensive morphological resilience grid map.

4.3.1 Connectivity of street system

Connectivity refers to the ability to connect components in a system, which can be measured by accessibility. Connectivity has both positive and negative effects on resilience, where low connectivity promotes structural preservation and memory preservation. Taking urban morphology protection as the goal, it is believed that the streets with high connectivity in the Dongnanyu and Xinanyu subdistricts have weaker resilience than the dendritic streets with low connectivity.

The sDNA was used to analyze the betweenness and closeness of the Dongnanyu and Xinanyu historical blocks to obtain the connectivity values of the streets. The results show that the "cross streets" inside the Dongnanyu and Xinanyu historical blocks have high accessibility and activity, and the connectivity of the dendritic streets inside tends to decrease. Based on the distance decay model, the road-based accessibility analysis is converted to the plot, which is convenient for grid overlay with the subsequent morphological resilience quantitative indicators[1)]. The accessibility value map converted from street connectivity to the plot is shown in Figure 7.

4.3.2 Modularity of plots

Modularity refers to the tendency of system components to decompose into smaller units or aggregate into larger wholes. The more modular the components of highly modularized urban morphology are, the lower their morphological resilience is. The plot area and shape index are selected as indices to characterize modularity. This study follows the principle that the larger the plot area, the lower its modularity and the stronger its resilience. Shape index[2)] reflects the degree of concavity and convexity of the streetscape. The larger the value, the more irregular the streetscape. Therefore, the plot with a larger shape index value has a weaker tendency to aggregate or decompose, and a higher stability, which is more conducive to the long-term preservation of the plot form.

Figure 7 Global integration of streets and accessibility of plots in theDongnanyu and Xinanyu historical blocks accessibility

The Dongnanyu and Xinanyu historicalarea has 4 blocks, 47 secondary blocks and 1,300 property plots. The sample size of secondary blocks and property plots is large, and the focus is on quantification. The results show that the average degree of concavity and convexity of secondary blocks and property plots is basically the same, and the difference between the shape index of property plots and the average is greater (Figure 8). The area and shape index of secondary blocks and property plots are reclassified in GIS to obtain the plot area and shape index raster maps (Figure 9).

Hierarchal level	Shape maximum/minimum	Shape mean	Shape standard deviation
Block	1.37/1.10	1.18	0.11
Secondary block	2.28/0.99	1.25	0.35
Property plot	2.23/0.99	1.25	0.20

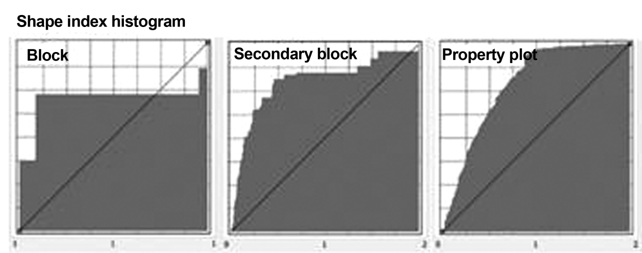


Figure 8 Shape indices quantification results

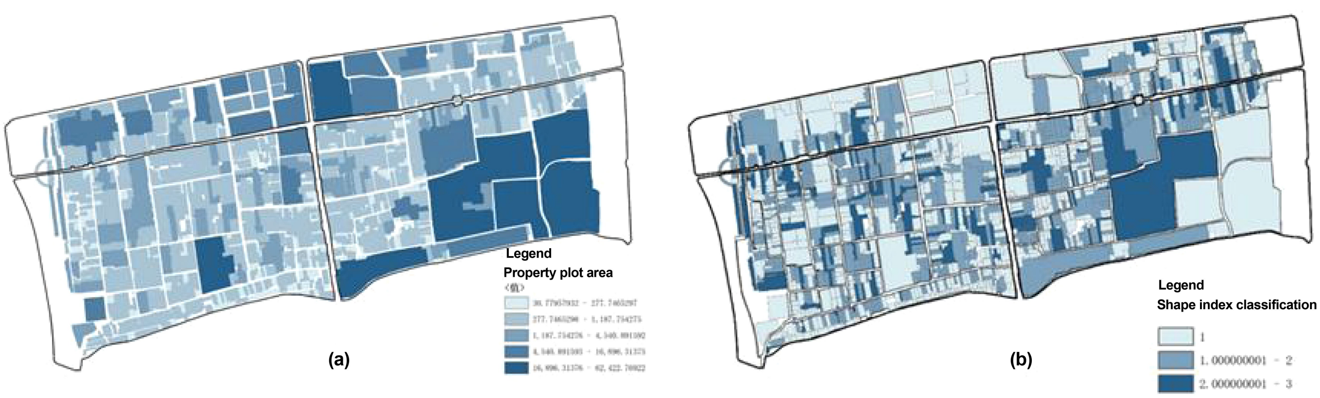


Figure 9 (a) Distribution of plot size (b) Classification of plot shape indices

4.3.3 Robustness of building fabric and land utility diversity

Robustness refers to the property of a system that can withstand internal and external shocks and pressures withoutserious loss or degradation of its main functions. The older the building, the more valuable it is to preserve and the more stable it is in the face of social changes. Building structure and building quality represent the objective level of resistance of the building in the face of future disturbances. The three indices of building age, building structure and building quality are used to represent the robustness of building fabric. The building age, building structure and building quality of the historical blocks in Dongnanyu and Xinanyu are shown in Figure 9 (a), (b) and (c).

