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Comparative Spatial Vitality Evaluation of Traditional Settlements Based on SUF: Taking Anren Ancient Town's Urban Design as an Example

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Abstract: Sustainable urban forms (SUF) guide spatial creation, significantly revitalise the development of traditional settlements, and are an essential theoretical support for urban design. At the same time, the emergence of quantitative spatial analysis technology further promotes the visualised evaluation of the performance of spatial vitality in urban design. However, current research rarely studies the spatial vitality of traditional settlements with quantitative spatial analysis from the SUF perspective. Therefore, this research takes Anren Ancient Town in Chengdu, Western China, as an example to propose a design based on sustainable urban form theory to raise local spatial vitality. Then, it introduces the vitality evaluation system based on the urban form index (UFI) with three measurement methods: Space Syntax, Spacemate, and MXI, and conducts a comparative spatial vitality evaluation of Anren Ancient Town's status quo to explain the process of how the design scheme came about. The results found that urban design proposals based on the principles of compactness, mixed land use and diversity in SUF design guidelines can effectively improve the vitality of traditional settlements. The high vitality of an urban settlement could be achieved by combining SUF-based design guidelines and UFI-based evaluation systems. The spatial vitality evaluation system based on the SUF could assist and optimise decision-making in design and act as a paradigm for urban design or urban regeneration in traditional towns.

Keywords: sustainable urban form; traditional settlement space; spatial vitality; Space Syntax; urban design

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1. Introduction

1.1. Challenges of Traditional Settlements

Traditional settlements could extend the radiation scope of public services for rural areas, create industrial nodes, and improve township integration [1]. However, due to extensive and intensive urban construction, traditional settlements have faced severe impacts, leading to the destruction of the traditional landscape, insufficient investment and management, and longer-term residents leaving [2–5]. In response to these challenges, current traditional settlement policies and planning directions are increasingly related to sustainable development [6,7]. For example, scholars have explored traditional settlement environmental creation and intervention combined with bioclimate characteristics [8], protecting and upgrading traditional settlements by improving energy efficiency and reducing energy consumption [9].

However, the merging process of traditional settlement intervention strategies and sustainable development may encounter difficulties, requiring a balance between tangible and intangible values [10]. In this context, SUF theory guides spatial activation and sustainable development, and is an essential theoretical support for urban design in traditional settlements [11].

1.2. Traditional Settlements Research in China

The construction process of traditional settlements in China faces many challenges, including the lack of regional characteristics and localised spatial creation [12]. In addition, the traditional settlements' planning and design include adopting a method that converges with planning and design in urban areas and implicitly imitates other design styles [13,14]. This leads to a monotonous spatial style and pattern, and the "one side of thousand towns" phenomenon has emerged [15]. This phenomenon is characterised by a highly similar spatial form and urban landscape that lacks the refinement of local culture and characteristics [14,16].

In response to various issues arising in traditional settlements, the Central Economic Work Conference in China issued a comprehensive strategy for promoting "rural revitalization" in 2021, identifying traditional settlements as crucial nodes connecting towns and villages [17]. In addition, the National Development and Reform Commission issued implementation policies such as the "Guiding Opinions on Accelerating the Construction of Beautiful and Characteristic Towns" [18,19]. It aims to encourage people-oriented, rational use of land and natural resources and promote high-quality development of traditional settlements.

Current research focuses on spatial cognition and evaluation systems from the development planning perspective while it focuses less on spatial activation [20]. SUF theory emphasises the importance of the relationship between spatial form and urban sustainability, promotes the sustainable development of traditional settlements and contributes to the "rural revitalization" strategy [21]. In addition, spatial vitality evaluation could support the assessment of spatial quality, identify areas that need improvement, and further enhance the reliability of the proposals based on SUF theory [22].

This research takes Anren Ancient Town in Western China as an example and proposes an urban design proposal based on SUF theory. Then, it introduces the vitality evaluation system based on the urban form index (UFI) and makes a comparative spatial vitality evaluation of Anren Ancient Town's status quo and urban design proposal. Through the urban design proposal based on SUF theory and comparative evaluation through the UFI, this study focuses on two primary research questions:

(1) How can we form the vitality evaluation framework and initiate the urban design proposal in a traditional settlement based on SUF theory?
(2) To what extent can the proposed urban design improve the existing traditional settlement?

This research structure is arranged as follows. First, a framework for creating and evaluating the vitality of a settlement space is presented based on a literature review, quantitative spatial analysis methods and indicators based on SUF theory. Then, the research object, Anren Ancient Town, is introduced, and an urban design proposal based on SUF theory is explained. Third, the research data and quantitative spatial analysis methods based on the UFI are presented, i.e., Space Syntax, Spacemate, MXI and the relevant variables. Fourth, according to the research framework, the UFI-based quantitative spatial analysis method is used to conduct the comparative evaluation between the existing site and the urban design proposal. Finally, the conclusion summarises effective models for shaping the spatial vitality of urban settlements in the context of new urbanisation and provides a paradigm for practitioners and academic research.

2. Literature Review of Sustainable Urban Form

2.1. The Connotation of Sustainable Urban Form (SUF)

The connotation of a SUF contains broader contents [23,24], which can not only serve as operational guides for shaping spatial forms, but also guide the creation of high-quality

urban dynamic space and the reactivation of stock space [25]. Current research on SUFs mainly includes high density, densification, land use, ecological environment, and other aspects [26,27]. Milder believes compactness is the essential factor for sustainable urban forms [28]. Holden believes sustainable urban development points to dispersed concentrations, relatively small settlements with highly dense populations and short distances between houses and public services [29]. Most relevant research topics focus on urban renewal and transformation, aiming to guide the construction of environmentally friendly spatial forms through SUF theory [30–33].

In terms of guiding the content of the SUF, compactness, high density, and mixed land use are significant factors that influence spatial vitality in urban design. These metrics are all used to respond to urban problems via rapid urbanisation, and relevant empirical research is also relatively comprehensive. It involves multiple disciplines and has formed a relatively complete qualitative and quantitative evaluation model, including concepts [34]. Scholars believe that the current theoretical exploration of sustainable urban morphology is faced with issues such as effectiveness, social acceptance and practical operability. Scholars have conducted research on sustainable urban form models [35–37] and practical applications; just as some scholars proposed a new network structure of a compact and multi-centre mode to guide urban development, others suggested building a new framework for a compact eco-city system by creating a six-law coordination system to make up for the current urban defects, and some scholars of the SUF theory point of view concluded that the urban morphology of Zhengzhou would be "L"-shaped (or sickle-shaped), and with the change of regional development environment, it would be "petal"-shaped or "T"-shaped in the long term [38–40].

In addition to urban space, traditional settlements as mediations of conventional culture and vernacular architecture should also be taken seriously [41]. They are a typical spatial carrier for villagers' working, living, and entertaining activities. The purpose of traditional settlements is mainly residence. The traditional spatial configuration and architectural elements reflect and carry important local culture and customs, represent local history and culture and are crucial for extending territorial identity. SUF theory provides significant guidance in creating vitality in settlements owing to its spatial synergetic and coordination impact [42]. However, few guiding principles focus on traditional settlements based on the SUF or solve issues such as that of "one side of thousand towns".

2.2. Spatial Vitality Creation and Evaluation

Traditional settlement research focuses on enhancing spatial vitality by forming a high-quality built environment and promoting sustainable development. The guidelines for creating vibrant spaces in settlements include the accessibility of streets [22], architectural forms [43], the functional mixing degree [44,45], and green ecological design in the physical space aspect. In addition, the aggregation of multi-element spaces and multi-level activities are very effective and important ways to reflect the cultural vitality of a space [46], establishing a spiritual space centred on natural landscape images [47], and thereby enhancing the vitality of the settlement space [48].

