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Sustainability Benefit Evaluation and Optimization of Rural Public Spaces Under Self-Organization Theory

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Abstract: Agriculture-oriented rural areas represent one of the forms of specialized agricultural practices and economic development. Public spaces serve as critical carriers within the rural spatial system. Rural public spaces are divided into two forms: explicit spaces and implicit spaces. The interaction between these forms significantly influences the morphological evolution of rural public spaces. This study takes the ancient village cluster in Anyi, Nanchang City, China as a case study. By collecting POI (Point of Interest) data and conducting surveys on visitors' landscape preferences, it employs a life circle spatial division method and the VEISD (Village Evaluation Indicators for Sustainable Development) entropy model to evaluate the sustainability benefits of rural public spaces. Based on the evaluation results, the study proposes a control and guidance method for public spaces under self-organization theory. This method leverages the interference effects of explicit rural public spaces on implicit spaces to optimize rural public spaces. The study focuses on the planning and renovation of public space nodes in Luotian Village. By adjusting the sub-indicator "Village Public Environment Construction D22", it validates the scientific robustness of the systems analysis theory and the VEISD framework. By adjusting the spatial layout and attributes of a critical spatial node—the Ancient Camphor Tree Square in Luotian Village—within rural public space planning, the study advances the guidance and control of public spaces during the self-organization evolution of rural areas. It enhances the openness of spatial forms and the functional integration of public space nodes. The results demonstrate that this method can analyze the vitality characteristics of factors within subsystems through the layout and indicator system of rural public spaces. It also validates the findings via correlation tests with the demands for POI and landscape preferences, ultimately constructing the VEISD framework for rural public spaces. This research provides theoretical support for optimizing the resource transformation and utilization of rural public spaces, offering a reference model for the sustainable development of rural areas.

Keywords: rural areas; self-organization theory; public spaces; sustainability; benefit evaluation

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Academic Editor: Lia Bárbara Cunha Barata Duarte

Received: 12 December 2024
Revised: 23 January 2025
Accepted: 23 January 2025
Published: 26 January 2025

Citation: Li, Z.; Cheng, S.; Xiao, L.; Wei, Y.; Fang, T. Sustainability Benefit Evaluation and Optimization of Rural Public Spaces Under Self-Organization Theory. *Sustainability* **2025**, *17*, 1019. https://doi.org/10.3390/su17031019

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1. Introduction

Rural areas, as a significant component of the social system, act as the material foundation and cultural carrier of rural social systems, forming a crucial basis for agricultural economic development [1]. Public spaces are characterized by dynamic changes, and the complex evolution of rural public spaces necessitates systematic methods for explanation [2]. However, the lack of understanding regarding the autonomous development patterns of rural living environment systems in planning and design research remains a major bottleneck in the development of rural public space systems [3].

Immanuel Kant first introduced the concept of self-organization, describing processes that spontaneously emerge and form ordered structures [4]. Building on interdisciplinary insights, Wu Tong defined it as a process of self-organization, creation, and evolution without external drivers, wherein systems autonomously transition from disorder to order, characterized by openness, non-linearity, and fluctuations [5]. From the initial formation of self-organization theory to its application in practical projects for rural public space construction, its role in promoting sustainability is assessed based on a series of variables, including the scale of resource systems, the number of users, leadership, and the importance of resources to users [6]. The Center for Integrated Rural Development (CIRD), in close collaboration with the U.S. Department of Agriculture, has jointly participated in and promoted various rural public space construction projects [7]. These efforts aim to optimize land use and functional layouts, significantly enhancing the overall landscape quality of rural areas and providing a more appealing visual experience for rural communities [8]. Additionally, the Project for Public Spaces (PPS), a nonprofit design organization, is dedicated to helping create sustainable public spaces to foster vibrant communities [9]. Diversified development, enhanced community cohesion, and improved service quality and visitor experiences can drive the sustainable and healthy development of rural tourism. These factors play a significant role in advancing the optimization of sustainability benefits in rural public spaces [10].

The openness of traditional villages facilitates exchanges of materials, economics, information, and energy with the external environment, such as continuous population migration, capital flow, commodity exchange, and information circulation within the village [11]. At the same time, villages can be regarded as complex macro-systems whose overall characteristics are shaped by the interactions and constraints among subsystems, demonstrating pronounced non-linearity [12]. For instance, changes in industries can lead to a redistribution of the population, reorganization of functional land use, and adjustments in transportation routes, thereby driving transformations in the overall village morphology [13]. Fluctuation is a systemic reflection of contradictions in village development, as no self-organizing system can remain in an absolute state of equilibrium. Thus, within certain threshold ranges, village systems can leverage the amplification effects of fluctuations and adopt rational organizational approaches to achieve evolution from gradual changes to sudden transformations and from lower-order to higher-order structured systems.

Among the innovative approaches to addressing the many challenges of rural development, introducing actionable public space management has proven to be the most effective. Rural areas achieve self-organized development by creating potential conditions and factors for sustainable rural transformation [14]. Therefore, the spatial distribution patterns and construction guidance and control of rural public spaces are critical issues in village management. Scholars have conducted extensive research and utilized various types of data to investigate the scope and characteristics of rural public spaces [15]. Wang Shujia et al. constructed a subsystem indicator system for community development and heritage protection using the Analytic Hierarchy Process (AHP) and Delphi methods. By evaluating 10 traditional villages in Lingnan, they validated the system's high reliability, which has been widely applied and guided practices in protecting traditional Chinese villages [16]. Yang Yuanyuan et al. developed an evaluation indicator system for the production–living–ecological functions of villages in the Beijing–Tianjin–Hebei region. Their assessment of these functions provides valuable references for decision making aimed at achieving rural sustainable development goals [17]. Similarly, Statuto et al. utilized Geographic Information Systems (GIS) to investigate mountainous areas in southern Italy and Montenegro. They analyzed the value of coordinated rural tourism development and overall landscape sustainability, offering tools and recommendations to promote local

sustainable development [18]. This study is based on the scientific hypothesis that rural sustainability has direct or indirect impacts on social, economic, and environmental aspects. By collecting extensive evaluation data on traditional villages, it conducts a correlation analysis of rural public space indicator systems to develop a more scientific evaluation framework. The study reveals the intrinsic logical relationship between rural public spaces and sustainable rural development, validating the potential for optimizing rural public space landscape nodes to promote the sustainability of rural public spaces. Furthermore, it proposes the VEISD framework as an evaluation system for the sustainable development of village systems.

Based on this, the study employs the guidance and control of public space construction as the primary method to promote the overall development of rural industrial environments [19]. Based on the self-organization development theory of village systems, this study conducts a systematic evaluation grounded in entropy theory to construct the VEISD. Subsequently, the evaluation scales for the terminal indicators within VEISD are determined, with qualitative and quantitative indicators assigned specific values. This approach reveals the interrelationships among nodes in rural public spaces. It considers optimization goals, such as different groups' landscape preferences, spatial node distribution, spatial accessibility, and node control design during the evolution of rural spaces to enhance the attractiveness and competitiveness of rural industries. The research also explores the synergistic interaction between spatial goals and social connections within rural public space nodes. By analyzing public space samples from three villages with varying organizational forms, historical cultures, social relationships, and economic development levels, it summarizes the specific evolution patterns of rural public spaces, deriving the rules for explicit/implicit public space systems and node transformations. By integrating the spatial usage of diverse stakeholders and addressing the demands of different groups, the study proposes more effective strategies to advance rural spatial evolution. Taking the Ancient Camphor Tree Square in Anyi Village, Jiangxi Province as a case study, the research conducts an optimized redesign of rural public space nodes. The objectives of this study are as follows:

(a) To reveal the patterns of explicit and implicit public spaces in rural areas;
(b) To analyze the guidance and control methods for rural public spaces, with a particular focus on accessibility demands and landscape preferences;
(c) To demonstrate the relationship between public space node optimization, based on the VEISD framework, and the evolution of rural spatial morphology.

The study aims to enhance the understanding of heterogeneous models of accessibility supply–demand and landscape preferences, providing a new perspective for the optimization and redesign of rural public space nodes. Additionally, it seeks to further improve the sustainability of rural public spaces and the sustainable transformation of agricultural resources [20].

2. Research on Self-Organization Development Theory in Rural Systems

A self-organized system refers to a system that can independently organize, create, and evolve without external instructions, autonomously transitioning from disorder to order to form a structured system [21]. Rural systems are complex, integrated systems with typical characteristics of self-organized structures. The theory of self-organization primarily encompasses dissipative structure theory, synergetics, fractal theory, and chaos theory [22]. Wu Tong from Tsinghua University has further analyzed the essence and interconnections of self-organization theory [23], as shown in Figure A1.

The study of spatial self-organization phenomena primarily involves the application of three types of theories. First is dissipative structure theory, which is used to determine the

self-organization of built environments. Second is synergetics, which studies the evolution and dynamic mechanisms of systems. Third is chaos theory, which examines the impact of small interventions on system behavior [24]. The openness of a system is a necessary condition for self-organization, which includes three main characteristics: (1) continuous exchange and interaction with the environment; (2) relatively balanced external input to the system; and (3) external input to the open system reaching a certain threshold. This study treats rural areas as self-organizing systems, using the three necessary conditions of self-organization theory to transform rural public space evolution patterns, as shown in Figure A2.

The self-organized governance of residents in traditional villages stems from historical contexts that precede rational planning and design. It arises naturally from factors like geographical environments, cultural customs, religious practices, topographical features, and the diverse lifestyle needs of individuals, forming what is described as "order under apparent disorder" [25]. This growth system embodies a strong sense of rural identity and vitality [26], encompassing three primary dimensions: space, population, and activities [27]. Self-organized space refers to the diverse village spaces spontaneously created without planning guidance or restrictions. Self-organized populations are individuals directly connected to the village who participate in its transformation despite lacking professional expertise or formal authority. Self-organized activities are those that occur within spaces and diverge from the activities outlined in organized systems. The interplay between the material and cultural environments shapes the basic structure of the self-organized systems in villages, characterized by three key attributes: space, activity, and culture. As rural construction practices advance, rural areas increasingly function as "nodes" within the hierarchical systems of urban–rural, village–town, and rural regions [28]. The functions, layouts, scales, and dimensions of rural public spaces form the foundation for the self-organized evolution of rural spaces [29]. Figure A3 illustrates research trends on self-organization theory from 2020 to 2024 across various countries and the evolution of related keywords in different fields. Figure A3a,b demonstrate that Chinese scholars have integrated self-organization theory into fields like rural development, sustainability, and environmental ecosystems.

Public spaces in Chinese villages are defined by the nature, frequency, and scope of villagers' public activities, exhibiting strong spontaneity. Rural public spaces include outdoor open spaces, such as squares, village entrances, threshing grounds, and opera stages, as well as indoor spaces open to the public, such as medical stations, libraries, and teahouses [30]. Based on their adaptability to different control strategies, rural public spaces can be divided into two categories: explicit public spaces and implicit public spaces. Explicit public spaces are characterized by strong ceremonial and structural features. They play a significant role in shaping the overall spatial structure of the village and guiding its evolution. These spaces are large in scale, rich in cultural characteristics, and often associated with historical events or memories of the village's development, making them easily recognizable and suitable for control and guidance. Implicit public spaces, on the other hand, are life-oriented and defined by villagers' specific collective behaviors. They change with variations in behaviors and interaction patterns, exhibiting uncertainty, variability, randomness, and informality. These spaces are less structured, harder to recognize, and more difficult to control. In practice, there are no clear boundaries between public space nodes of different levels and attributes. Instead, nesting and transformation phenomena often occur. Higher-level rural public spaces and nodes are more recognizable and easier to control, fitting the definition of the explicit system in this study [31]. The classification methods for rural public spaces are mostly based on sociological perspectives while also considering the architectural field's focus on physical space. Common classification methods are summarized in Table 1 [32].

Table 1. Study of the classification methods of rural public spaces.

Category	Type	Characteristics
By System	Explicit	(a). Connected by the main rural road system, with strong accessibility; (b). Clear cultural characteristics, associated with historical events and memories of rural development; (c). Strong controllability of nodes;
	Implicit	(a). Includes rural public spaces at the individual and neighborhood levels; (b). Public spaces in private domains for daily activities; (c). Uncertainty, variability, spontaneity, and informality; (d). Low controllability of nodes.
By Physical Form	Point Spaces	Typically spaces like ancient trees or wells.
	Linear Spaces	Typically streets or alleys.
	Surface Spaces	Typically ponds or plazas.
By Duration	Fixed Spaces	Long-term: Public spaces formed through stable social organization and interpersonal relationship structures.
	Temporary Spaces	Cyclical: Not recognized as public spaces outside of specific periods.
By Function	Road Spaces	Like streets and alleys, linear spaces serve as connections between rural areas and the outside world and act as links between rural space nodes.
	Entrance Spaces	Like village entrances, they serve as transportation nodes that connect rural areas to the outside world, functioning as the starting or ending points of rural streets and alleys.
	Ceremonial Spaces	Like ancestral halls—the centers of rural governance—or temples, these are the spiritual centers of rural areas.
	Recreational Spaces	Like plazas, these are surface spaces that have road connections and attract people; they often merge with streets and village entrances to form central gathering areas in rural settings.