Diversity is considered to be the attribute that can most affect the resilience of the urbanorganism and can be measured from multiple perspectives such as economic mix, building mix, and transportation options [19]. This paper uses the degree of economic activity mixing as an index to reflect the degree of mixed use of land functions in a region. The crawler technology was used to obtain the POI point data of various public facilities in the Dongnanyu and Xinanyu historical blocks. The facility density index[3)] and the facility mixedness index[4)] were used as the representation of the degree of economic activity mixing. The larger the value, the higher the diversity of land use types and the stronger the resistance and resilience. The GIS processing results show the diversity of facility functions in the Dongnanyu and Xinanyu historical blocks (Figure 10d).

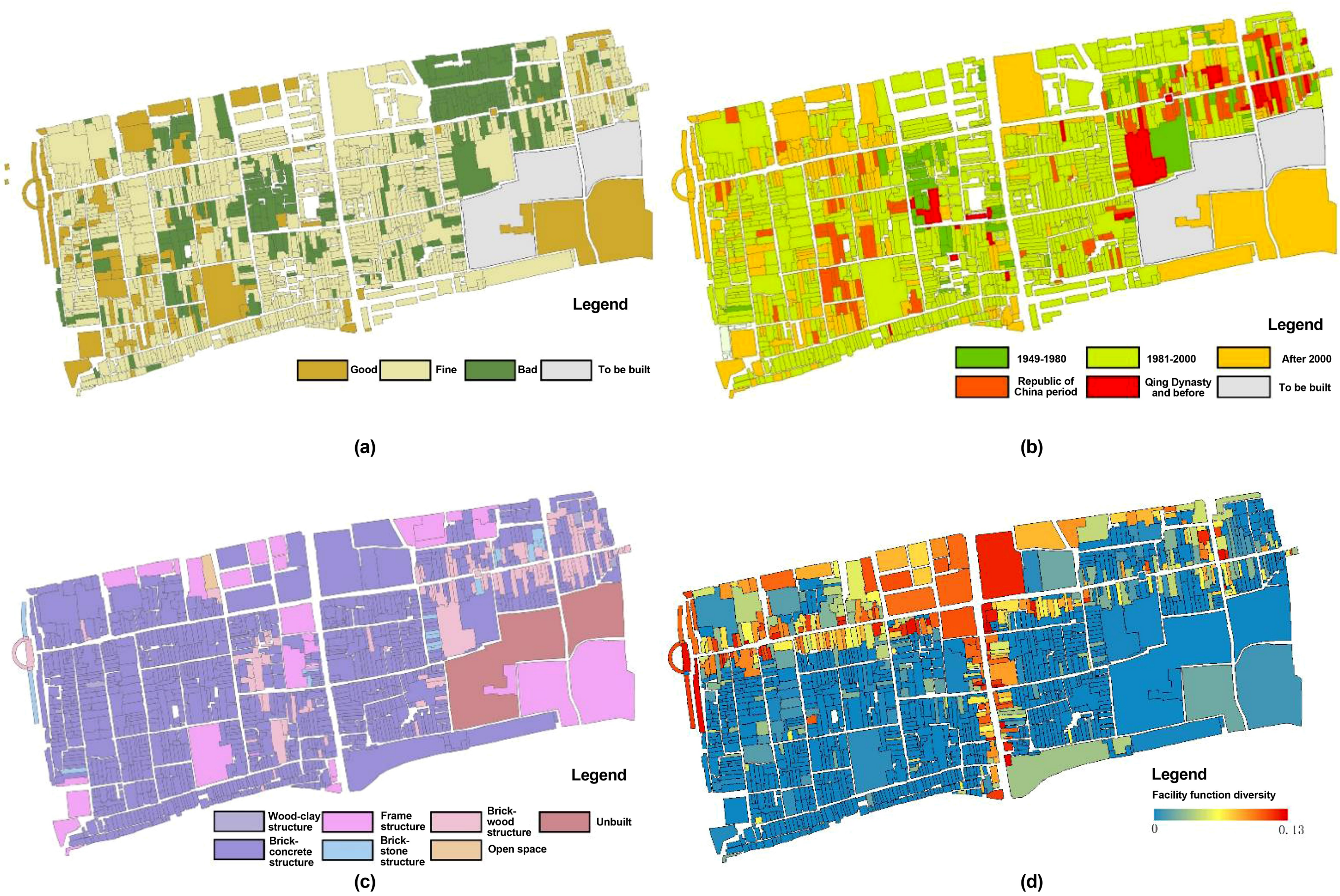


Figure 10 (a) Building quality (b) Building age (c) Building structure (d) Diversity of facility functions