Current researchers have constructed evaluation methods with a specific judgment matrix based on the SUF [49], such as density, diversity, mixed land use, and compactness [24,50]. These metrics respond to the economic and environmental needs of urban settlements for industries during the transformation process. SUF-based settlement research methods are biased towards qualitative research, which involves quantitatively evaluating indicators in the evaluation system through field surveys based on interviews and questionnaires [51,52]. However, qualitative and quantitative methods such as the analytic hierarchy process (AHP) [53] and Delphi [54] are used to integrate evaluation results. Limited by sample size, there are still problems of being too subjective and inefficient, making it difficult for these methods to adapt to the current demand for high-quality development of traditional settlements. With a new round of technological breakthroughs and the improvement of statistical methods [55–60], new possibilities have been provided for quantitatively assessing sustainable urban morphology. Berghauser and

Haupt sorted out the current quantitative methods for determining urban morphology from the perspective of density and space in 2009 [61]. Ye extended the research methods with an urban form index (UFI), including "Space syntax, Spacemate and spatial mixing (MXI)", and selected three cities with different historical backgrounds in the Netherlands for empirical research. Ye found that the UFI-based quantitative spatial analysis results were matched with those of the GPS individual circulation investigation, proving the analysis framework's validity and reliability [62]. Recent research shows that the UFI has been proven to have a high reference value for the evaluation of spatial vitality creation [63,64] (Figure 1).

In general, the current research on creating and evaluating the vitality of space mainly focuses on the urban and regional scale [65], while the methodology focuses on qualitative research [66]. Nevertheless, there are few studies on developing and assessing the vitality of space in small-town settlements with quantitative spatial analysis based on the SUF perspective.

2.3. Research Framework Based on SUF

This article attempts to form a research framework for urban settlement space based on the judgment matrix of SUF theory [29] and spatial vitality creation [67,68], combined with the evaluation model of the UFI [63,64] (Figure 1). The research framework of this article is mainly divided into two parts. The first part extracts the spatial guiding factors of settlement space under the SUF theory. In this part, four elements are extracted based on the characteristics of settlement space, with high density, diversity, land mixing, and compactness as the urban design pioneer conditions. The second part is the urban vitality assessment based on the UFI; Space Syntax mainly measures the accessibility of pedestrian and vehicle traffic. Spacemate specifically analyses building density and architectural forms, while MXI mainly analyses mixed land use and the degree of diversity.

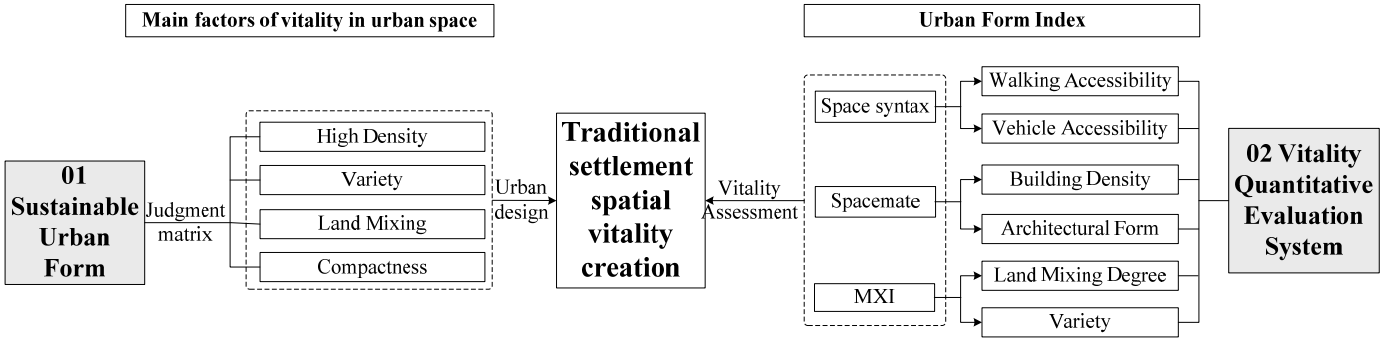


Figure 1. Framework for creating and evaluating the vitality of settlement spaces based on SUF.

3. Anren Ancient Town Analysis and Urban Design Proposal

3.1. Anren Ancient Town Settlement

Anren Ancient Town is located in the west of Chengdu Plain, with abundant historical and cultural resources. The existing old-style street buildings in Anren Ancient Town were mainly built during the late Qing period and the early period of the Republic of China, especially during the residences of the Liu family during the period of the Republic of China. The building style combines Chinese and Western elements, and contains various courtyards that are solemn and elegant, known as the "boutique of Western Sichuan architectural culture". The region has distinguished local residential environments in Western Sichuan, including vernacular houses, water systems, forest fields, and industrial and living facilities, with outstanding regional cultural characteristics (Figure 2). Many residential buildings' central and southern parts are typical forest landscapes in Western Sichuan. The forest landscape in Western Sichuan refers to the rural residential environment formed by the organic integration of farm yards in Chengdu Plain and hilly areas with surrounding tall trees, bamboo forests, rivers, surrounding farmland and other natural environments.