The village system, as a human settlement system, possesses all of the characteristics expected of a system, including openness, hierarchy, and feedback mechanisms. Due to the complexity of the village system, its composition is multidisciplinary, rooted in the architectural discipline while also encompassing ecology, economics, sociology, and other major fields. This reflects the balanced input characteristic of the self-organization process within the village system [33]. The SUCCESS project (Sustainable Users Concepts for China Engaging Scientific Scenarios) links the concept of sustainable development with self-organization development. It brings together professionals from fields like ecology, economics, socio-cultural studies, agriculture, and architecture to collaboratively conduct research. Through surveys, the project carries out comprehensive analyses of pilot villages and formulates feasible plans for the sustainable development of village systems [34].

Through cross-disciplinary research in both horizontal dimensions and vertical depths with the architectural discipline, this study explores the conditions required for villages to function as self-organizing systems. Based on the identified components of the system, this research focuses on the vertical structural analysis of village systems and the interconnections among horizontal subsystems, optimizing the functions of key system nodes to achieve in-depth updates of the village system. Chen Bingzhao mentioned in his work "Research on the Sustainable Development of Human Settlements in Small Towns in the Suburbs of Shanghai" that human settlements consist of three subsystems: economic and social, natural ecological, and artificial physical systems. These include both material and spiritual environments and involve factors at household, community, and regional levels [35]. Peng Zhenwei, in "Framework and Cases for Sustainable Development of Rural Construction", identified three key components for sustainable development in rural human settlement construction, settlement conditions, settlement construction, and sus-

tainability, with a focus on rural land use, planning, and the characteristics of rural human environments [36].This study adopts the definition of village systems from the SUCCESS project, which categorizes the village system (System A) into four subsystems: the natural ecological subsystem (B1), the socio-cultural subsystem (B2), the economic production subsystem (B3), and the architectural environment subsystem (B4).

This study places rural public spaces within the framework of a self-organizing system, as the two exhibit structural consistency. Public space nodes at different levels play varying organizational roles within the rural self-organization system [37]. The explicit public space system, in conjunction with the rural environment, forms the foundation for spatial evolution and serves as a structural element in the development of rural spatial morphology. Distinctive rural public spaces can be considered valuable resources for rural areas and can be developed as tourist attractions [38]. Some scholars have also explored the role of public space nodes in driving rural public space development and how industrial transformation enhances rural public spaces and human settlement environments [39].

3. Materials and Methods

3.1. Research Area and Data Collection

This study focuses on the ancient village cluster of Anyi in Nanchang City, Jiangxi Province, China to analyze its public space sustainability benefits and node optimization. The sample area is sparsely populated and has limited industrial resources to support sustainable development. However, as a tourism-oriented rural cluster, its vast and rich natural landscape resources serve as advantageous conditions for industrial development. Notably, the sample area holds significant representativeness, particularly in studying the evaluation index system for the sustainable development of village systems and the heterogeneity of landscape demands and preferences among different groups. Jiangxi Province boasts excellent environmental resources and abundant rural resources, with its distinctive villages distributed as shown in Figure 1. The Anyi ancient village cluster, located in Shibi Town, consists of three ancient villages, Jingtai Village, Luotian Village, and Shuinan Village, forming a characteristic rural cluster dominated by industry, as illustrated in Figure 2. These represent the fusion of Gan culture and Gan merchant culture and are typical examples of traditional Gan-style architecture on the Ganfu Plain [40].

The study categorized 200 Points of Interest (POIs) within the selected area into ten categories, including culture, education, services, attractions, and others (as shown in Table 2). These categories were further matched with sampling points within the study area, as shown in Figure 3a [41]. Based on the POI data, the study introduced the concept of a 15 min living circle to analyze the spatial distribution patterns of visitors within the scenic area, primarily using walking and cycling as the modes of transportation [42]. Additionally, Open Street Map data were utilized to acquire street network geographic information for two key nodes: the scenic area's parking lot and the Ancient Camphor Tree Square. To collect data on visitors' needs and preferences, the study conducted a questionnaire survey based on social and ecological indicators, such as population density, landscape types, and aesthetic categories within the scenic area. Different POIs in three villages within the sample area were selected for this survey [43]. Additionally, typical POI locations were documented through on-site photography, as shown in Figure 3b. Spatial data were classified into various levels or types to ensure that the sample points were distributed across all categories and levels.

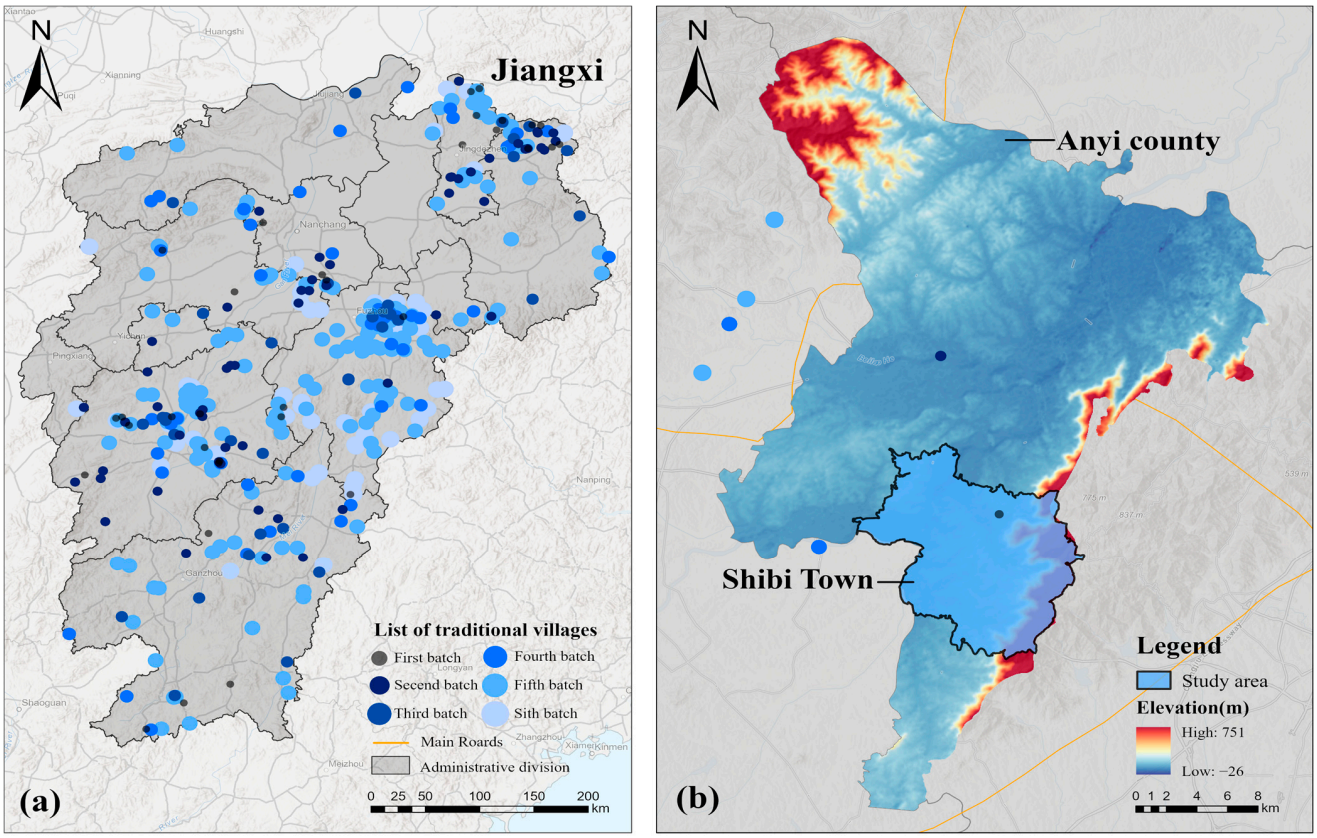


Figure 1. (**a**) Distribution of characteristic tourism villages in Jiangxi Province; (**b**) location map of Shibi Town.

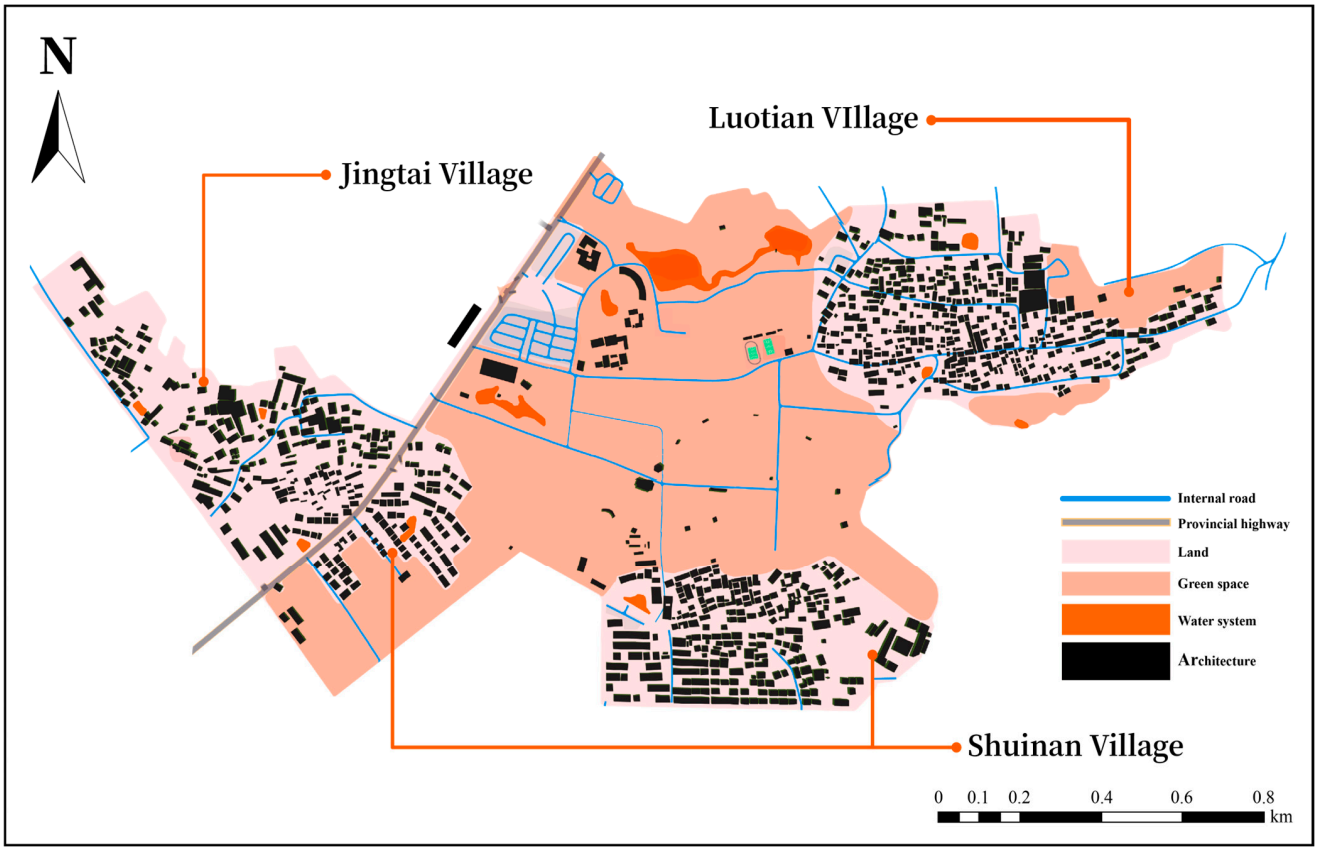


Figure 2. Spatial layout of the Anyi ancient village cluster.