4.3.4 Comprehensive morphological resilience

For evaluation index weight calculation method, this paper adopts the analytic hierarchy process (AHP) and the expert survey method (Delphi Method). Combined with existing domestic and foreign literature [12-14] and expert inquiries from universities and planning management departments, the importance of each layer of indiceswas scored, and the analytic hierarchy model was constructed using yaahp software. After establishing a pairwise judgment matrix, the scores were normalized, and the results were tested for consistency. When determining the index weight, the index weight was modified according to the expert opinions obtained by survey, and finally the weights of the four resilience characteristics of connectivity, modularity, diversity and robustness and their element layer indices were formed (Table 2). The comprehensive morphological resilience grid map of the Dongnanyu and Xinanyu historical blocks was formed by weighted overlay in the GIS platform (Figure 11). It should be noted that the current element layer index selection and its weight take into account and combine the actual situation of the Dongnanyu and Xinanyu historical blocks. For example, in the criterion layer B4 building quality, since the most prominent features of the buildings in the blocks are building age, quality and quality, these three items are selected as indices reflecting building quality. When this method is applied to other research objects, the indices or weights can be adjusted according to the situation.

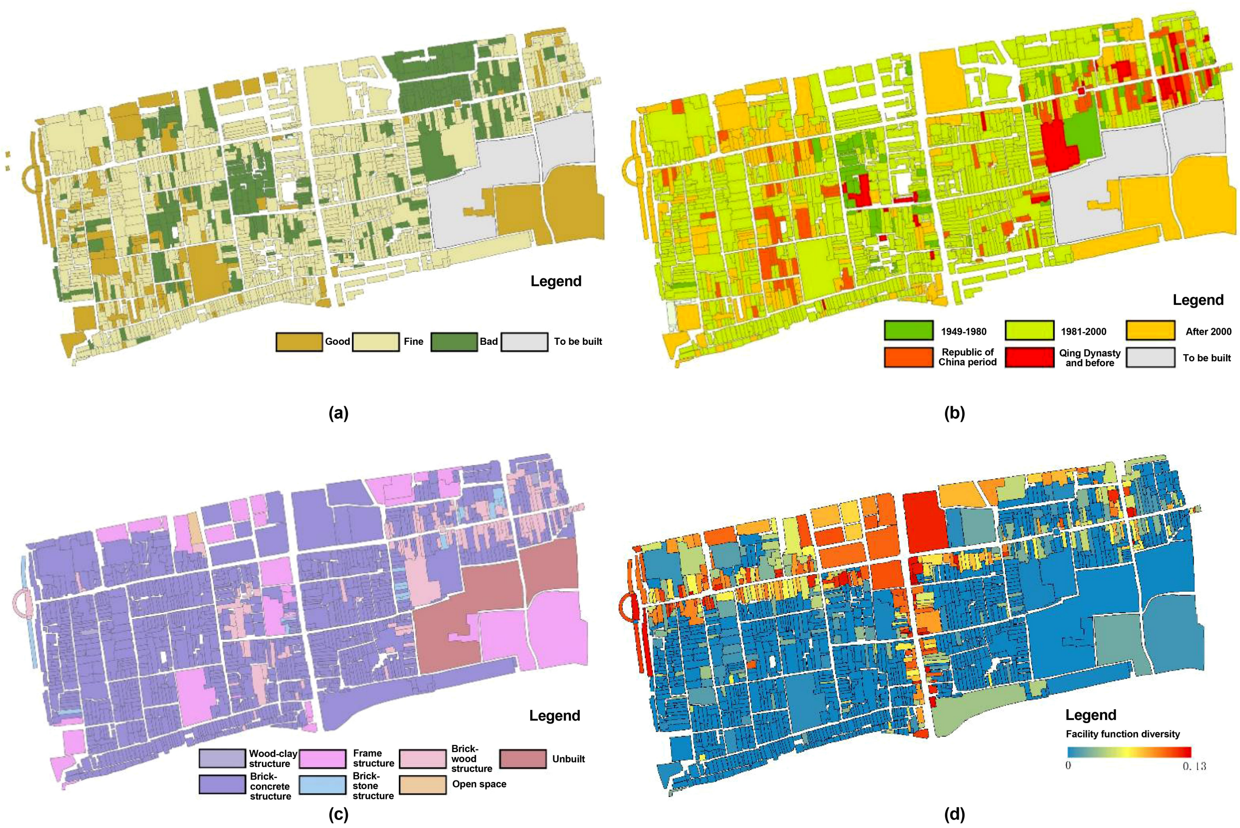


Figure 10 Weight of resilience indices

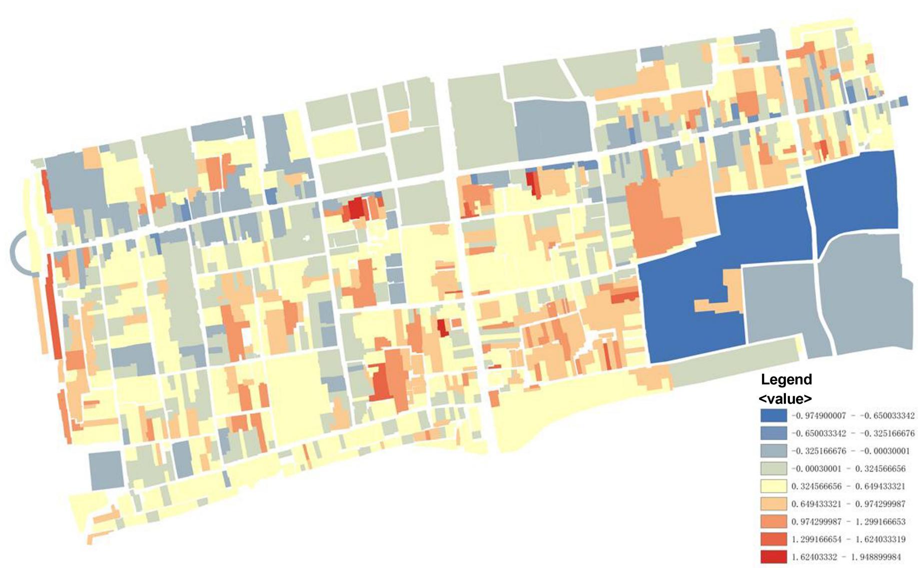


Figure 11 Grid map of comprehensive resilience of the Dongnanyu and Xinanyu historical blocks

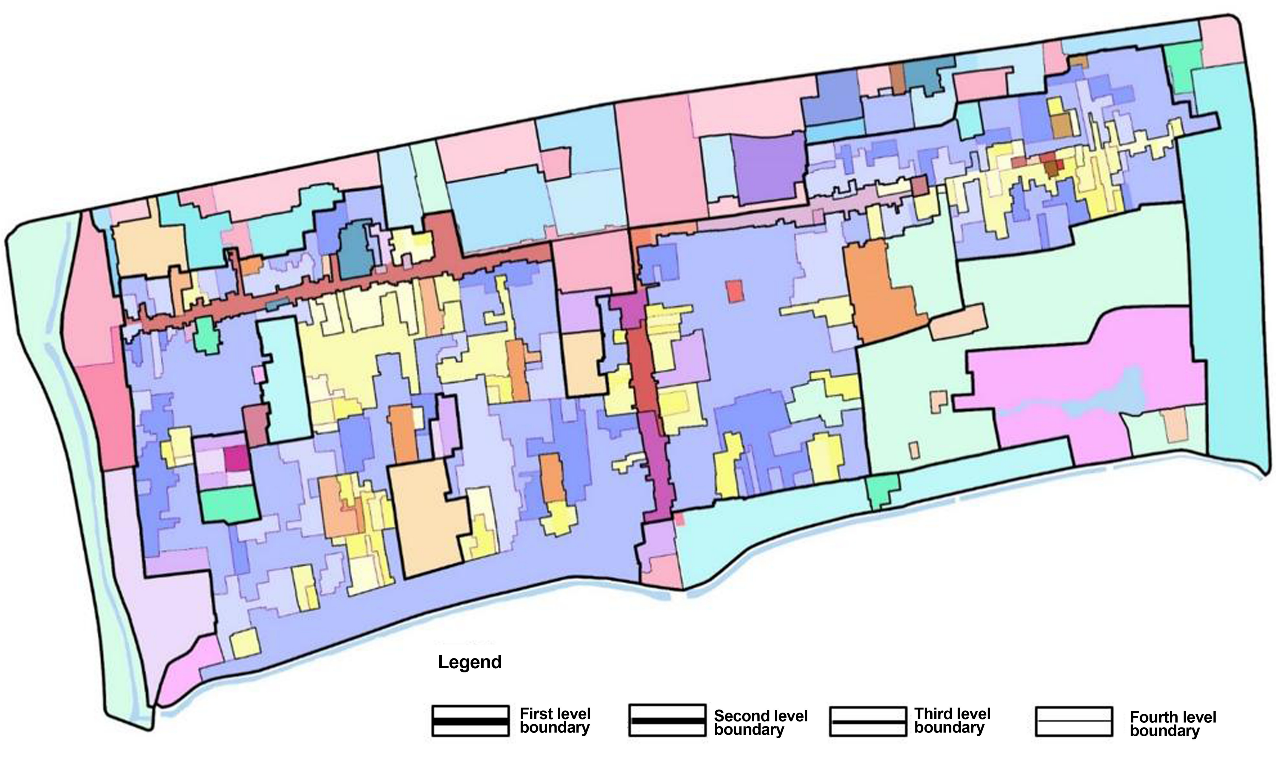
4.4 Morphological resilience regions of the Dongnanyu and Xinanyu historical and cultural blocks