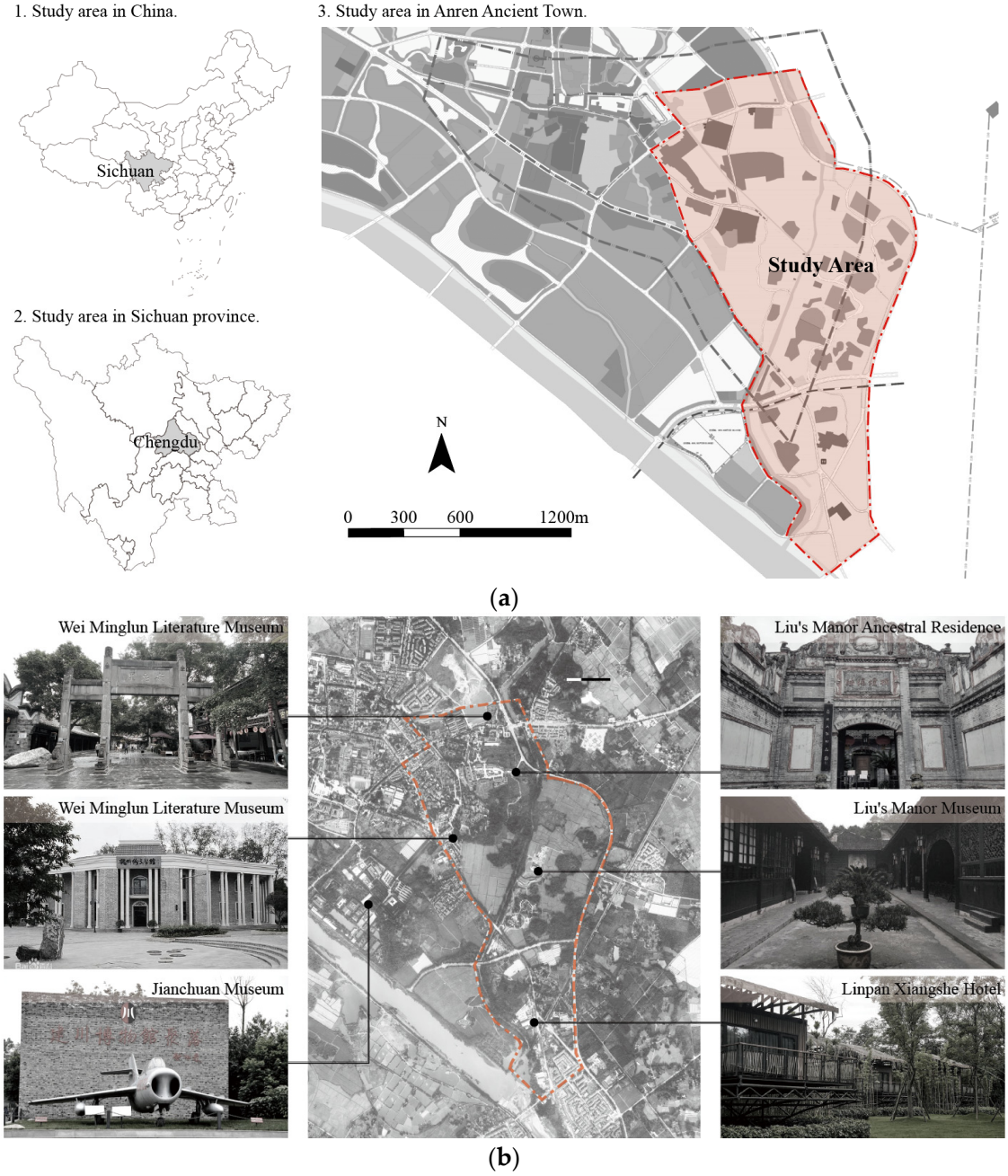


Figure 2. Site situation. (**a**) Site location; (**b**) current spatial images.

The historical culture and unique living environment of Anren constitute the typical characteristics of the study area. On the one hand, the study of the area protects local characteristics, clarifies the development positioning of the area, and promotes rural revitalisation. On the other hand, urban design was conducted for the study area with the guidance of SUF theory, exploring how SUFs initiate urban design proposals in the context of protection and development and how traditional settlements can be improved.

The overall urban design work mechanism was divided into three parts. Firstly, after the theme was released, we conducted on-site research. We thoroughly investigated the local space and architectural status, and communicated with local government officials and residents by inquiring about their demands for the design. The main issues raised were the balance between development and protection, the potential exploration of space, the continuation and reshaping of the architectural culture of Linpan Manor, and the

coordinated development of urban and rural areas. Secondly, there was the mid-term report phase. Based on the result of the research, the initial urban design proposal was issued and communicated with the officials, experts, and scholars in the field to provide design modification guidance. Suggestions focused on enhancing scenario creation, spatial consistency, morphological and cultural feature extraction, and integrated configuration. In the final report, the organiser invited a team of experts led by academician Wu Zhiqiang to review our proposal. They believed that the design proposed in this case, based on sustainable urban form elements such as compactness, land use mixing, and functional diversity, was the ideal direction among all proposals and was selected as the winning award.

According to the filed survey and communication with local officials and residents, the main current spatial development problems were synthesised as follows:

(1) The streamline route is relatively chaotic and has poor accessibility.
(2) The current land use is relatively monotonous, with low diversity and overall vitality. The number of supporting facilities, such as themed hotels, service centres and theme parks, is insufficient.
(3) The current architectural form has a weak sense of connection, and there are significant differences in style and appearance. For example, the scenic spots lack integration, scenic areas are relatively isolated, and links between scenic spots and commercial streets are weak.

3.2. Urban Design Strategies and Proposals Based on SUF

The proposal is based on the principles of SUF, namely, compact layout, mixed functions, and diversified forms (the traditional settlement's urban design originated from the "Solicitation of Planning and Design Proposals for the Construction of Chengdu's Featured Towns" held in 2019. Then, in April 2022, the urban design proposal was incorporated by "Technical Regulations and Guidelines for Planning and Management of Construction Projects in Chengdu Urban-Rural Integration Development Area"). At the initial stage of the design, all the characteristics of the original site were taken into account, such as the historical and cultural buildings, natural heritage culture, and Linpan culture (a traditional residence type in the rural area). The detailed design is as follows:

(1) Compact layout—improved accessibility; the overall proposal continues the texture of the West Sichuan Forest tissues (Figure 3a), enhances land use efficiency in the main functional area, and presents a "compact centre" spatial agglomeration pattern based on retaining the original water system's green space. Additionally, the "Linpan" settlement space on the southwest side is tightly developed internally to improve the space utilisation rate. It ultimately forms a locally dispersed spatial distribution pattern with a compact centre.
(2) Function mixing—diversity improvement; the functions within the venue focus on multiple types of mixed land, especially the design of three spatial clusters around the vitality core: "Immersion Manor", "Creative Garden", and "Lehuo Garden", covering various types of auxiliary functions (Figure 3b), such as exhibitions, hotels, leisure, entertainment, and so on. In terms of the premise of respecting and inheriting the spatial structure of the Western Sichuan forest tray, it enhances the functional mix within the forest tray, and adds various functions such as farmhouse entertainment, shared kitchens, and characteristic homestays.
(3) Diversity of forms—improvement of diversity; the architecture and spatial morphological design proposal are diverse. The buildings on the south and north sides continue the texture of the mansion, while the central facilities assume the core functions of the plot (Figure 3c). Spatial and symbolic images are extracted and redesigned based on the local characteristic texture and material cultural forms. The main architectural form is the courtyard style (Figure 4a). While shaping the form, the design also pays attention to controlling the alignment rate of the buildings on the plot, forming a

relatively continuous street interface, paying attention to the node design of landmark buildings, and enhancing the memory space of the place.