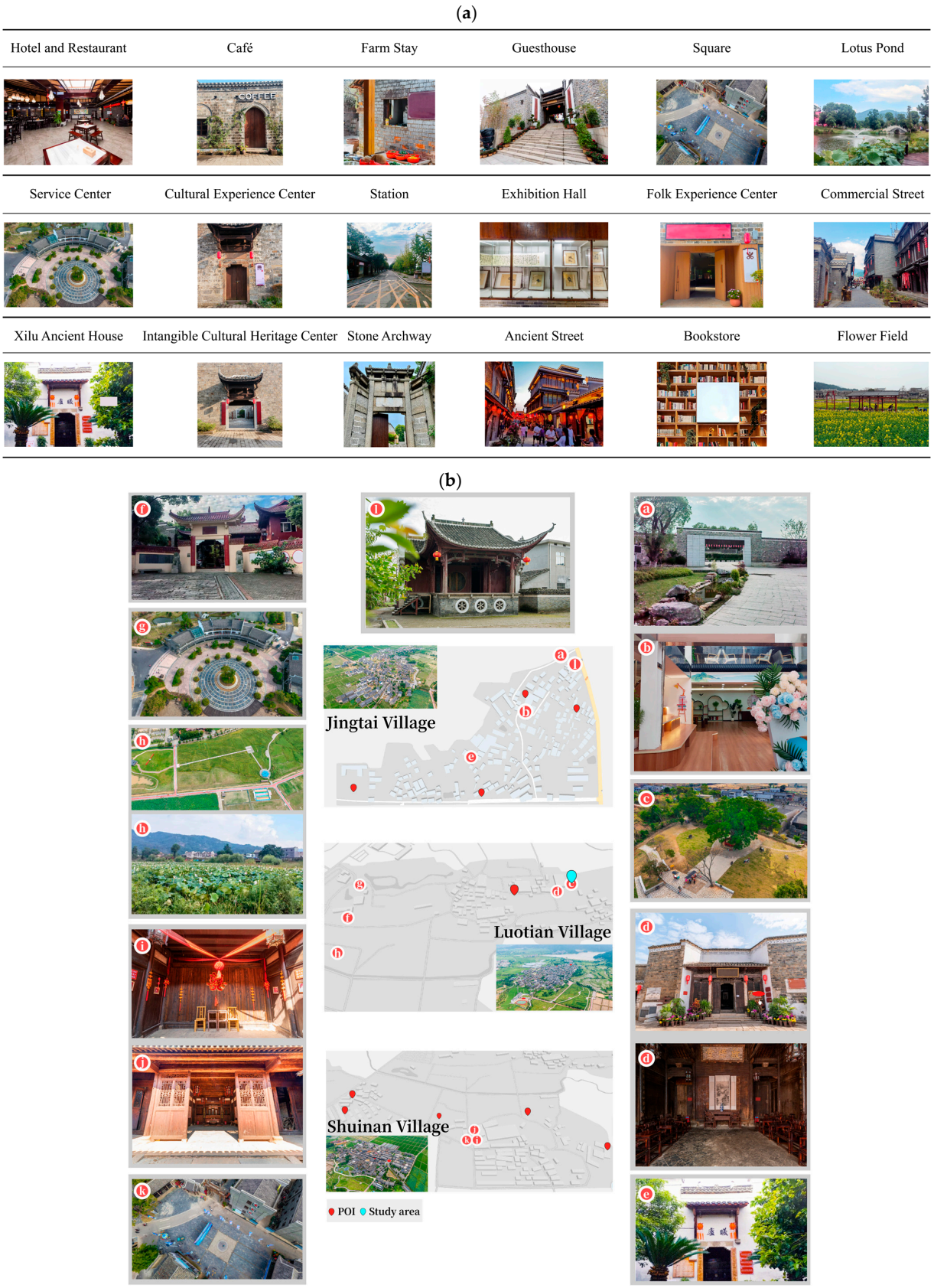


Figure 3. (**a**) POI and field sampling points; (**b**) distribution of sampling points and real-scene images (a: Jingtai Cultural Courtyard; b: Ruzishu Study Room; c: Ancient Camphor Tree Square; d: Shidafu Residence (internal and external perspectives); e: Xilu Residence; f: Xialian Courtyard; g: Tourist Service Center; h: Lotus Field (internal and external perspectives); i: Guixiu Tower; j: Huang Family Ancestral Hall; k: Cultural Square; l: Jingtai Village Opera Stage).

Table 2. Categories and subcategories of POI samples within the tourism villages.

Main Category	Sub-Fields
Catering Services	Restaurants, Cafes, Fast Food, Bars, etc.
Shopping Services	Malls, Supermarkets, Retail Stores, etc.
Living Services	Logistics, ATMs, Government Services, Hospitals, etc.
Cultural Services	Schools, Libraries, Exhibition Halls, etc.
Recreation and Entertainment	Cinemas, Leisure Plazas, Parks, etc.
Residential Areas	Residences, Dormitories, etc.
Hotels	Star Hotels, Motels, etc.
Parking and Charging Stations	Parking Lots, Vehicle Charging Stations, etc.
Companies	Companies, Industries, etc.
Transport Stations	Airports, Subway Stations, Bus Stops, etc.

3.2. Analysis of Village System Structure and Factor Screening Methods

Village system A comprises four subsystems: the natural ecological subsystem (B1), the socio-cultural subsystem (B2), the economic production subsystem (B3), and the architectural environment subsystem (B4). This study focuses specifically on the architectural environment subsystem (B4), analyzing its components and interactions to better understand and optimize the tangible aspects of village systems.

The study compares the natural ecological subsystem and the architectural environment subsystem of villages to identify factors with a high degree of correlation with the architectural environment subsystem. These factors serve as the foundation for constructing the village system evaluation index system. To assess and screen factors within each subsystem, the strength of their interconnections is categorized into four levels: 0 (no correlation), 2 (weak correlation), 4 (moderate correlation), and 6 (strong correlation). Natural ecological subsystem: the resource sub-subsystem includes land resources, encompassing geological features, topography, and land development and utilization, representing the inherent characteristics of the land. Architectural environment subsystem: the public space construction sub-subsystem already incorporates aspects of land use but focuses more on land use within the context of residential environment planning. This study integrates these aspects, classifying them under village public space construction for further analysis. Following the principles of the entropy-based village system evaluation index framework, the study identifies factors with close interrelations across subsystems. These factors are consolidated to construct a comprehensive village system.

3.3. Entropy Change Model for Sustainable Benefit Assessment and Entropy Calculation Model

The self-organization methodology facilitates the study of various aspects of organic systems, including their evolutionary conditions, generation mechanisms, critical "potential points" of transformation, and the intrinsic uniformity of self-similarity [44]. Entropy theory and the self-organization methodology for complex systems provide a scientific framework for evaluating rural sustainability benefits [45]. The overall conceptual framework is depicted in Figure 4.

The study adopts entropy as a tool to evaluate the sustainability benefits of rural systems. By designing a systemic entropy framework, it constructs an evaluation index system for the sustainable benefits of rural public spaces, thereby enabling a quantitative description of sustainability [46]. The study develops the Village Evaluation Indicators for Sustainable Development (VEISD) entropy-based evaluation index system, defining evaluation scales for terminal indicators in the VEISD system, as illustrated in Table 3. It assigns specific values to qualitative and quantitative indicators, providing a comprehensive methodology.

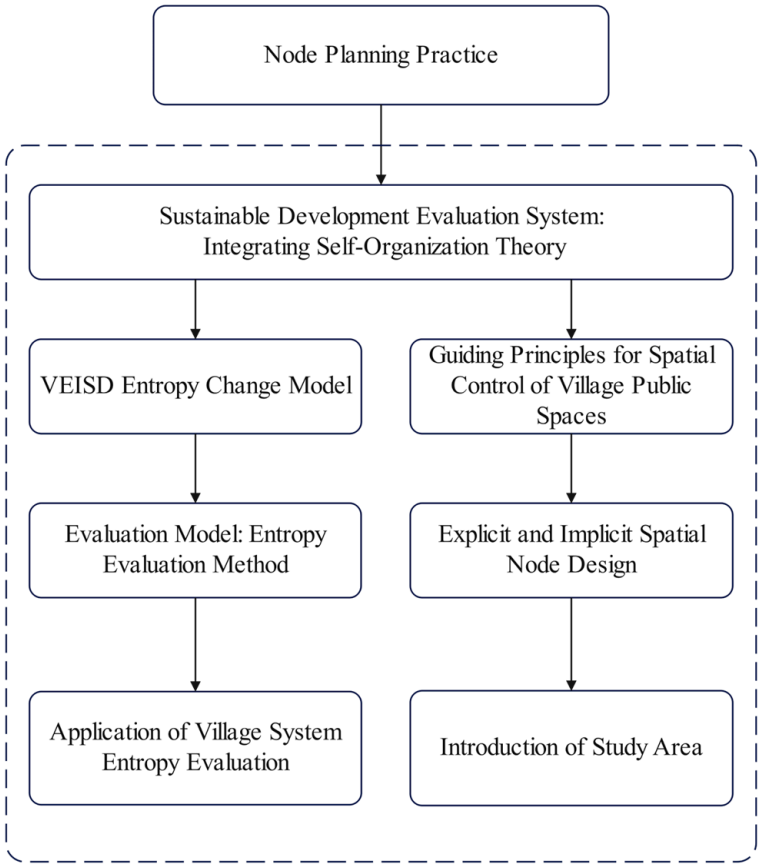


Figure 4. Conceptual framework for sustainable benefit evaluation of rural public spaces.

Based on the specific data from the evaluation of rural public space benefits in the samples, and following the principles of the VEISD (Village Evaluation Indicators for Sustainable Development) framework, the study integrates four key subsystems—economic production, natural ecology, social culture, and architectural environment—into economic entropy, ecological entropy, social entropy, and architectural entropy, respectively, as subsystem entropies [47]. Because VEISD is a multi-level hierarchical model, it aligns with the system factors at each level, forming a four-tier evaluation index system: total entropy (A), first-level entropy (B), second-level entropy (C), and third-level entropy (D).

The total system entropy A is composed of economic entropy B_1, social entropy B_2, ecological entropy B_3, and architectural entropy B_4, and it is expressed in the following functional form:

$$H = f(B_1, B_2, B_2, B_4, T) \tag{1}$$

Then,

$$H = H(B_1) + H(B_2) + H(B_3) + H(B_4) \tag{2}$$

Taking the derivative of both sides of Equation (2) with respect to time, we have

$$\frac{\mathrm{d}H}{H_{t+1}} = \frac{\mathrm{d}H(B_1)}{= H(B_1)_{t+1}} + \frac{\mathrm{d}H(B_2)}{+H(B_2)_{t+1}} + \frac{\mathrm{d}H(B_3)}{+H(B_3)_{t+1}} + \frac{\mathrm{d}H(B_4)}{+H(B_4)_{t+1}} \tag{3}$$

Let

$$H_1 = H(B_1)_t + H(B_2)_t + H(B_3)_t + H(B_4)_t \tag{4}$$

Then,

$$\nabla H = \frac{\left[H(B_1)_{t+1} - H(B_1)_t\right]}{\nabla t} + \frac{\left[H(B_2)_{t+1} - H(B_2)_t\right]}{\nabla t} + \frac{\left[H(B_3)_{t+1} - H(B_3)_t\right]}{\nabla t} + \frac{\left[H(B_4)_{t+1} - H(B_4)_t\right]}{\nabla t} + \frac{\left[H(B_4)_{t+1} - H(B_4)_t\right]}{\nabla t} \quad (5)$$

Then,

$$\nabla H = \frac{H}{t+1} - H_t \nabla t \quad (6)$$

In Equation (6), H_{t+1} and H represent the final state entropy value and the initial state entropy value of the sustainable development evaluation index system for the rural system, respectively. Therefore, we have the following.

(a) When $\nabla H < 0$, it indicates that the entropy increase generated by the rural system over a certain period is less than the negative entropy introduced from the external environment. The system is in a phase of overall entropy reduction, and the internal structure tends to develop in an organized manner.

(b) When $\nabla H > 0$, it indicates that the entropy increase generated by the rural system over a certain period is greater than the negative entropy introduced from the external environment. The system is in a phase of overall entropy increase, and the internal structure tends to develop in a disorganized manner.

(c) When $\nabla H = 0$, it indicates that the entropy increase generated by the rural system over a certain period is approximately equal to the amount of negative entropy flow introduced. The system is in a special state of dynamic equilibrium. Measures should be taken based on the actual state to introduce more negative entropy flow or reduce the entropy increase, guiding the system to develop in a favorable direction.

The basic entropy calculation model is described as follows:

Let the indicator X have n bottom-level codes, with corresponding indicator values x_1, x_2 ..... x_n. The entropy of the indicator X can be expressed as

$$H(x) = -k\sum_{i=1}^{n} P_i \ln P_i \quad (7)$$

where, i = 1, 2, 3 ....., n. In the equation,

$$P_i = \frac{x_i}{\sum_{i=1}^{n} X_i}, \quad k = \frac{l}{\ln n} \quad (8)$$

assuming that when

$$P_i = 0, \text{then} P_i \ln P_i = 0 \quad (9)$$

Let the weight coefficient of the bottom-level codes be W_i; then, the weighted entropy of the indicator X can be expressed as

$$H(x) = -w_i k\sum_{i=1}^{n} P_i \ln P_i \quad (10)$$

This study uses entropy values to assess the dynamic development of the village system and applies these insights to guide and control targeted node areas within the research region. The entropy evaluation results of the village system provide feedback data for the development of key nodes, offering clearer data support for the sustainable development of rural public spaces.

Table 3. Composition of the VEISD system entropy under the rural tourism benefit sustainability evaluation index system.

Total Entropy	First-Level Entropy	Second-Level Entropy	Third-Level Entropy	Bottom-Level Code
A: Rural System Sustainable Development Evaluation Index System	B1: Rural Economic Entropy: Economic Development Capability	C1: Degree of Rural Industrial Structure Optimization	D1: Degree of Agricultural Industrialization	En
			D2: Degree of Development of Village Enterprises	En
			D3: Degree of Development of Local Cultural Industries	En
		C2: Rural Values	D4: Rural Economic Performance	En
			D5: Rural Input–Output	En
	B2: Rural Social Entropy: Cultural Coordination in Rural Society	C3: Psychological and Behavioral State of Villagers	D6: Sense of Security in the Village	En
			D7: Sense of Community Belonging	En
			D8: Villager Participation	En
		C4: Rural Culture and Democratic Politics	D9: Education Level of Villagers	En
			D10: Historical and Cultural Traditions	En
			D11: Level of Rural Policy and Administration	En
	B3: Rural Ecological Entropy: Balanced Development of Rural Ecology	C5: Development and Utilization of Rural Resources	D12: Recycling of Water Resources	En
			D13: Soil and Water Conservation	En
		C6: Status of Rural Energy Usage	D14: Development and Utilization of Renewable Energy	En
			D15: Optimization of Conventional Energy	En
		C7: Pollution Prevention and Control	D16: Prevention of Production Pollution	En
			D17: Management of Household Waste	En
	B4: Rural Architectural Entropy: Quality of Architectural Space Environment	C8: Quality of Public Space Environment	D18: Extension of Rural Environment	En
			D19: Layout of Public Spaces	En
			D20: Utilization of Construction Land	En
			D21: Status of Rural Infrastructure Development	En
			D22: Status of Rural Public Environment Construction	En
			D23: Safety and Disaster Prevention	En
		C9: Quality of Courtyard Space	D24: Quality of Courtyard Environment	En
			D25: Quality of Indoor Physical Environment	En
			D26: Use and Development of Local Building Materials	En

3.4. Visualization of Visitor Landscape Preferences

This study uses travel distances to reflect visitors' preferences for the accessibility of natural and cultural landscape nodes within the village [48]. These preferences are evaluated using two metrics: the Recreation Potential Index and the Accessibility Index. The Recreation Potential Index can be used to assess the vibrancy of a space. The overall evaluation approach for visitors' landscape preferences is illustrated in Figure 5.