The morphological regions are superimposed with the morphological resilience grid map to form the final morphological resilience regions of the Dongnanyu and Xinanyu historical and cultural blocks (Figure 12). The morphological resilience regions include both urban morphological type information and morphological resilience strengthattributes (divided into high, medium and low). The morphological resilience regions are divided by four levels of dividing lines (in order of era of style, plot type, use function and morphological resilience). Each color group in the figure represents a morphological type, and the color bands from light to dark represent the morphological resilience from weak to strong. The area proportions of different levels of resilience of the seven main morphological types in the Dongnanyu and Xinanyu historical and cultural blocks are shown in Figure 13.

The zoning results of the morphological resilience of theDongnanyu and Xinanyu historical show that among the seven main morphological types in the blocks, the low resilience areas of traditional historical commercial streets, modern row-style residential areas and traditional full-paved historical residential areas rank in the top three in terms of their respective area. This suggests that traditional commercial streets and modern residential areas with high accessibility and high modularity are more likely to undergo adaptive morphological changes when faced with disturbances, whereas historical monuments with low accessibility and low modularity and the morphological characteristics of residential buildings with historical value are preserved due to their strong resistance.

4.5 Morphological resilience management unit of the Dongnanyu and Xinanyu historical and cultural blocks

The morphological renewal and management of the Dongnanyu and Xinanyu historical blocks is carried out by constructing morphological resilience management units. Morphological resilience management units are the superposition of morphological resilience regions and style types, which are divided into five types: preservation units, improvement units, remodeling units, open space units, and vacant land units. There are 61 preservation units, 126 improvement units, 73 remodeling units, 4 open space units, and 2 vacant land units in the Dongnanyu and Xinanyu historical blocks (Figure 14).



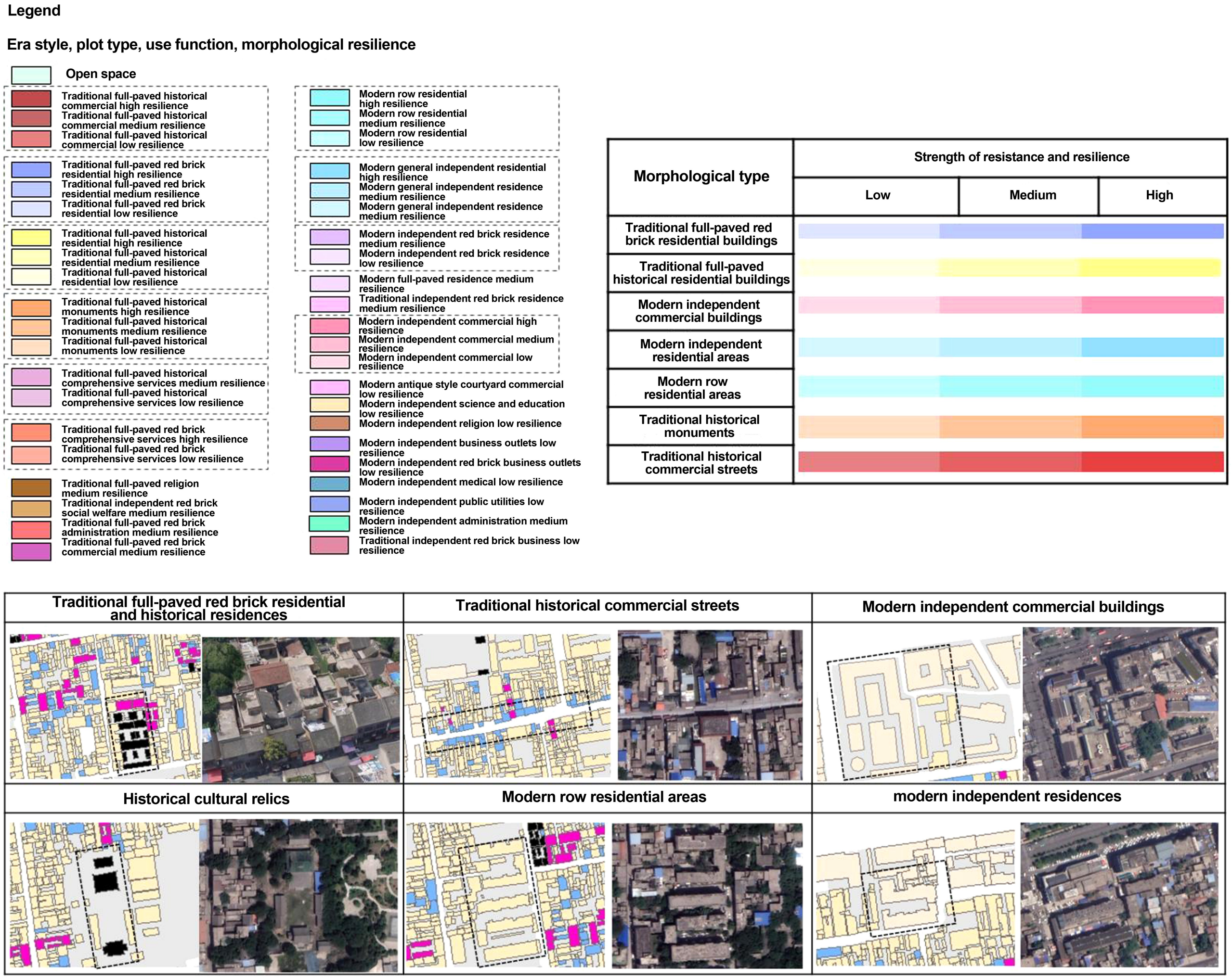
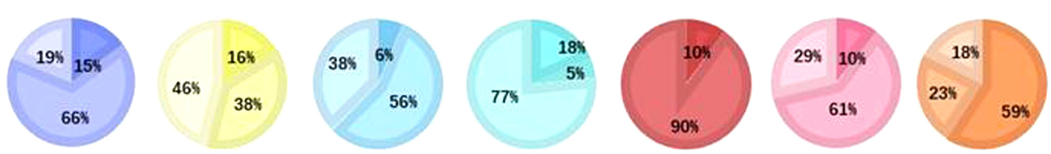