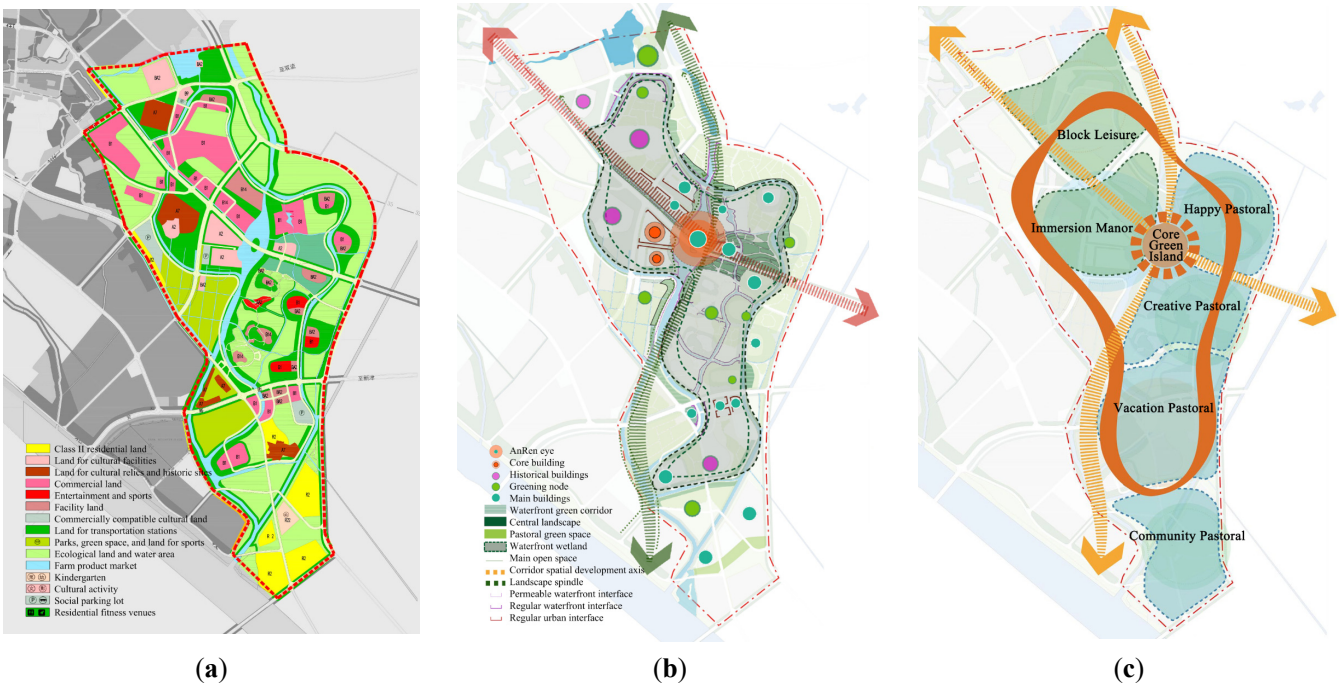


Figure 3. Urban design proposal. (**a**) Land use analysis diagram; (**b**) design proposal's spatial structure analysis; (**c**) schematic diagram of diversified-theme districts.

Figure 4. Schematic diagram of core functions of vitality space. (**a**) Overall master plan; (**b**) aerial view of the centre area.

Around the central area, the design proposes the creation of a new vitality core—"Anren Eye". By shaping the vitality core, the waterfront vitality ring and forest disk vitality cluster (Figure 4) are developed. At the same time, the functional distribution within the dynamic space is relaxed and moderate, creating a diverse waterfront spatial interface around the Qimu River. Based on ensuring the original spatial pattern and corridors, the design aims to create rich architectural forms from traditional languages as

much as possible. Regarding functional diversity, the design places the cultural experience, the Shuxiang pastoral experience, and the static sightseeing in Anren Town properly in the corresponding space. Compared to the current situation, it adjusts and realises the shaping of a new spatial pattern.

4. Data and Analysis Methods

4.1. Data Acquisition

The data were mainly obtained via online searching, field survey and mapping. There are three major data categories: road data, building indicators, and function areas (Table 1). The current status of road data, building indicators and function areas were derived from digital geographical maps authorised by government departments and updated and adjusted based on online searching and field surveys. The data in urban design proposals were obtained from the master plan of the proposal and processed into relevant mappings.

Table 1. Data Sources.

Item	Usage	Contents	Source
Road Data	Road accessibility analysis	Draw a road axis map based on the road trend.	Satellite map; the master plan of urban design.
Building Indicator	Form matrix analysis	Building floors, built-up area and building type data.	Field survey; urban design architectural composition.
Function area	Functional Mix Analysis	Internal functional area data of the building.	Field survey; urban design function analysis chart.

4.2. Analysis Methods

This research mainly involved spatial measurements based on the UFI, including Spatial Syntax [69], the form matrix, and functional mix (Table 2). This accessibility analysis is conducted using the sDNA v4.1.0 software [70], using the global accessibility of the sDNA calculation as an accessibility index; this indicator can reflect the degree of compactness. It takes the average as the plot's reachability value according to the interface's size. Integrated accessibility is the accessibility of the entire region. The classification method with fixed spacing is used to analyse the obtained results.

Table 2. Measurement methods and analysis equations.

Measurement Method	Equation	Meaning
Road Accessibility (RA)	RA = NQPDAn in sDNA	NQPDAn is an indicator in sDNA that calculates global accessibility, reflecting the accessibility level of roads based on its numerical value.
Building Form and Construction Intensity (BC)	$F_x = F \times L$ $FSI = \frac{F_x}{A_x}$ $GSI = \frac{B_x}{A_x}$ $BC = L{:}Form$	F is the single-storey building area, L is the number of building floors, F_x is the total building area, A_x is the plot area, and B_x is the floor area of the building. Form is the architectural form, and different architectural forms can reflect the construction intensity and density [71].
Functional Mix (FM)	$P_w = \frac{S_w}{S}$ $P_c = \frac{S_c}{S}$ $P_r = \frac{S_r}{S}$	P_w is the percentage of working places, P_c is the percentage of commercial places, P_r is the percentage of living places, S_w, S_c and S_r refer to the work, residence, and business areas, and S refers to the total area.
Vitality (V)	V = RA + BC + PM	The road accessibility, building form, construction intensity, and functional mix are superimposed.

In the analysis of building form and construction intensity, the form matrix was used to classify buildings according to their height, which could be divided into few floors (1–3 floors), multiple floors (4–7 floors), and many floors (more than 7 floors). It could

effectively evaluate the diversity of building forms in the urban design proposal. According to the building form, it could be divided into three types: the point type, plate type, and enclosed type. The overall urban form could be divided into nine types according to the first two indicators; part of the data was calculated using the formula in Table 2. According to existing research, forms such as the multi-layer plate type or enclosed type and high-rise enclosed type positively impact urban vitality [72]. Therefore, it uses the low-layer dot formula as the lowest region for density and morphology analysis, and the high-layer enclosure as the highest region for density and morphology analysis, i.e., the low-level dot type is 1 point, low-level plate type is 2 points, low-level enclosed type is 3 points, multi-level dot type is 4 points, high-level dot type is 5 points, high-level plate type is 6 points, multi-level plate type is 7 points, multi-level enclosed type is 8 points, and high-level enclosed type is 9 points. Each building was assigned scores based on the above rules. Finally, the average score was signed for all buildings within the plot as the building form and construction intensity. The higher the final score, the stronger the plot's building form and construction intensity.

Regarding functional mixing analysis, if the area occupied by any of the residential, work, and commercial functions in a certain plot is less than 5%, this function will be ignored [62]. If the floor area ratio of a specific function of a plot is more excellent than 95%, it belongs to a single-function plot. If it has two functions and the proportion of each is more significant than 5%, it belongs to a dual-function plot. If there are three functions and each ratio exceeds 5%, it belongs to a mixed plot. A score of 1 is given for a single residential function, 2 is given for a single workplace function, 3 is given for a single commercial location, 4 is given for a mixture of residential and commercial functions, 5 is given for a mix of residential and work functions, 6 is given for a mixture of work and commercial functions, 7 is given for a low degree of mixing of the three functions, and 8 is given for a high degree of mixing. Each building was assigned scores based on the above rules. Finally, the average score was signed for all buildings within the plot as the functional mixing level of the plot. The higher the final score, the higher the functional mixing level of the plot.

The spatial vitality value of a sustainable urban form is generated by the superposition of accessibility indicators, form matrix indicators, and functional mix indicators. The resultant superposition value is used to reflect the vitality of the land parcel. This article compares the vitality differences before and after urban design practice, summarises their characteristics, and proposes design methods and strategies based on sustainable urban morphology.

5. Spatial Vitality before and after Analysis Results

5.1. Space Syntax—Accessibility Analysis

From the status quo accessibility analysis shown in Figure 5, the accessibility of most street interfaces is between 0.6 and 0.7, and there are about 40 street interfaces larger than 0.7, so the overall accessibility of the plot is low (Figure 5a,b). Based on the analysis of current block accessibility, it can be seen that the current block accessibility is mainly concentrated on the west side of the plot, the area adjacent to Anren Town, and the intersection of main roads is concentrated on the east side of the plot. The accessibility within the plot is generally at a low to medium level. The internal ecological green space, forest sites, and historical legacies such as residences are not easily accessible (Figure 5c).