In spatial system evaluation studies, functional diversity, environmental quality, and transportation accessibility are essential guarantees for ideal street activities [49]. Accessibility, on the other hand, evaluates spatial vibrancy from four aspects: culture, environment, space, and facilities [50]. Using these two indicators as references provides an effective means to evaluate visitors' preferences for landscape accessibility within the sample area. This approach offers scientific support for the planning and management of the study region, demonstrating strong rationality and practical applicability. The Recreation Potential Index is assessed based on the naturalness of the landscape, the distribution of nature

reserves, and the attractiveness of water features. The Accessibility Index is indirectly measured by analyzing the Euclidean distance (straight-line distance) between each grid cell and the target area or major roads, reflecting regional accessibility and transportation convenience [51].

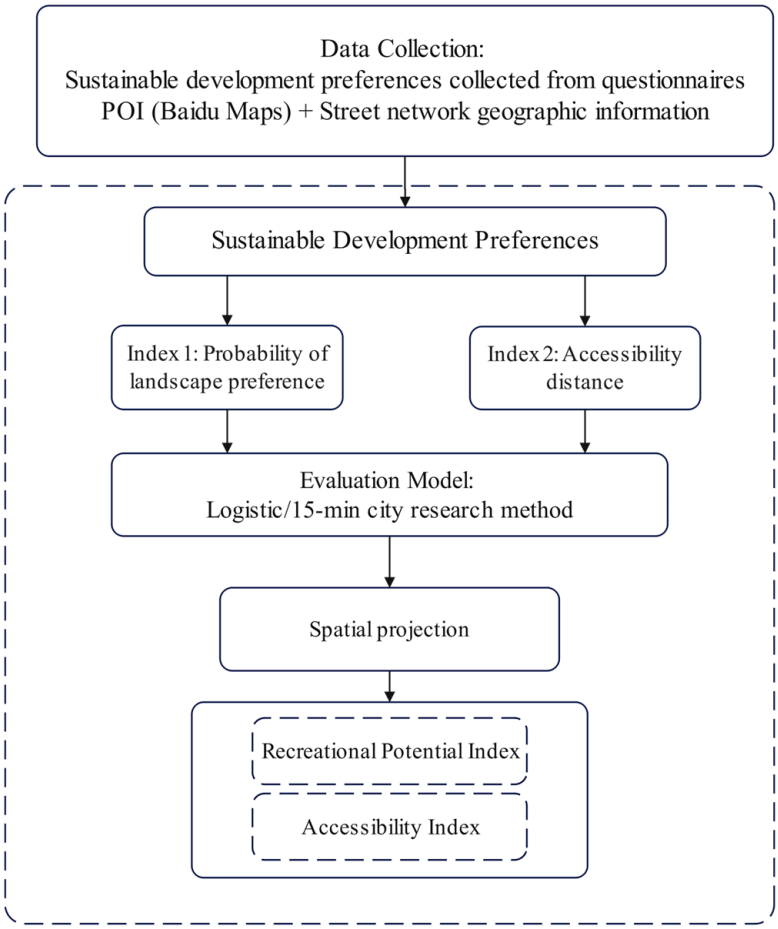


Figure 5. Overall evaluation approach for tourist landscape preferences.

(a) Regression Model of Landscape Preferences.

The study employs a Logistic regression model to analyze data on visitor preferences regarding various landscape types, including forests, water bodies, grasslands, agricultural landscapes, mountains, canyons, barren land, and artificial infrastructure. The analysis incorporates demographic characteristics (e.g., gender, age, income, and residency status) and geographic attributes to spatially project the landscape preferences of different population groups. To accurately assess the travel distances associated with visitors' preferred landscape types, the study uses Equations (11) and (12) to calculate data models for 100 m × 100 m grid units within the village. These equations estimate the likelihood of a specific landscape preference at each grid unit. By evaluating the probability of group preferences, the study visualizes the probability that visitors prefer a particular landscape type within each grid unit. For each pixel in the grid, the percentage of the population favoring a specific type of landscape is equal to the average probability of preference for that landscape type among different demographic groups [52].

$$\ln\left(\frac{p_i}{1-p_i}\right) = X_i\beta + Z_i\gamma + e_i \quad (11)$$

$$P_i = \frac{e^{(X_i\beta + Z_i\gamma + e_i)}}{1 + e^{(X_i\beta + Z_i\gamma + e_i)}}. \quad (12)$$

where P_i is the probability that individual i prefers to visit a given landscape (e.g., a forest); X_i represents a set of overall characteristic variables for individual i; Z_i denotes the attributes of geographic factors and urban development factors, consistent with those in the equation; β and γ are the coefficients; and e_i is the error term.

(b) Spatial Distribution of Regional Travel Behavior.

Because walking or cycling is a more feasible travel option within rural scenic areas, the spatial distribution of tourist behavior should account for differences between urban core areas and non-urban regions (using urbanization level as a proxy) [53,54]. The 15/20 min life circle method is more widely used [55,56]. Willberg et al. developed a life circle accessibility model based on walking speed measurements [57], while Barbieri et al. used a schematic model to calculate the 15 min life circle range [58]. To measure the walking time to the nearest facility, the maximum walking time to various facilities is used to define the range [59,60], and some researchers base the division on population proportions or population-weighted areas [61].

The study combines travel time–space circles with Mapbox time–space circles to reduce the impact of grid discrepancies on the accuracy of travel boundaries, as well as the time lag of Mapbox data. The tourist walking or cycling range within 15 min is determined by obtaining isochrone JSON files, which are then processed in GISpro software (2022) to compute the life circle ranges of two nodes in batches [62]. The Mapbox platform is used to acquire the time–space circles for walking or cycling within a specific period. The study is based on two key node coordinates—Ancient Camphor Tree Square and the Tourist Service Center. By accessing the Mapbox website, 15 min walking or cycling geojson isochrones are generated for these two nodes. Although the isochrones lack internal attribute data, they contain only spatial boundary information. After vectorization via GISpro, the Mapbox time–space circle ranges are obtained.

3.5. Guidance and Control Methods for Rural Public Spaces

Differences in rural morphological patterns, particularly in the built environment and population density, are key factors influencing the functional mechanisms of explicit public spaces and the generation and evolution of implicit public spaces [63]. The sample study area, constrained by geographical space, can be categorized into two types of overall morphologies: “clustered villages” (e.g., block-shaped, linear, circular) and “dispersed villages” (e.g., free-form, scattered, discontinuous strip-shaped). The layout of different rural public spaces and their modes of interaction vary between these types. Node attributes, such as scale, function, and openness, alter the structural framework of rural public spaces (Figure 6).

The study of guidance and control methods for rural public spaces must take into account three key elements—rural morphology, rural public space systems, and rural public space nodes—as well as their interrelationships across different spatial levels [64]. The framework for optimizing and guiding rural nodes is shown in Figure 7.

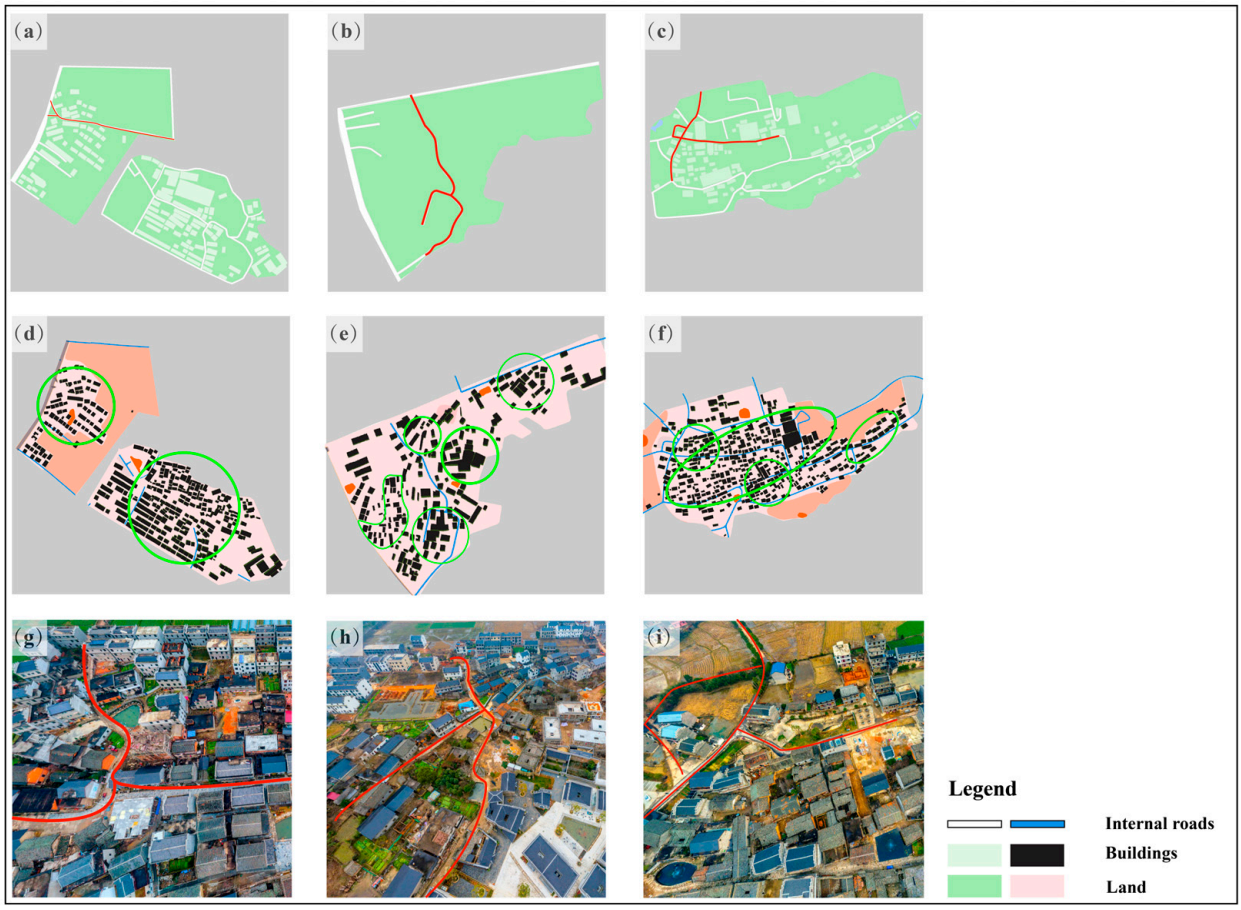


Figure 6. Density differences in the built environment between dispersed and clustered villages in the sample area. (**a**) Shuinan Village grid image. (**b**) Luotian Village grid image. (**c**) Jingtai Village grid image. (**d**) High-density housing in scattered village—Shuinan Village. (**e**) High-density housing in clustered village—Luotian Village. (**f**) Residential texture in group pattern—Jingtai Village. (**g**–**i**) Comparison of density differences in the built environment of scattered and clustered villages.

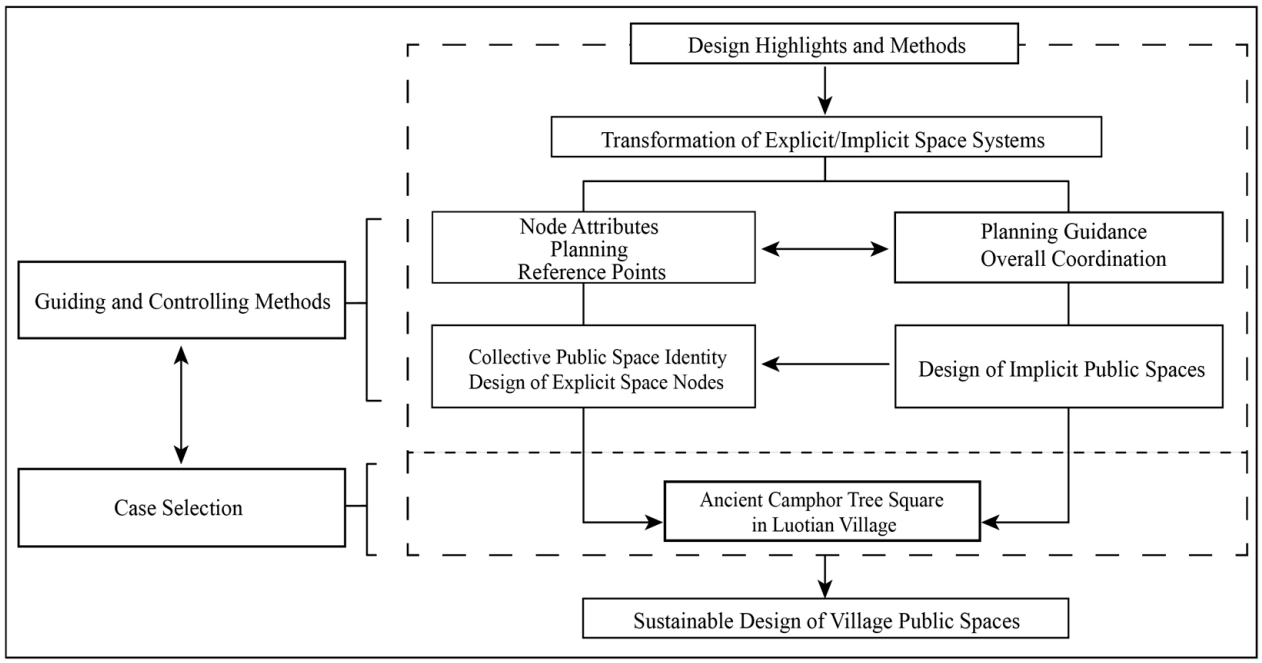


Figure 7. Framework for guiding and controlling rural public spaces.