Figure 12 Morphological resilience regions in the Dongnanyu and Xinanyu historical blocks



	Traditional full-paved red brick residential buildings	Traditional full-paved historical residential buildings	Modern independent residential areas	Modern row residential areas	Traditional historical commercial streets	Modern independent commercial buildings	Traditional historical monuments	Total
High resistence and resilience	69085	30491	4225	7925	169	12052	24201	148148
Medium resistence and resilience	307241	71773	37946	2205	5585	69469	9456	503675
Low resistence and resilience	87228	25294	32993	52199	21147	48225	7198	274284

Figure 13 Proportion of area at differentresilience levels for seven main morphological types

The management unit guidelines include at least three aspects, namely, status information summary, management projects and management regulations, among which management projects and management regulations are the core [20]. The morphological resilience management guidelines of the Dongnanyu and Xinanyu historical blocks adopt the composition method of "basic project + targeted project", among which the basic project is to propose the construction direction of material environment improvement from the overall level based on the regional style characteristics, and the targeted project is to optimize and improve the resilience attributes of the weak morphological elements in the management unit in a targeted manner (Figure 15). Traditional residential upgrading units account for the highest proportion of traditional residential management units, whose resilience measures are those aimed at encouraging residents to maintain daily maintenance and maintain the style and targeted strengthening of the robustness of the building. Traditional commercial remodeling units account for the highest proportion of traditional commercial management units, whose morphological resilience measures are those aimed at unified style guidance and specification, as well as improving the modularity of the plot, the degree of functional mixing, and the robustness of the buildings. Modern residential upgrading units and remodeling units account for a high proportion of modern residential management units, whose morphological resilience measures are those aimed at style rectification, as well as improving the accessibility of the plot, the degree of functional mixing, and the robustness of the buildings.

Through the evaluation of the morphological resilience management unit, "policy according to local conditions" is achieved. First, the macro-style control goals are determined, and targeted strengthening of element indices are carried out to ensure the orderly and organic protection, development and inheritance of the historical block morphology. The maintenance and upgrading units are optimized on the basis of inheritance, the remodeling units are adjusted and comprehensively rectified, and the vacant units aspire to style coordination and creating a highly robust, diverse and connected morphological region. Ultimately, the morphology of the Dongnanyu and Xinanyu historical blocks is protected and organically updated to adapt to social changes.