Compared to the accessibility of existing street interfaces, the accessibility level of the urban design proposal is significantly higher, with most interfaces having an accessibility value of between 1.5 and 1.8, while the accessibility of lower street interfaces is around 1.1 (Figure 5d,e). Therefore, the new urban design significantly improves the accessibility of the plot. Based on the urban design proposal, the accessibility of the plot was analysed, and the overall accessibility of the site was greatly improved compared to the current situation. Multiple high-accessibility plots are distributed in the central core area. At the same time, the northwest to southeast roads and green river axes shape the spatial axis of the proposed plan to enhance spatial accessibility. The accessibility of the main roadside

areas is significantly higher than that of other areas. The central and southern residential areas maintain low accessibility and maintain a sense of privacy (Figure 5f).

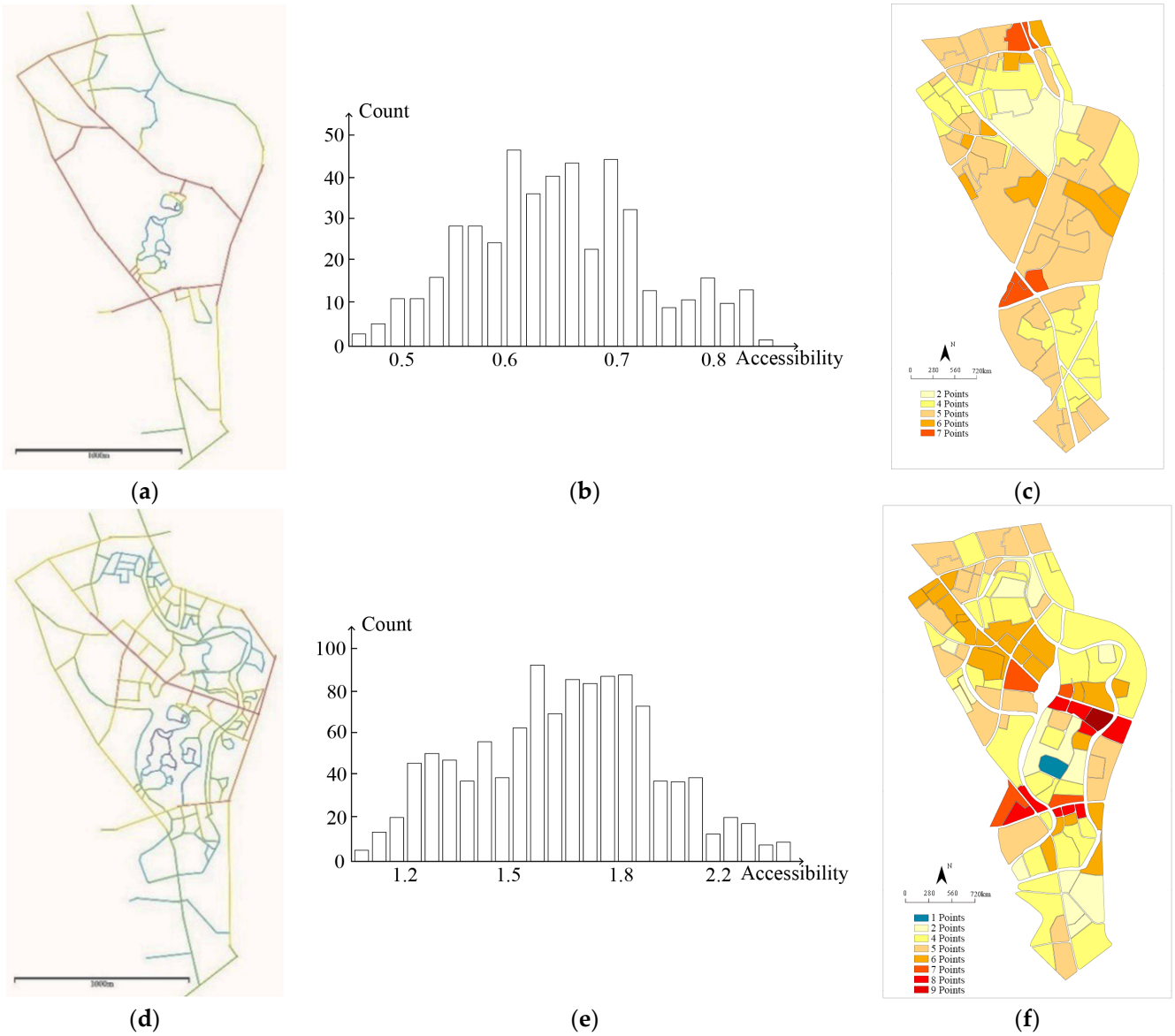
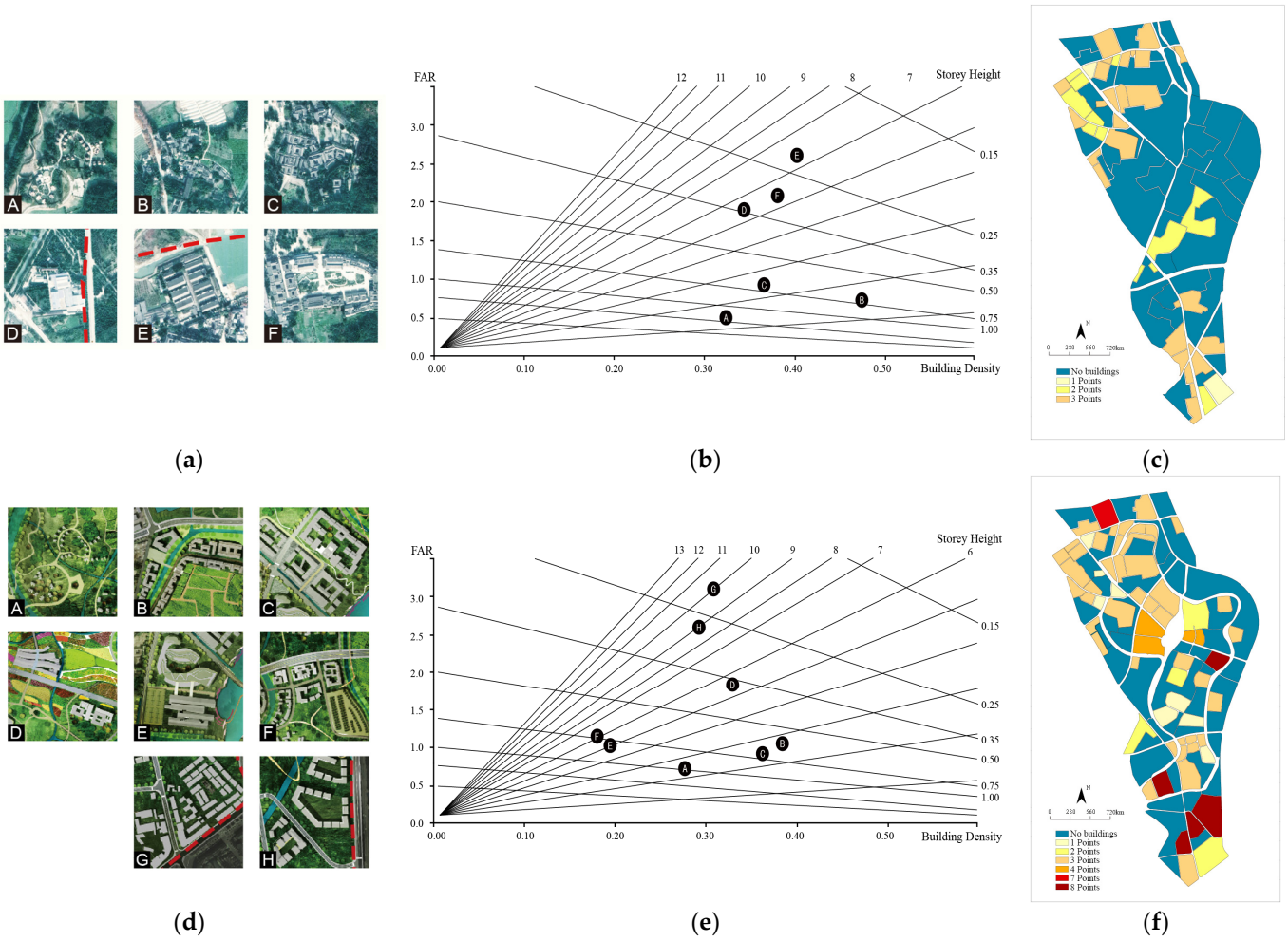