The rural public space system should enhance public facility layouts, promote participatory landscape features, and emphasize thematic cultural characteristics distinct from natural open spaces [65]. It should predict visitor capacity based on the location of public space nodes while evaluating their functions, facilities, users, scale, and dimensions [66]. To increase visitor engagement, interactive elements like sports, entertainment, games, wellness, and music facilities should be integrated, leveraging rural natural landscapes and human-made structures. Additionally, multifunctional needs, such as gatherings, communication, leisure, and entertainment, should be addressed, optimizing the use of nodes to minimize the impact of location and external environments. Furthermore, nighttime public life can be enriched by establishing lighting systems and integrating festival culture, enabling recreational and entertainment activities after dark. Figure 8 illustrates the transformation relationships between tourism nodes in explicit and implicit public spaces. This evolution does not have an immediate impact on public spaces; rather, the feedback from spatial nodes exhibits a certain delay [67].

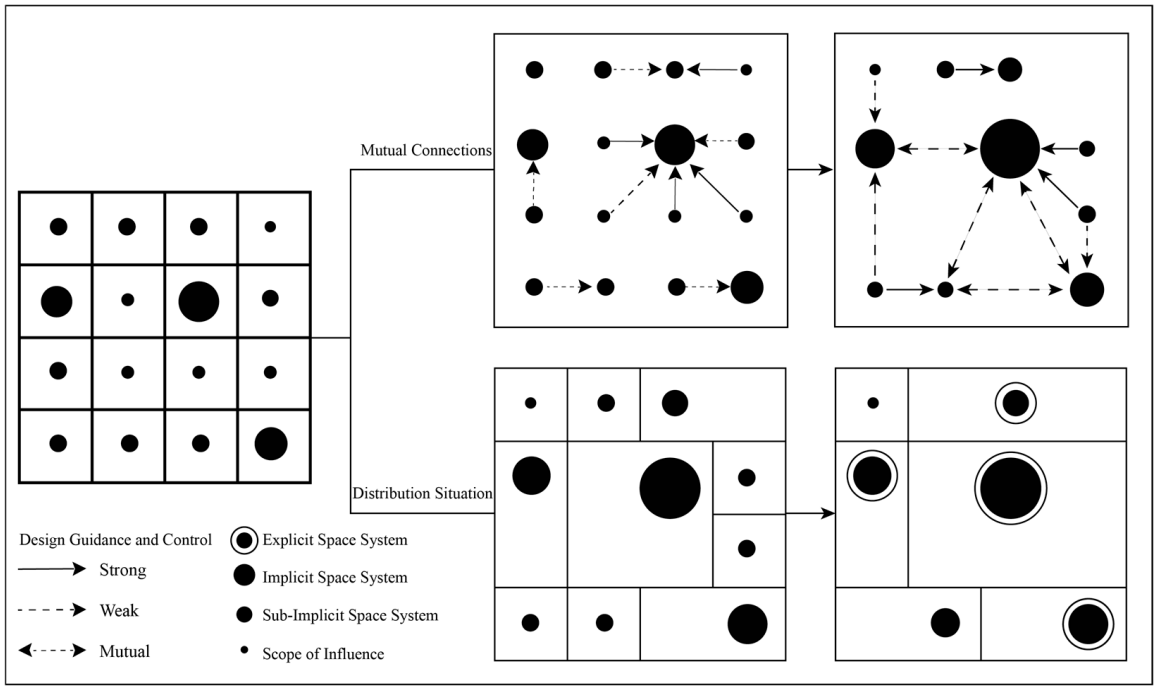


Figure 8. Interaction between explicit and implicit spaces in rural areas.

In rural public space layouts, implicit public spaces can be categorized into three types: communication spaces for private–public interpersonal exchanges; public service spaces balancing accessibility and privacy to support tourism while preserving rural residential privacy; and external tourism spaces, such as accommodations and dining areas, that integrate functional upgrades and highlight local cultural and tourism characteristics. The generation and evolution of explicit and implicit public spaces in tourism-oriented rural areas are driven by node location selection and spatial function differentiation, with production-oriented implicit spaces heavily influenced by explicit public nodes. Explicit functional modules, such as visitor service points, clinics, and shops embedded within residential areas, gradually transform into explicit public space nodes. Similarly, inter-residential spaces evolve into public nodes through improvements in accessibility, service facilities, transportation, and spatial scale. Additionally, as rural residences adapt to tourism, changes in functional complexity and openness lead to the separation of public activities from private spaces, resulting in a shift in the explicit–implicit structure of public spaces.

4. Results

4.1. Results of Visitor Landscape Preferences

To gather data on tourists' landscape preferences, a survey was conducted at 28 tourist sites across three villages within the sample area based on key indicators, such as tourism industry level, tourist volume, landscape type, and functional zoning. A total of 764 tourists were surveyed, yielding 346 valid responses (response rate of 45.3%). The survey included questions on preferred types of scenic spots within the area, maximum travel distance from accommodations to scenic sites, and satisfaction with landscape features. Participants scanned a QR code linked to the Questionnaire Star app on their mobile phones to complete the survey, which recorded the survey locations automatically, as shown in Figure 9.

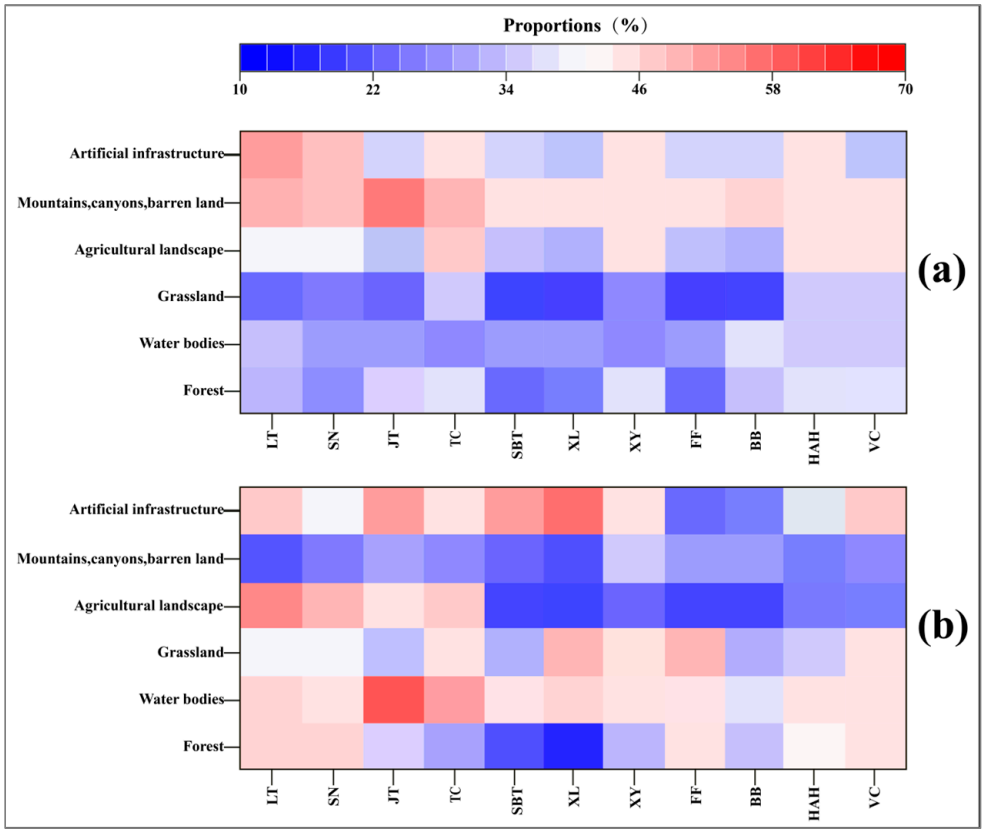


Figure 9. Tourist landscape preferences across different regional gradients. (**a**) Edge of the study area; (**b**) study points: LT = Luotian Village; SN = Shuinan Village; JT = Jingtai Village; TC = Thousand-Year-Old Camphor Tree; SBT = Scholar's Residence; XL = Xilu Residence; XY = Xialian Courtyard; FF = Lotus Field; BB = Guixiu Pavilion; HAH = Huang Clan Ancestral Hall; VC = Tourist Service Center.

According to the results, 86% of tourists rated the rural landscapes of the Anyi ancient village cluster as "beautiful". However, 69% of tourists expressed "no knowledge" regarding rural tourism planning. Regarding satisfaction with tourism planning, 24% of tourists were "generally satisfied", 43% had "no particular expectations", and the remaining 23% expressed dissatisfaction. Key issues cited by dissatisfied respondents included "insufficient service nodes", "unreasonable and highly variable accommodation prices", "low-quality design of scenic nodes", and "inadequate basic amenities". The survey results also indicated a strong preference for "water bodies", followed by "woodlands", while fewer tourists favored "agricultural landscapes" or "mountains and canyons".

4.2. Visualization of Tourists' 15-Minute Accessibility Spatial Distribution

By retrieving tourist coordinate data from the Tourist Service Center and the Ancient Camphor Tree Square, combined with a 15 min accessibility evaluation model, the study conducted a visual assessment of tourist accessibility within the sample area [68]. The spatial distribution of 15 min accessibility by walking presents a linear pattern, while cycling accessibility shows a more dispersed pattern, as illustrated in Figure 10a,b.

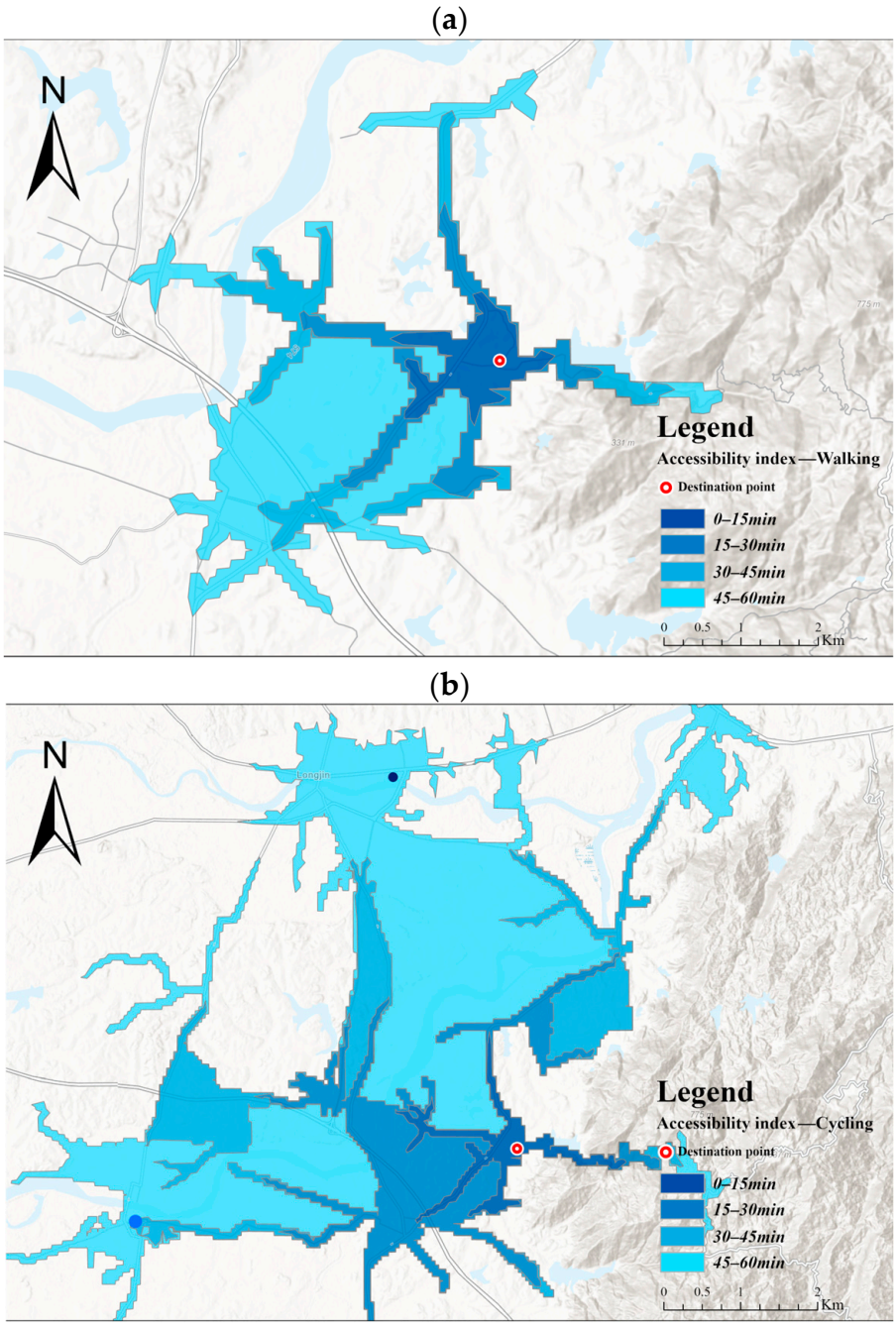


Figure 10. (**a**) Isochrone map of 15 min accessibility by walking; (**b**) isochrone map of 15-min accessibility by cycling.