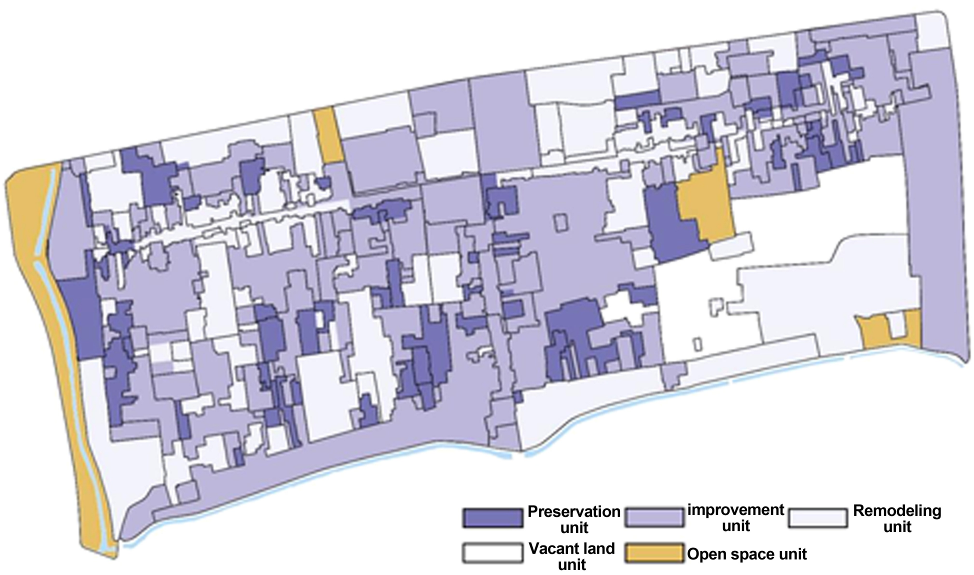


Figure 14 Morphological resilience management units in the Dongnanyu and Xinanyu historical blocks

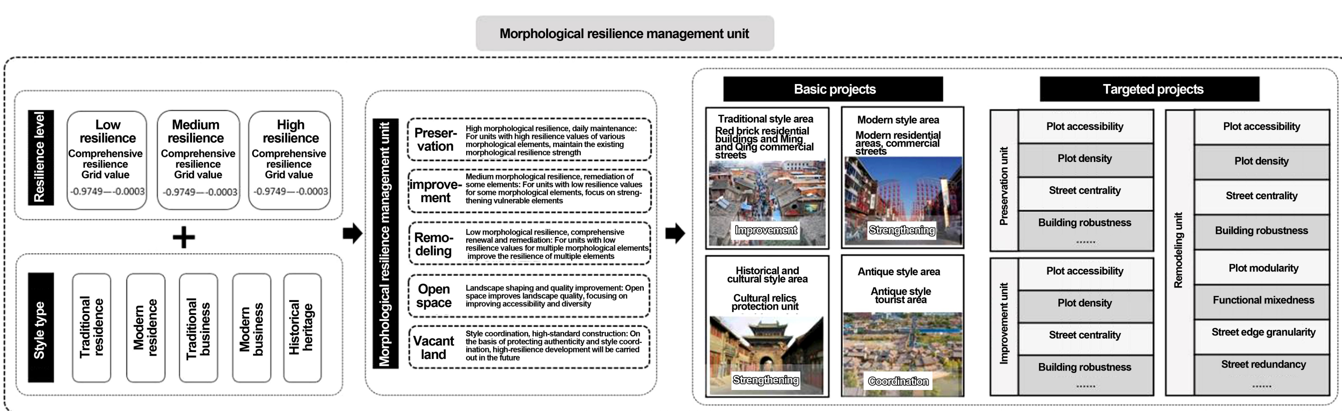


Figure 15 Schematic diagram of the project composition of the morphological resilience management unit

5 Conclusion and discussion

For the purpose of morphological protection, this paper takes the resistance performance in the morphological resilience of historical blocks as the subject of quantitative evaluation of the morphological resilience of historical blocks. The morphological resilience region is the core concept in this quantitative evaluation method, which is formed by the superposition of morphological region and morphological resilience. In the evaluation system, Conzenian urban morphology and resilience system are organically combined, and the "three elements" of morphology correspond to connectivity, diversity, modularity, and robustness in the resilience attributes. Through the selection of morphological resilience indices and the quantification of information data, the abstract concept of resilience is finally concretized, and it is also possible to translate the resilience theory into the planning and design of urban morphology. Five types of management units are further divided on the basis of the obtained morphological resilience regions, and management guidelines are formulated from both macro and micro levels to meet the requirements of refined protection and management of historical block morphology. As a supplement, future research is expected to cover the changes in urban morphological resilience over time and reveal the relationship between morphological resilience and urban social development.

Figure and table sources

Figures 1, 5, 6, 7, 8, 11, 12, 13, 14, 15,and Table 2: Created by the authors.

Table 1: Created based on references [11], [12], [14]

Figures 2, 3, 4, 9, and 10: Self-drawn based on theDetailed Construction Plan of the Historical and Cultural Blocks in the Dongnanyu and Xinanyu Subdistricts of Luoyang City (2019-2035)

Notes

1) The formula is $B_b = \sum_{i=1}^{n} BtAR_{(x)i} \frac{L_i D_i^{\alpha}}{\sum_{i=1}^{n} L_i D_i^{\alpha}}$, where B_b represents the accessibility of the plot, $BtAR_{(x)i}$ represents the accessibility of a street i surrounding the plot, L_i represents the length of the centerline of street i, D_i represents the shortest geometric distance between the centerline of street i and the edge of the plot, and α is the distance attenuation coefficient.Reference: [15]

2) The formula is SI = shape length / 4sqr (shape area), where SI is the shape index, shape length is the perimeter of the street, and shape area is the area of the street.