Figure 5. Horizontal distribution of accessibility. (**a**) Accessibility in the current site; (**b**) Quantity distribution of global accessibility of current site; (**c**) Accessibility in the current block; (**d**) Accessibility in urban design proposal site; (**e**) Quantity distribution of global accessibility of urban design proposal; (**f**) Accessibility in urban design proposal block.

5.2. Spacemate—Analysis of Building Density and Form

As shown in Figure 6a,b,d,e, the space is mainly divided into the following eight categories. Categories A, B, and C are mostly 2–3 story buildings, with a density generally between 25% and 40, and mainly distributed along the street. D, E, and F types are point, slab, and enclosed buildings with 4–5 floors. The point type is a museum or complex building. Due to the small interface along the street, the vitality is generally not very high. E and F types are spread around the street and are integrated well with the street and landscape leisure space, so the vitality is generally high. Buildings of categories G and H are the types with the highest construction intensity. Due to the poor connectivity between

buildings, the plate type has a slightly lower vitality, and the high-rise enclosed bearing function is greater, with an extended interface and high vitality.



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

(**d**) (**e**) (**f**)

Figure 6. Classification of architectural form and construction intensity in the site. Note, A: low-level dot type; B: low-layer plate type; C: low-level enclosed type; D: multi-layer dot type; E: multi-layer plate type; F: multi-layer enclosed type; G: high-rise slab type; H: high-level enclosed type. (**a**) current building type; (**b**) current building indicators; (**c**) current building spatial matrix; (**d**) urban design building type; (**e**) urban design building indicators; (**f**) urban design building spatial matrix.

Considering the existing settlement space, putting the FSI (floor space index), GSI (ground space index), and OSR (open space ratio) indicators of the block into the matrix diagram, we found that most of the existing buildings have few floors, with the plot fraction being mostly less than 1. Still, the building densities are generally higher, mostly being above 0.35, and some of them are greater than 0.75, resulting in a small vacant land proportion (Figure 7). The overall architectural density and form scores of the current residential buildings, forest sites, and completed blocks are generally in the middle section, which is consistent with the current survey. That is, the quality of protected buildings is good, including residential buildings, notable folk buildings, etc. However, the overall diversity of commercial and residential buildings is relatively general, and the architectural form lacks regional characteristics (Figure 6c).

Considering the urban design proposal, putting the FSI, GSI, and OSR indicators of the block into the matrix diagram, we found that the number of building floors in the urban design proposal is widely distributed, ranging from the first floor to the sixth floor. The overall floor area portion of the building is evenly distributed from 0 to 3, the building

density is also distributed from 0 to 1, and the greening rate level is found in all sections. The construction intensity and architectural form evaluation results of the entire plot in the urban design proposal greatly improved. The newly built buildings in the south, central south, central, and northern regions are superior to the current residential distribution blocks in terms of the evaluation results. The comprehensive buildings in the central region are more densely clustered than the surrounding commercial streets and communities are according to the evaluation results (Figure 6f).

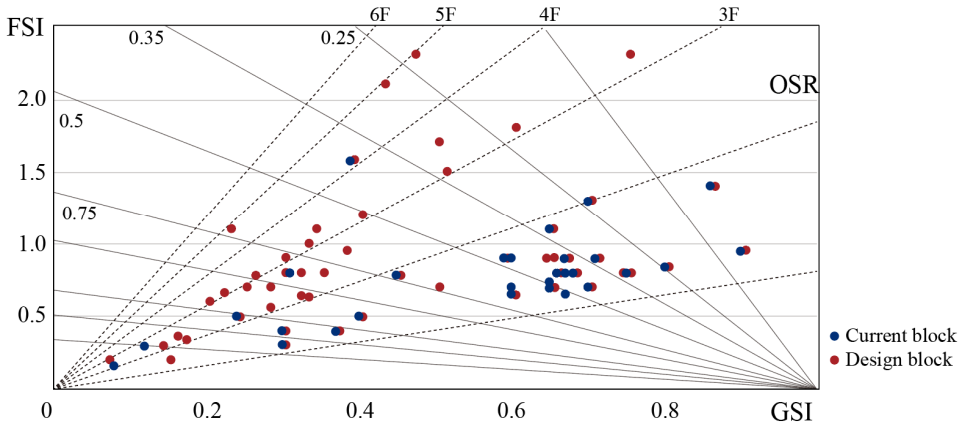


Figure 7. Comparison of site construction indicators.

The spatial matrix is an indicator that reflects the shape and density of a building. According to the analysis results of the spatial matrix, the plot with a score of 3 is surrounded by the bottom layer, and the score of the newly designed area is changed to a more saturated red colour, which is well-arranged. Areas with low scores are conducive to integrating rural areas' beauty, folk customs, and forest elements in Western Sichuan. There are also areas with high scores conducive to the joint creation of a new space between three generations and shared by host and guest. Then, the "Cultural Expo Park" is formed with the old town space.

5.3. MXI—Functional Mix Analysis

The functional mixing degree of the existing settlement is a single functional block, with a relatively uniform overall distribution, which is consistent with the current research situation. It shows the lack of integration of tourism routes, the isolation of different scenic spots, and the weak connection between scenic spots and non-scenic spots, as well as between scenic spots and commercial streets (Figure 8a). The main functions of a building are a mixture of single and dual functions. The proportion of a particular type of function is usually greater than 80%, and the two types of functions account for a large proportion (Figure 8b).

Based on the urban design proposal, the entire plot's functional mixing degree analysis shows a significant increase in high- and medium-mixing degree blocks. High-mixing degree blocks are mainly concentrated in the middle of the plot, and a medium functional mixing degree extends southward along both sides of the central road (Figure 8c). The remaining blocks maintain a low level of mixing degree, with a significant concentration in the centre. The functional combinations of buildings are diverse, with some being single-functional and dual-functional, while the rest are multi-functional (Figure 8d).

5.4. Comparative Analysis of the Vitality Evaluation

Based on the perspective of road accessibility, architectural form, construction density, and functional mixing mentioned above, the urban design proposal was issued. It focuses on the central area, creating a new vitality core, "Anren Eye", which shapes the surrounding waterfront vitality ring and forest disk vitality cluster mainly driven by the vitality core. There are multiple high-accessibility plots distributed around the area. It can be seen that

the roads from northwest to southeast are highly accessible roads. The river's green axis forms the application plan's spatial axis. At the same time, the dynamic ring structure is also attached to the circular road network within the plot, which is presented. At the same time, the dynamic spatial distribution is relaxed and flexible. The cultural experience and the static sightseeing in Anren Town are reasonably located in the corresponding space. Differing from to the current situation, a new spatial pattern is adjusted and achieved.