Using 15 min intervals to represent accessibility for walking or cycling is more suitable for rural landscape tours [69]. The study utilized geographic data from OpenStreet Map (OSM) and the Mapbox platform to provide vector data for time–space boundary isochrones. To enhance comparability, the study selected two datasets: the accessibility range from the

Ancient Camphor Tree Square and the accessibility range from the scenic area entrance. The 15 min walking and cycling isochrone maps are shown in Figures 11 and 12.

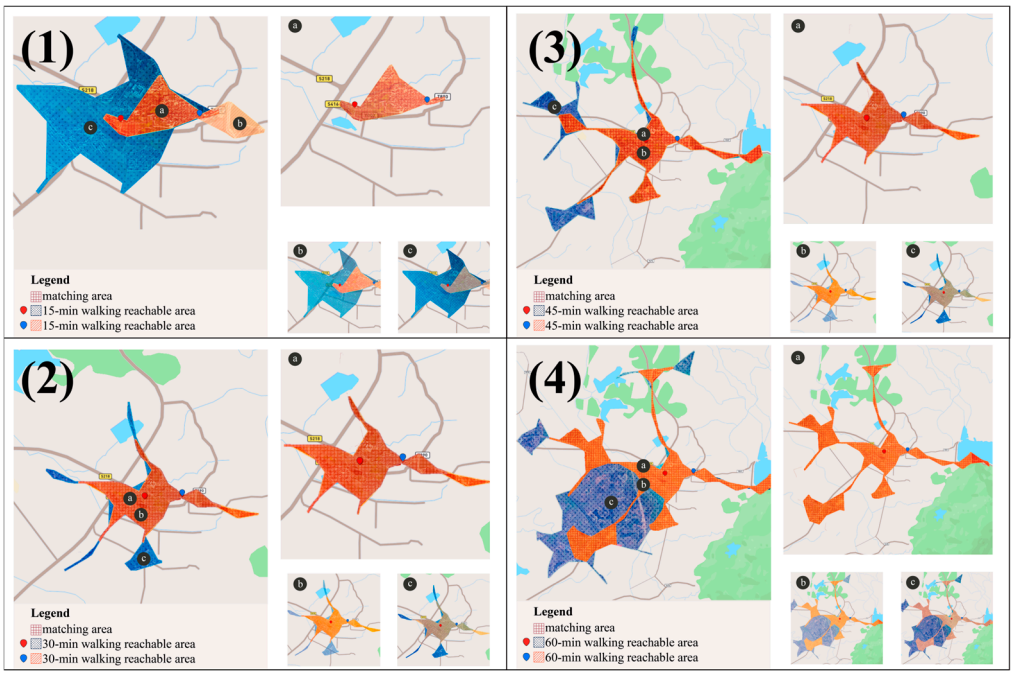


Figure 11. The 15-min walking isochrone ranges (1–4 represent 15, 30, 45, and 60 min). (**a**) Overlapping areas; (**b**) accessibility range from the Ancient Camphor Tree Square node; (**c**) accessibility range from the Scenic Area Entrance node.

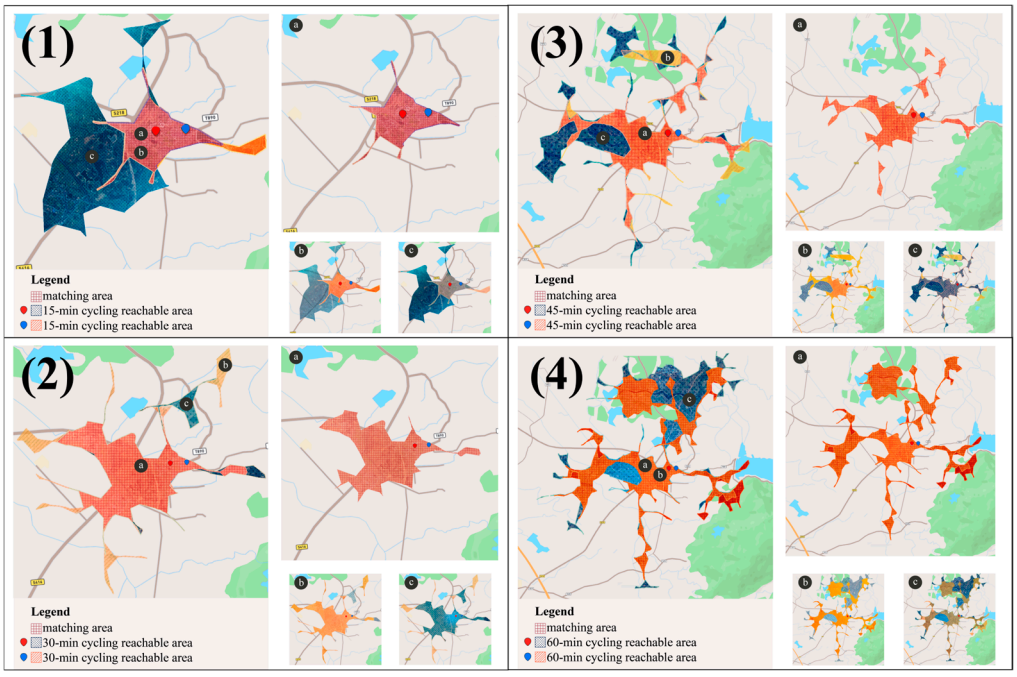


Figure 12. The 15-min cycling isochrone ranges (1–4 represent 15, 30, 45, and 60 min). (**a**) Overlapping areas; (**b**) accessibility range from the Ancient Camphor Tree Square node; (**c**) accessibility range from the Scenic Area Entrance node.

Based on coordinate data from the Mapbox platform, the visual representation of foot traffic changes within the 15 min interval accessibility zones is shown in Figure 13. Using the 15 min life circle, along with the point density, coverage, and nearest distance of

POI, the study further analyzed the accessibility of convenience services within the scenic area [70]. The results showed that commercial service facilities had higher accessibility than other types, while healthcare, education, and daily transportation facilities were moderately accessible. In contrast, cultural activities, sports, and municipal facilities had poor accessibility, as illustrated in Figure 14.

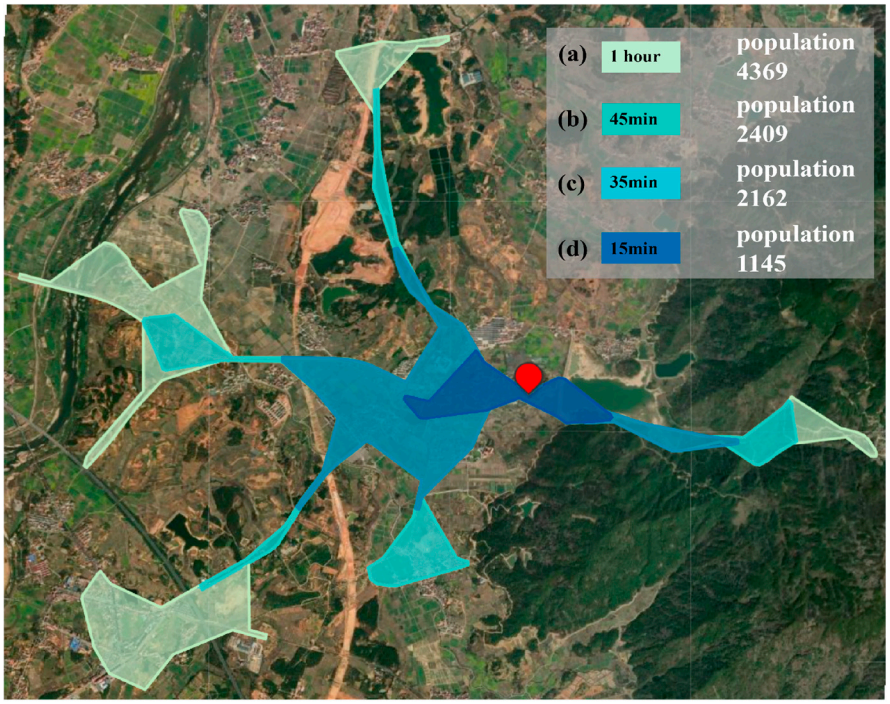


Figure 13. Population flow changes within 15-min accessibility intervals. (**a**) One-hour population flow changes; (**b**) forty-five-minute population flow changes; (**c**) thirty-minute population flow changes; (**d**) fifteen-minute population flow changes.

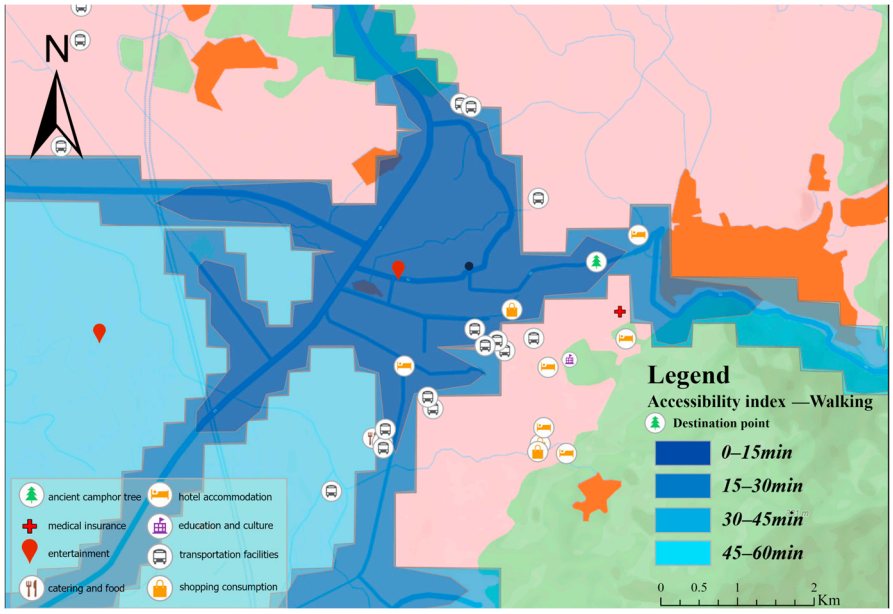


Figure 14. Distribution map of POI accessibility within 15 min.

4.3. Entropy Calculation of Typical Rural Systems and Optimization of Public Space Nodes Under the VEISD Model

4.3.1. Integration of Village Systems

Through an analysis of the relationships between the architectural environment subsystem and other subsystems, this study focuses on the architectural discipline to screen factors within the natural ecological, economic production, and socio-cultural subsystems. Factors with minimal non-linear associations with the architectural environment were removed. By overlapping the three subsystems (natural ecology, economic production, and socio-culture) with the architectural environment subsystem, the village system was integrated to form a cohesive self-organizing system [71]. For instance, the pollution sub-subsystem within the natural ecological subsystem encompasses production pollution, living pollution, and pollution prevention and management. Because similar content is included in the public space construction of the architectural environment subsystem, these elements were categorized and addressed within the natural ecological subsystem after integration. The details of this classification are shown in Table 4.

Table 4. Subsystem correlation analysis table (village natural ecology and architectural environment subsystems).

Primary Subsystem			**Village Architectural Environment Subsystem (B4)**							
Primary Subsystem	**Secondary Subsystem**		**Village Public Space Construction**							
	Subsystem Secondary	**Tertiary Subsystem**	**Village Structure**		**Village Land Use**			**Village Public Environment**		**Score**
	Subsystem Tertiary		**Village Hierarchical Structure**	**Solar Lighting Needs**	**Village Public Activity Areas**	**Village Greenery and Water Systems**	**Village Transportation Roads**	**Public Service Facilities**	**Village Landscape System**	
Village Natural Ecology Subsystem	Resources	Water Water Resources Recycling	2	0	6	6	0	0	0	14
		Land Topography	6	4	6	4	6	6	6	38
		Natural Building Materials	0	0	6	0	0	0	6	12
	Energy	Renewable Energy	2	4	0	4	0	6	2	18
	Pollution	Production and Living Pollution	4	2	6	2	0	2	4	20
		Pollution Prevention and Treatment	4	4	6	6	0	2	6	28
	Score		18	14	30	22	6	16	24	

The study constructs VEISD by analyzing village systems and developing entropy change and entropy evaluation models. Using factor screening methods and defining external environmental parameters, the study establishes a comprehensive village system that primarily includes natural ecology, architectural environment, and their subsystems. Through vertical structural analysis and horizontal subsystem correlation analysis, the study explores and integrates the village system. It identifies that if subsystems lack factor heterogeneity, these factors become less competitive and negatively affect the overall development of the village system. Conversely, the complex non-linear dynamics between subsystems enhance the multi-level transformation efficiency of internal entropy flows, reduce the entropy output of the village system, and lower the overall entropy value.