3) The formula for calculating the density of public facilities is: FDIn= Tn/Sn, where Tn is the number of facilities in plot n and Sn is the area of plot n.

4) The formula for calculating the facility mixedness is $FMIn = -\sum_{i=1}^{Nn} \left\{ \left(\frac{Pi}{Pn}\right) \times \ln\left(\frac{Pi}{Pn}\right) \right\}$, where Nn is the sum of all types of facilities in plot n, Pi is the number of facility i in plot n, and Pn is the number of all facilities in plot n.

References

[1] DAI Wei, SUN Yimin, HAN Meir, Taneer Kunikao Bachin. Towards Resilience Planning: a Study On Delta Planning From An International Perspective [J]. Urban Planning International,2018, 33(3):83-91.

[2] ZANG X Y, WANG Qiao. Concept Evolution, Research Content And Development Trend of Urban Resilience [J]. Science and Technology Review,2019,37(22):94-104.

[3] XIE Wenlong, SUN Cheng. Analysis on the Contemporary Development Trend of Resilience-Oriented Urban Design [J]. Contemporary Architecture,2021(12):21-24.

[4] XU Chan, ZHAO Zhicong, WEN Tianzuo. Resilience: Concept analysis and reconstruction from a multidisciplinary perspective [J]. Journal of Western Human Settlements and Environment, 2017, 32(05): 59-70.

[5] DASTJERDI M S, Lak A, GHAFFARI A, et al. A Conceptual Framework for Resilient Place Assessment Based on Spatial Resilience Approach: An Integrative Review [J]. Urban Climate, 2021, 36: 100794.

[6] FUSCO G, VENERANDI A. Assessing Morphological Resilience. Methodological Challenges for Metropolitan areas [C] // International Conference on Computational Science and Its Applications. Springer, Cham, 2020: 593-609.

[7] PENG Chong, GUO Zuyuan, PENG Zhongren. The Theoretical And Practical Progress of Community Resilience in Foreign Countries [J]. Urban Planning International,2017,32(4):60-66.

[8] GUO Xiaodong, FEI Zhitao, WANG Zhitao. The Rigidity, Elasticity and Resilience of Urban Disaster Response [J]. Urban and Rural Planning,2021(3):35-42.

[9] YUAN Qifeng, CAI Tianshu, HUANG Na. Preservation and Renewal of Historic Blocks From the Perspective of Resilience: A Case Study of Shantou Small Park Historic Block and Foshan Zumiao Donghuali Historic Block [J]. Planner,2016,32(10):116-122.

[10] QIU A. Ten steps Towards Toughness City [J]. Journal of China city, 2021, 35 (01) : 1-8.

[11] LU Y, ZHAI G, ZHOU S, et al. Risk Reduction Through Urban Spatial Resilience: A Theoretical Framework[J]. Human and Ecological Risk Assessment: An International Journal, 2021, 27(4): 921-937.

[12] FELICIOTTI A, ROMICE O, PORTA S. Design for Change: Five Proxies for Resilience in the Urban form[J]. Open House International, 2016.

[13] CHEN Bilin, SUN Yimin, LI Yinglong. Study on Adaptive Transformation of Meso-Micro Resilient Urban Morphology: A case study of Shekou Industrial Zone in Shenzhen [J]. Urban Development Research, 201,28(6):101-111+ 2+ 45.

[14] FELICIOTTI A. Resilience and Urban Design[D]. University of Strathclyde, 2018.

[15] YE Y, ZHUANG Y. Evolution Hypothesis of Spatial Form and Vitality of New District: Based on Integrated Analysis of Street Accessibility, Building Density, Form and Functional Mixing Degree [J]. Urban Planning International,2017,32(02):43-49.

[16]TIAN Yinsheng. The Management Unit of Urban form: Significance, Construction and Application [J]. City Planning Review, 2021,45(7):9-16.

[17] YAO Sheng, TIAN Yinsheng, CHEN Jintang. Theory of Regionalization of Urban Form and its Role in Heritage Protection [J]. City Planning Review,2013(11):47-53,66.

[18] ZHANG Jian, TIAN Yinsheng, GU Kai, et al. Property plot Under the Perspective of Western Urban Morphology Research and Enlightenment [J/OL]. Urban Planning: 1-9 [2022-03-19].http: // kns.cnki.net/kcms/detail/11.2378.TU.20220301.1650.004.html

[19] FELICIOTTI A, ROMICE O, PORTA S. Urban Regeneration, Masterplans and Resilience: the Case of Gorbals, Glasgow[J]. Urban Morphology, 2017, 21(1): 61-79.

[20] TIAN Yinsheng, CAI Meng, DENG Shushan. Organic Renewal of Historical Towns Based on "Management Unit"—An experiment of Wenquan Town in Conghua District, Guangzhou [J]. Urban construction, 2017 (33) : 33-37.