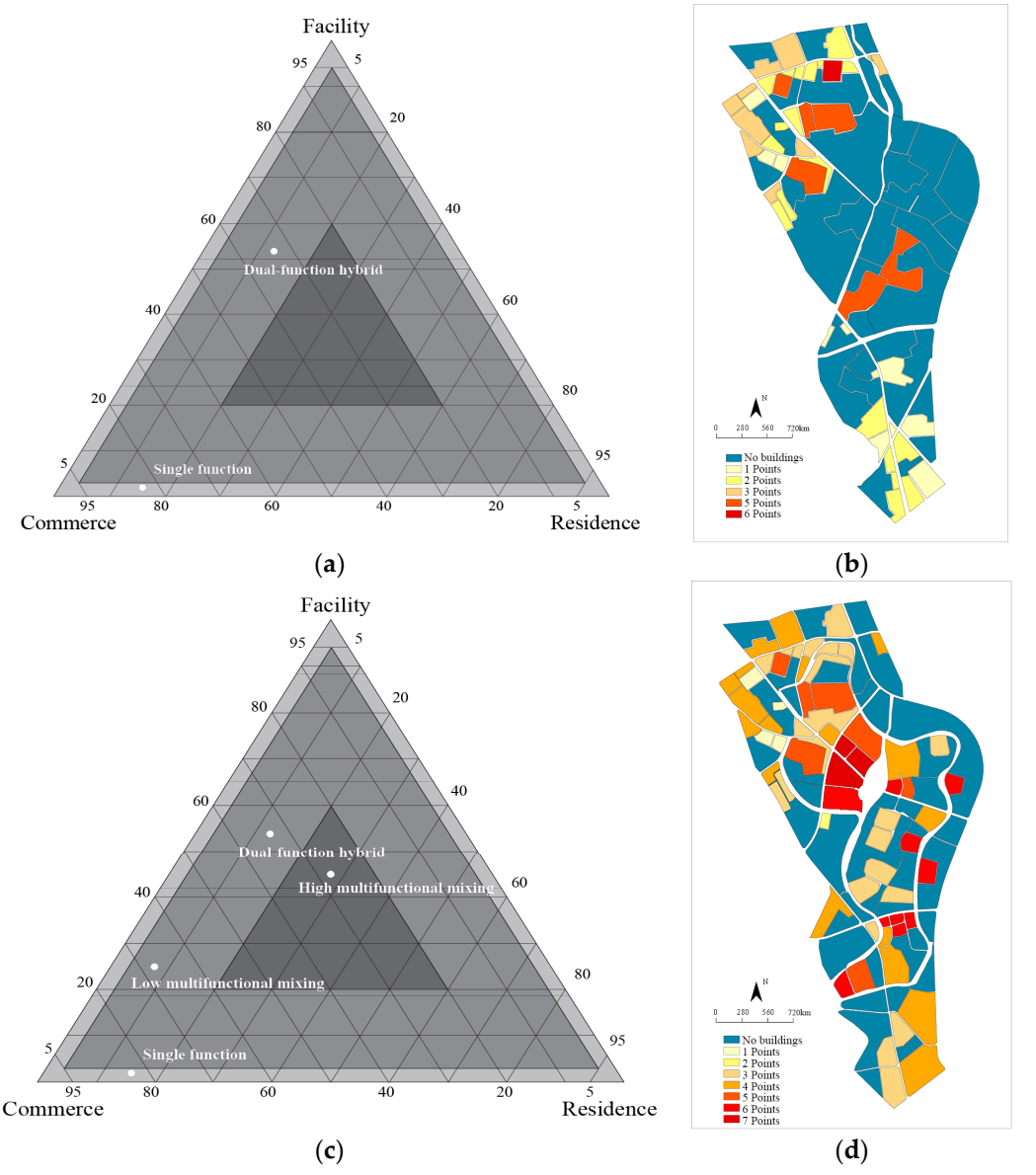


Figure 8. Main type of functional mixing. (**a**) Current situation diagram; (**b**) current space functional mixing evaluation; (**c**) urban design proposal diagram; (**d**) functional mixing evaluation.

In this section, we attempt to stack three indicators to form a single result for spatial vitality creation and evaluation. According to Table 3, the accessibility of the current space is mainly concentrated at the medium level, accounting for 87.80%. The building density and the degree of mixing of form and function are relatively low, accounting for 98.95% and 82.93% of the second level, respectively. The superimposed vitality status quo space has no high-vitality parcels, while the medium-vitality parcels account for 6.10%. Based on the superposition analysis of the quantitative results of dynamic space based on different indicators of design, it can be found that, as shown in Table 3 below, the accessibility of urban design space is mostly concentrated at the medium level, accounting for 72.22%,

with high and low accessibility also accounting for 14.81% and 12.96%, respectively. The degree of building density and form and function mixing is relatively low. Still, the degree of high building density and form also accounts for 5.56%, and the degree of functional mixing accounts for 64.81%. The medium mixing degree accounts for 33.33%, with most of the low functional mix and building density and form being ecological land. The superimposed dynamic urban design space consists of 6.8% high-dynamic plots and 8.33% medium-dynamic plots.

Table 3. Superposition results of morphological elements.

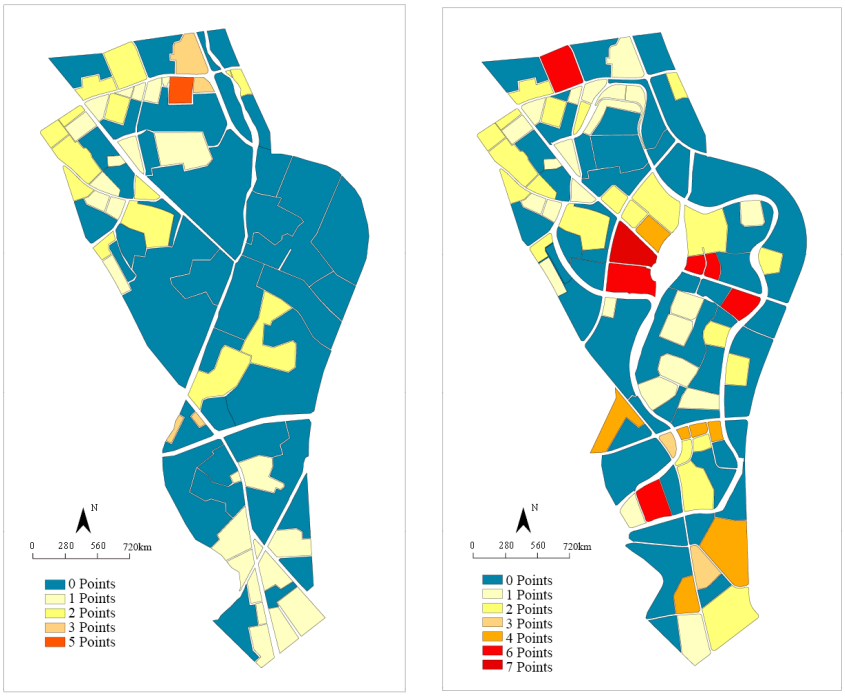
	Form Element Evaluation	Street Accessibility	Building Density and Morphology	Function Mixing Degree	Superimposed Result
Current urban space	High	7.32%	0.00%	0.00%	0.00%
	Middle	87.80%	1.05%	17.07%	6.10%
	Low	4.88%	98.95%	82.93%	93.90%
Urban design proposal	High	14.81%	5.56%	1.85%	6.48%
	Middle	72.22%	3.70%	33.33%	8.33%
	Low	12.96%	90.74%	64.81%	85.19%

Compared with the current site situation, the design proposal retains the existing buildings, and the overall layout of the newly planned plot presents a highly dynamic spatial distribution. (Table 3).