4.3.2. Entropy Calculation for the VEISD System in Rural Areas

The openness of the system to external environments, the degree of internal structural heterogeneity, and the interrelations among evaluation indicators collectively form a multi-dimensional perspective for measuring the sustainable benefits of rural public spaces [72]. The impact of external environments on the system is reflected in changes in the heterogeneity of internal factors, making it a key indicator for evaluating the sustainable benefits of rural public spaces [73].

The study employs entropy value calculation as a quantitative tool to capture and measure the disorder and complexity within system information. By cumulatively calculating entropy values across various levels, it reflects the sustainable development status of rural systems at different tiers [74,75]. The heterogeneity of tertiary entropy indicators and their relationships with other factors constitute the foundational data units for the sustainable benefits of rural public spaces, elucidating the formation process of base codes [76]. Base codes are fundamental building blocks for the VEISD framework, encompassing parts of the overall entropy structure. Using entropy theory and self-organization development theory, this research explores the heterogeneity of internal factors and interconnections within the four subsystems: environmental ecology, economic production, socio-culture, and architectural environment [77]. As an example, the study applies the VEISD system entropy to assess the sustainable benefits of public spaces in Luotian Village. It focuses on public space environmental quality (C8) under rural architectural entropy (B4), selecting base codes D18, D19, D21, and D22 closely related to public space nodes, as shown in Table 5.

Table 5. Table of VEISD system entropy and base-level codes for sustainable benefit evaluation of public spaces in Luotian Village (•: Dots represent correlations).

Levels of Entropy			Threshold	Bottom-Level Codes	Very Poor <50%	Poor 60%	Average 70%	Good 80%
B4: Rural Architectural Entropy: Quality of Rural Architectural Space Environment	C8: Public Space Environmental Quality	D18: Extension of the Rural Environment and Surroundings	Sustainable development	Consider continuity between the road system and the external environment in rural planning		•		
				Based on the environmental carrying capacity of the village, achieve symbiosis				•
		D19: Public Space Layout	Planning meets sunlight distance standards	The rural planning structure is reasonable, meeting sunlight and lighting needs			•	
				Inter-house spacing meets sight distance requirements		•		
		D21: Status of Rural Infrastructure Construction	Road standards meet requirements	Improve infrastructure construction		•		
				Organized discharge of wastewater			•	
				Refine the classification of rural roads				•
				Strengthen road construction, adding sidewalks to main roads	•			
		D22: Status of Rural Public Environment Construction	Implement resource reuse	Reasonably distribute various public service facilities and landscape environment construction	•			
				Rural public spaces are well-structured			•	
				Create new landscape environments in the countryside	•			
				Public service facilities promote traditional local cultural industries		•		

As an industry-driven rural village, the key public space node in Luotian Village is the Ancient Camphor Tree Square. This node serves as the only relatively spacious area for visitor activity and movement. At the center of the square stands a giant camphor tree that is approximately 1200 years old, one of the largest and oldest camphor trees in Jiangxi Province. With a diameter of about 3 m and a circumference reaching 10 m, the tree holds immense historical and cultural significance. The square where the camphor tree is located serves not only as a vital venue for local villagers to cool off and gather for social interactions in the evenings but also as a landmark attraction that draws tourists to pause and admire the site [78], as shown in Figure 15.

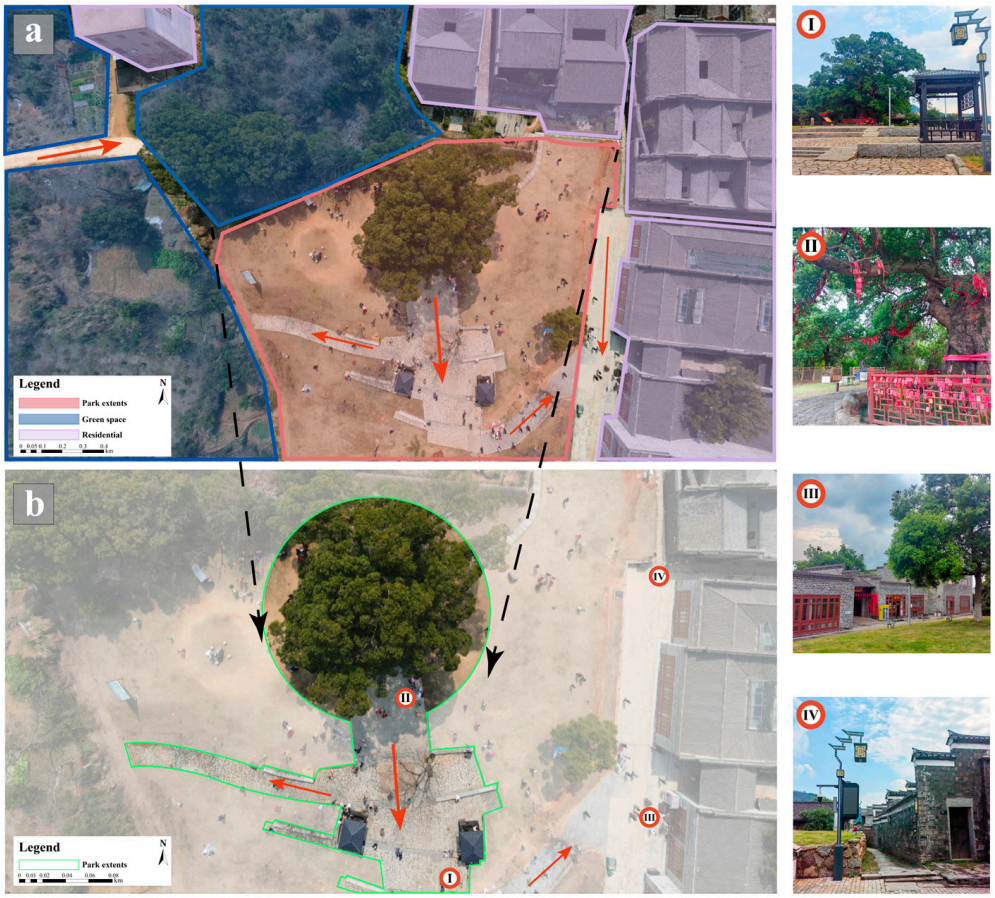


Figure 15. Location map of the Ancient Camphor Tree Square in Luotian Village. (**a**). Condition of the Ancient Camphor Tree and the surrounding environment; (**b**). Focus on the spatial distribution of nodes in the Ancient Camphor Tree Square. I. Direct access to the steps of the Ancient Camphor Tree. II. Current state under the Ancient Camphor Tree. III. Lawn around the square. IV. Roads surrounding the square.

The optimization design of key public space nodes can invigorate rural industries by actively channeling the flow of existing populations and tourists to surrounding areas. This process further facilitates the formation of a dynamic industrial network across the entire village, enhancing industrial benefits, land economic value, natural ecological benefits, and socio-cultural value [79]. As a prominent explicit public space node, the Ancient Camphor Tree Square serves as the center of cluster-based village group evolution. It plays a pivotal role in optimizing the structure of public space nodes in Luotian Village, as illustrated in Figure 16.

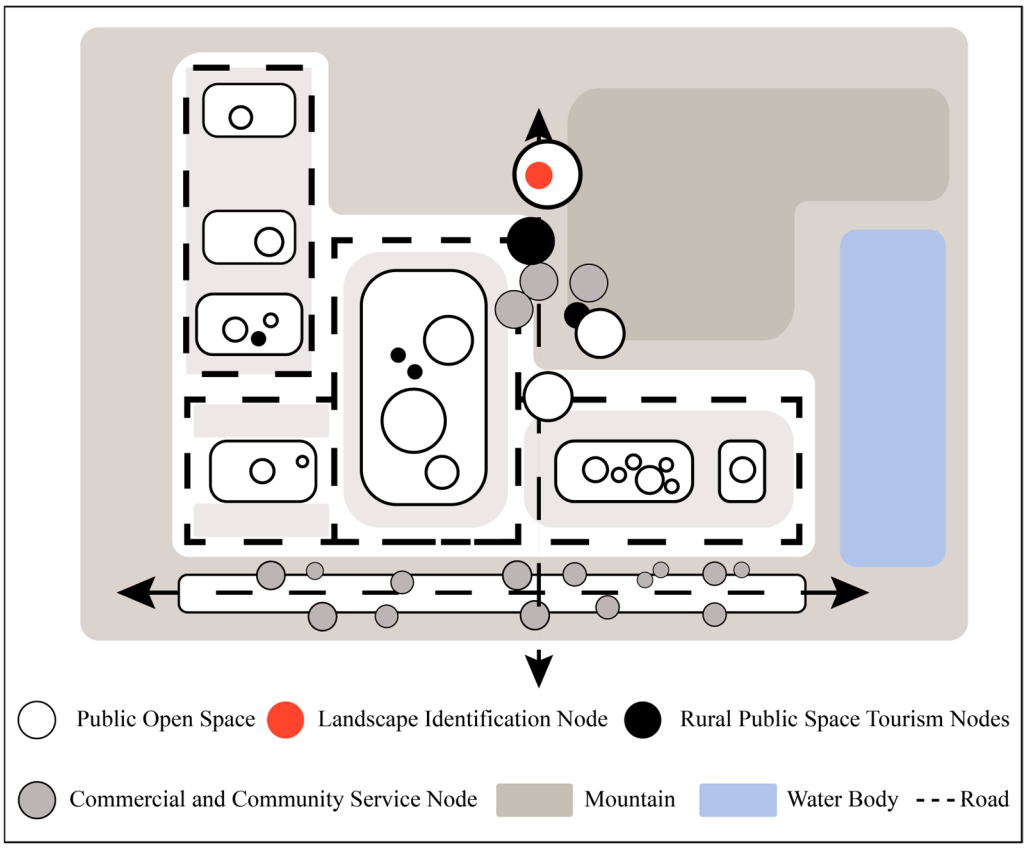


Figure 16. The core role of the Ancient Camphor Tree Square public space node.

4.3.3. Optimization Design of Public Space Nodes—Luotian Village's Ancient Camphor Tree Square

Based on the entropy indicator system for "rural public environment construction", the optimization of the Ancient Camphor Tree Square node in Luotian Village requires building upon its existing role as a public interaction space while further meeting the multifunctional demands of a cultural center, distribution hub, public facilities area, and commercial center. Its surrounding public space layout centers on the Ancient Camphor Tree, forming a harmonious and layered public space structure. Within the sample node area, there is a mix of commercial and residential spaces, with the surrounding public space layout centered on the Ancient Camphor Tree, forming a layered and harmonious public space structure. Before the renovation, the node lacked sufficient openness as a public space and exhibited weak synergy with surrounding commercial and community service nodes, limiting its potential for cluster benefits. Additionally, the node's landscape design received low evaluation scores, resulting in shorter visitor stays. Therefore, this study selected the node for optimizing public space service performance to enhance its multifunctionality and promote the sustainable development of Luotian Village's public spaces. The comparison of the Ancient Camphor Tree Square node before and after the renovation is illustrated in Figure 17.

The planning and renovation of the Ancient Camphor Tree Square node preserved the vegetative structure along the square's boundaries, while adjusting the density of the plants by removing overgrown and weakened vegetation. The tree clusters formed by the paths and the surrounding greenery created transitional spaces between the walking paths and the square. Through landscape planning, spatial flow and pedestrian movement were optimized, and fluid, linear pathways were designed to connect the surrounding areas

with the space under the Ancient Camphor Tree, effectively linking the public space nodes (Figure 18).

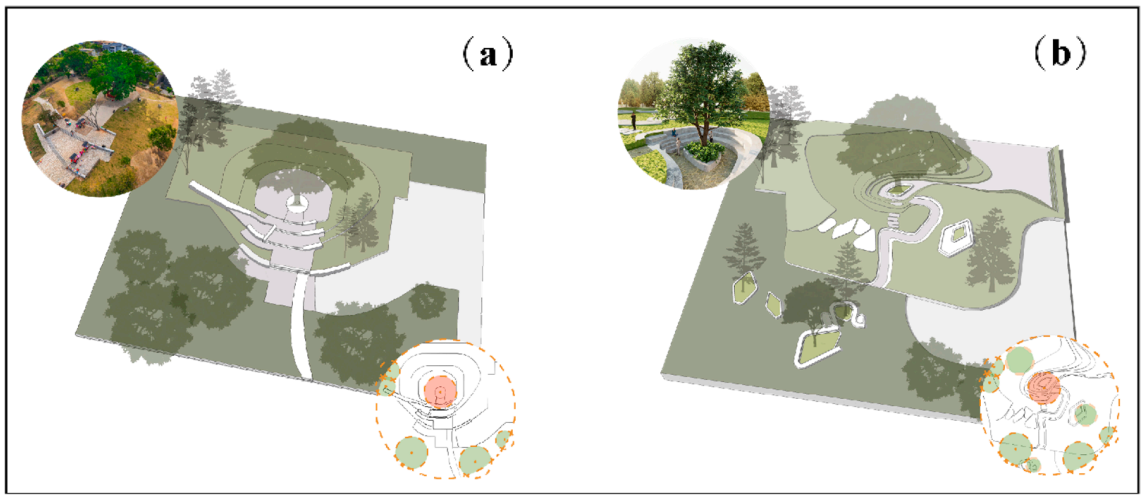


Figure 17. Before and after comparison of the Ancient Camphor Tree plaza tourism node renovation. (**a**) Before renovation—the Original Millennium Camphor Tree plaza; (**b**) after renovation—multi-functional gathering plaza centered around the ancient tree.