In terms of street accessibility, the winning proposal for Anren Ancient Town would dramatically improve the current situation. The reason for the low rating of building density, form, and the functional mixing is that the design considers the good ecological background of the site, and some towns have good historical buildings. Therefore, there are significant restrictions on the construction volume and building height, and there is no significant gap overall.

As shown in Figure 9 below, based on the evaluation and analysis results, it is found that the overall spatial vitality of the design proposal significantly improves that of the current situation, with high-vitality areas mainly concentrated in the landscape core of "Anren Eye". This indicates that creating a core of spatial vitality can significantly enhance spatial vitality, and also validates the high application value of the design method of combing urban settlement space with landscape nodes and optimizing accessibility. At the same time, the proposal considers the low-vitality areas of the current space, creating vitality corridors on both sides of the river, and optimizing the overall architectural form and density [73]. The urban design proposal effectively enhances the overall spatial vitality and verifies the effects of architectural forms and densities on the overall spatial vitality. In addition, a few yellow and orange blocks are distributed in the loop inside the plot, and their internal vitality level is generally higher than that of other blocks, confirming that sufficient functional mixing is beneficial to enhancing spatial vitality.

The proposal concludes that urban design with high vitality has the following characteristics: high accessibility, multiple-building density degree and construction intensity, forming a space with distinctive structural characteristics, and a high degree of functional mixing of plots, with the highest degree of mixing in the core structural area. Therefore, it posits that urban design with high vitality should be a mixture of high- and low-density spaces, solid land diversity and mixing degree, relative compactness in the core area, and sustainable traffic conditions.



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

Figure 9. Spatial vitality measurement analysis. (**a**) Present situation; (**b**) urban design proposal.

6. Discussion and Conclusions

6.1. Discussion

This article attempts to form a framework of spatial vitality creation based on SUF theory and evaluation based on the UFI of traditional settlements. The research could act as a pilot case for guiding SUF-based traditional settlement revitalisation. The requirements for refined and precise urban design are becoming increasingly stringent, and correlated quantitative spatial analysis methods are needed. This article further elaborates on how to match the diverse and personalised needs of the future beyond the existing context, also leading to the following reflections on the creation of spatial vitality:

(1) The accessibility of a settlement space should consider comprehensive transportation factors, such as vehicles, pedestrians, water, etc. In the design proposal, the "slow" life experience of the settlement space is enhanced by creating a comprehensive transportation system with all elements, such as a slow-moving ecological system, and a "water bus" cruise system. In general, in the process of shaping spatial accessibility, it is not only important to focus on the impact of a single "road traffic" attribute on spatial vitality [74], but also to use a multi-dimensional "traffic" system as a medium for spatial intervention to strengthen the connection between various elements of space. However, it should avoid excessive growth and be in line with the actual development condition.

(2) Building density and form are essential indicators of spatial vitality. On the level of building density, it is advocated to activate spatial vitality through appropriate building density. In some cities and places in China, many copy-and-paste styles from Europe and America have been introduced to attract people's attention. Although this increases the diversity of urban forms, it substantially destroys local culture. The proposal discussed encourages the carrying out of relevant planning and design under the concept of ecological civilisation, respects the existing landscape texture and natural background [75], conducts intensive and appropriate development based on local conditions, and promotes spatial integration. At the same time, on the overall form level, attention should be paid to the guidance of regional culture and

style characteristics [76]. It needs to exhaustively investigate existing buildings' architectural vocabulary and cultural symbols, refine the cultural representation of space, shape buildings and spatial forms based on localisation [77], and highlight the construction of "characteristic towns" under the guidance of local culture.

(3) The degree of functional mixing is also an essential factor in creating vital urban settlements. The analysis results of the functional mixing degree indicate a significant correlation between spatial vitality and functional mixing degree, which is also consistent with relevant research [62]. The abundant functional mixing degree guides spatial element aggregation, strengthening spatial coordination, functional adaptability, and transportation accessibility. From the perspective of sustainable urban morphology, functional mixing requires the deep cultivation of regional culture, cultivation of relevant cultural and creative industries, and promotion of localised development. At the same time, considering the principle of proximity [78], attention must be paid to the relationship between overall planning and the current situation, and the design of single elements must be replaced with an integrated and comprehensive regional coordination design orientation, thereby promoting the vitality of the settlement space.

In addition, this study also puts forward possible implications and planning policies for other traditional settlements. Firstly, accessibility is the crucial element that enhances a traditional settlement's connections within and outside the region. The planning and design need to emphasise multiple transportation systems and fully consider the local environmental conditions. Secondly, spatial configuration, architectural and landscape forms with local characteristics should be protected and inherited, promoting diverse forms and avoiding singularity. Last but not least, functional mixing should be highlighted in policy-making, encouraging the creation of distinctive multi-functional programs that fulfil the potential development scenarios.

6.2. Conclusions

Based on the theory of SUF and spatial vitality creation, this paper conducted a spatial vitality creation and design efficiency evaluation for Anren Ancient Town, with the Linpan settlement in Western Sichuan as the primary spatial feature. The vitality evaluation results of the urban design proposal are consistent with the design expectations, and the characteristics of high vitality in the traditional settlement space are high accessibility, moderately compact building density, and complete construction of multiple transportation systems. The architectural and spatial forms with regional cultural characteristics and the diverse and complex functional mixing degree influence spatial vitality. This finding is consistent with that of a study carried out in Turkey, requiring better accessibility and diversified functions [79]. The accessibility of a settlement space should fully respect the existing natural landscape and ecological civilisation background, and a multi-level vehicle, slow traffic, and water transportation system should be built. A study of traditional settlements in Southeast Asia and Africa also demonstrated the importance of regional culture and natural landscape [80]. Architectural density and morphology are essential indicators of spatial vitality. In terms of density, emphasis is placed on intensive and moderate development. In terms of form, local cultural conformity and style characteristics are combined to create a distinctive architectural spatial form. The control of functional mixing needs to combine regional cultural characteristics and create spatial vitality according to local conditions. The research from Tehran also confirmed that the integration of local cultural identity and architectural accessibility is crucial for creating vitality [81].

In general, the design paradigm under the concept of SUFs has particular significance in the construction of traditional settlement space. As a demonstration of the results of the planning control and guidance of the "Technical Regulations and Guidelines for Planning and Management of Construction Projects in Chengdu Urban-Rural Integration Development Zone", this urban design proposal has an exemplary role in shaping urban morphology, guiding urban planning, territorial space renovation, and promoting "rural

revitalization". Urban design is the intervention of people in urban space, with obvious subjectivity. Quantitative analysis and evaluation based on the UFI are remedies to the objectivity of urban design proposals. Vitality measures based on Spatial Syntax, the morphological matrix, and the functional mixing degree quantify urban morphology from a more comprehensive perspective, effectively assisting in the current site research and decision-making of urban design proposals.

6.3. Limitation

This study has some limitations; due to the number of research samples and the scale of the research scope, the locality of the measurement results cannot be completely ruled out. In the next step, a study needs to be conducted with more samples to make the conclusion more rigorous and objective. For further research, urban design and quantitative spatial analysis could adopt more multi-level spatial conditions comprehensively, and extract integrated morphological features that potentially impact spatial quality and vitality.

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