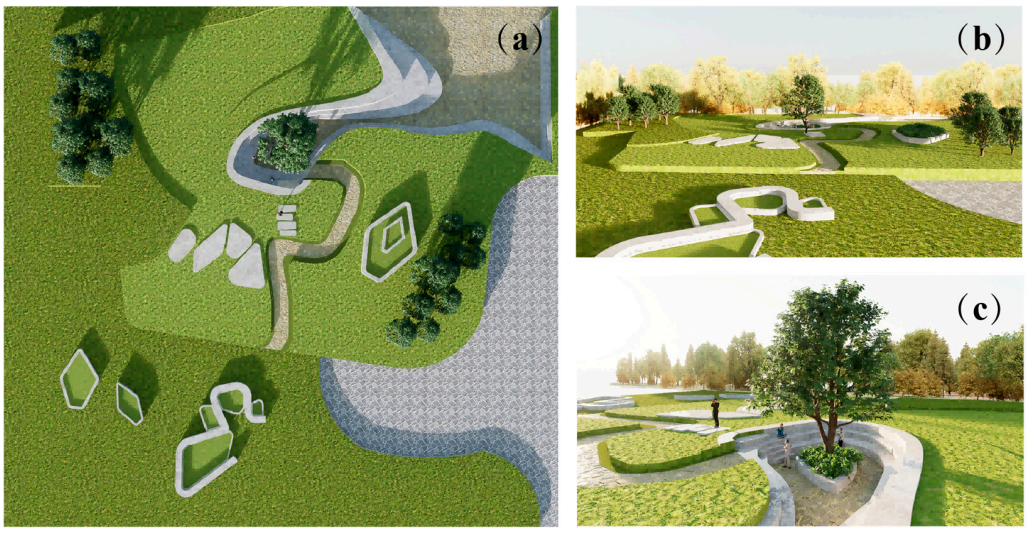


Figure 18. Reference renderings of the renovated Ancient Camphor Tree Square. (**a**) Aerial view; (**b**,**c**) multi-angle display.

Based on the functional characteristics of explicit public spaces, the optimization design of the Ancient Camphor Tree Square node centers on pedestrian flow routes, further creating a multifunctional event space filled with spatial tension (Figure 19a) and a green sunken area for tourists to rest (Figure 19b). Taking advantage of the terrain surrounding the square, the lawns are naturally laid out to follow the landscape. Most of the space beneath the large trees is preserved, allowing the public area to evolve into an open space with gradient changes under the tree canopy, providing a more engaging experience for visitors (Figure 19c). Additionally, the renovation incorporates lighting to enhance a peaceful and warm nighttime atmosphere, in line with the temporal characteristics of explicit public spaces. This design extends the operational hours of the rural tourism node, improving nighttime visual appeal and supporting the growth of the local homestay industry Figure 19d.



Figure 19. (**a**) Multifunctional event gathering space filled with spatial tension; (**b**) tourists in the gathering space beneath the Ancient Tree; (**c**) interesting spatial experience from rich terrain variations; (**d**) Ancient Camphor Tree Square under the night sky.

The study constructed the VEISD model for Luotian Village and, through the optimization of key nodes, adjusted the associative effects among natural ecology, socio-

culture, economic production, and architectural environment. Specifically, it regulated the sub-indicator "Village Public Environment Construction (D22)", redefining the role and significance of the "Under the Tree" spatial node within Luotian's spatial morphology. This reconfiguration facilitated the integrated development of the economic, ecological, and socio-cultural values of the "Under the Tree" space. The study also organically combined the "Outside the Tree" and "Inside the Tree" public spaces, addressing local structural collapses in the village layout. This approach enhanced the vitality of the overall village morphological structure and contributed positively to the sustainable development of the village's public spaces.

5. Discussion

Traditional tourism-oriented rural areas often lack cultural depth in their tourism offerings, with public space nodes serving a single function and exhibiting poor multifunctionality. Additionally, inaccurate positioning of node accessibility and tourist preferences reduces the sustainable benefits of rural tourism. In terms of research methods, this study employs self-organization theory and the VEISD model to conduct quantitative analysis and screening of multiple factors related to rural public spaces. Practical verification is carried out on specific node cases, leading to the establishment of general principles for optimizing and renovating rural public space nodes. Notably, this study further deepens the analysis of rural public space accessibility and the pathways for transforming rural tourism resources. Using GIS technology and landscape preference surveys, the study visualizes tourist node accessibility, emphasizing the importance of key node renovation in promoting sustainable benefits for rural tourism. The findings provide valuable insights for exploring rural public space planning strategies and achieving sustainable rural development. The experiences from the study area offer better guidance for promoting sustainability in other rural regions.

5.1. Analysis of the Sustainability of Tourist Landscape Preferences

A "bottom-up" approach to public space node design allows tourism resources to better cater to tourists' needs [80]. According to feedback from survey data on tourist landscape preferences, tourists exhibited higher demands for entertainment and more diverse recreational activities, indicating a need for higher-quality social engagement during concentrated leisure time [81]. Artificial infrastructure, agricultural landscapes, water features, and grasslands were more favored in controlled node areas, while there was less inclination toward sports activities like hiking and climbing in mountains or canyons. The diverse landscape preferences observed in the survey sample can guide the optimization of spatial nodes' multifunctionality [82]. Explicit public space nodes, through the optimization of landscape elements and the enhancement of entertainment facilities, contribute to tourists' mental and physical well-being, as well as psychological recovery [83]. Vulnerable groups, including the elderly and low-income individuals, showed higher visitation frequencies, although their travel distances were relatively short, focusing mainly on activities within the tourist village. Improving the leisure experience for tourists, while integrating the preferences of vulnerable groups to design multifunctional community squares with grasslands, water features, and woodlands, can enhance the sustainable benefits of public space nodes [84].

5.2. Spatial Distribution Based on Tourist Data

Accessibility and mobility are key indicators in assessing the 15 min isochrone of an area [85]. In the objective measurements of 15 min accessibility within the sample villages, the density of various facilities was generally high, while the coverage and proximity

metrics were relatively low. Public service facilities had lower point density and per capita availability compared to the overall facility coverage and nearest distance measures. Among commercial service facilities, convenience stores, dining services, and logistics facilities had a coverage rate exceeding 80%, indicating high service availability, although dining facilities had relatively low point density. Health management facilities, such as health service centers, clinics, and hospitals, had lower coverage and were insufficient to ensure medical care for tourists within the 15 min walking circle. Basic support facilities, such as elementary schools, kindergartens, cultural stations, cultural centers, fire stations, and bus stops, also showed low coverage rates. Additionally, cultural stations, parks, and plazas were located too far from accommodation areas. By optimizing the spatial layout and multifunctionality of the Ancient Camphor Tree Square public space node in Luotian Village and guiding self-organization processes within the village, the sustainable benefits of public spaces in the tourism industry can be enhanced, promoting the overall development of the tourism sector in the village.

5.3. Sustainable Benefit Assessment of Entropy and Sustainable Design of Public Space Tourism Nodes

Through the VEISD indicator system of Luotian Village, by specifically adjusting the sub-item indicator "Rural Public Environment Construction D22", the Ancient Camphor Tree Square public space node's role and position in the spatial structure of the village are redefined, realizing the comprehensive development of economic, ecological, and socio-cultural values. The study combines tourists' landscape preferences with node accessibility to plan and renovate this key explicit public space node. The sustainable benefits of the Ancient Camphor Tree Square public space node include the following.

(a) Spatial Efficiency and Multifunctionality. By analyzing the relationship between the Ancient Camphor Tree Square node and rural public spaces, the design guides the development of rural public spaces toward being livable, suitable for business, and tourism-friendly. The west side of the square features a landscape boardwalk and walls, integrated with rest benches and activity platforms. The varying heights of the landscape walls are arranged to optimize the layout around the main square of the camphor tree. This node becomes a multifunctional public space for visitors to enjoy sightseeing, conversations, rest, gatherings, socializing, leisure, and entertainment, accommodating different age groups.

(b) Engagement and Experience. Under the premise of protecting the ancient tree, the design introduces ecological interactive installations, such as sound-sensitive lights and plant interaction devices, to enhance visitor interaction with the natural environment. The topography of the square is leveraged to create tiered spaces, forming small stage-like plazas or commercial hubs. This enhances visitors' participation and sensory experience while also fostering economic benefit conversion.

(c) Guidance and Control Optimization of Public Space Nodes. The efficiency of land use is driven by continuously changing human and natural conditions. In the renovation and design of rural tourism public space nodes, attention is paid to the optimization of key node guidance and control, while also considering future land use trends and industrial symbiosis [86,87]. The flow line signage system in the Ancient Camphor Tree Square integrates node optimization with land use efficiency. The square's pathways direct the flow of people towards surrounding commercial, residential, and functional areas, transforming the space into a comprehensive rural landscape node cluster, integrating commerce, culture, and leisure. This promotes the overall guidance and regional optimization of the village's tourism public space system.

Using the "Village Public Environment Construction D22" status in Luotian Village as an example, this study evaluates the degree of sustainable development in village systems based on criteria like heterogeneity and inter-factor relationships, analyzing the formation process of the base codes. The findings indicate that through systematic analysis grounded in self-organization theory and the VEISD framework, adjusting the sub-indicator "Village Public Environment Construction D22", specifically by redesigning the landscape node of the Ancient Camphor Tree Square, can reconstruct and optimize the overall spatial morphology and vitality of Luotian Village. This adjustment enhances the openness of the spatial form and the multifunctionality of the key public space nodes in the village.

6. Conclusions

This study focuses on the Anyi ancient village cluster in Nanchang City, Jiangxi Province, China and establishes a comprehensive evaluation system for the sustainable development of traditional village public spaces. The system integrates three subsystems with the architectural environment subsystem to construct a self-organized village system framework through the integration of village systems. By analyzing the vertical composition of the village system and the horizontal interrelations among subsystems, the study determines the weight of each indicator within the evaluation system. Using the public spaces of Luotian Village as an example, the study employs key public space node guidance and the VEISD evaluation method to identify critical nodes for public space guidance. Based on optimized data, such as visitor landscape preferences, spatial node distribution, and spatial accessibility, the study redesigns the explicit public space node of the Ancient Camphor Tree Square. This redesign achieves greater openness in spatial forms and multifunctionality of public space nodes.

Rural public spaces, rural culture, natural resources, and artificial elements hold significant weight in the indicator system for the sustainable evaluation of village systems. Factors like spatial accessibility distribution, visitor landscape preferences, and spatial node distribution play an active role in promoting the sustainable optimization of public spaces in traditional villages. In the selected sample of the Anyi ancient village cluster, Shuinan Village represents a dispersed village with high-density housing, Luotian Village features a clustered village with high-density housing, and Jingtai Village showcases a group-patterned residential texture. Overall, Luotian Village's public space quality has significant potential for improvement. The selection of the Ancient Camphor Tree Square node for optimization is supported by scientific reasoning for spatial enhancement and adequate spatial resource conditions. The results indicate that by evaluating the interrelationships among subsystems within traditional village systems and implementing critical node renovations, the openness and multifunctionality of rural public space nodes are significantly enhanced. The sustainable evaluation framework developed in this study provides a valuable tool for planners and policymakers to assess the quality of village public spaces and offers technical support for optimizing public space layouts. The study aims to enhance the vitality of rural industrial structures, stabilize the economic symbiosis system, and improve the long-term sustainable benefits of rural industries, thereby boosting rural economic vitality and contributing to sustainable rural development.

This study has certain limitations. Public space nodes vary in hierarchy and organizational structure across different types of rural areas. The transformation rules and patterns of public space nodes identified in the sample village cluster may not be fully generalizable to all types of rural clusters. Therefore, the general applicability of this study requires further validation and examination. Additionally, the research needs to collect more data on the experiential demands of residents and tourists through questionnaires and interviews. Satisfaction ratings can be used to assess the quality of already constructed village public

space nodes. Incorporating these evaluation standards as indicators of sustainability features into the system evaluation framework will enhance the practical value of this research. In future studies, we plan to broaden the types of villages evaluated, increase the sample size of villages, and validate the effectiveness of related spatial optimization methods through feedback. This will provide more theoretical foundations and case references to support the sustainable development of rural public spaces.

Author Contributions: Conceptualization, Z.L. and Y.W.; methodology, S.C. and L.X.; software, S.C. and Y.W.; validation, Z.L., T.F. and S.C.; formal analysis, S.C.; investigation, S.C. and L.X.; resources, Z.L.; data curation, S.C. and T.F.; writing—original draft preparation, S.C.; writing—review and editing, Y.W. and T.F.; visualization, Y.W., L.X., and S.C.; supervision, Z.L. and Y.W.; project administration, Z.L. and T.F.; funding acquisition, Z.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Social Science Fund of China (20BSH089).

Institutional Review Board Statement: The sample questionnaire in this study does not cause harm to humans, does not involve sensitive personal information or commercial interests, and does not involve experiments with biomedical samples. Therefore, ethical review and approval for this study were waived by the Academic Committee of the School of Architecture and Design at Nanchang University.

Informed Consent Statement: Participants voluntarily participated in this study and indicated their consent by completing the anonymous surveys. All data were collected anonymously to ensure privacy and confidentiality.

Data Availability Statement: Data are available upon request.

Acknowledgments: We are grateful for the generous support provided by the China Urban Science Research Association Smart City Joint Laboratory. We thank the reviewers for their valuable feedback.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

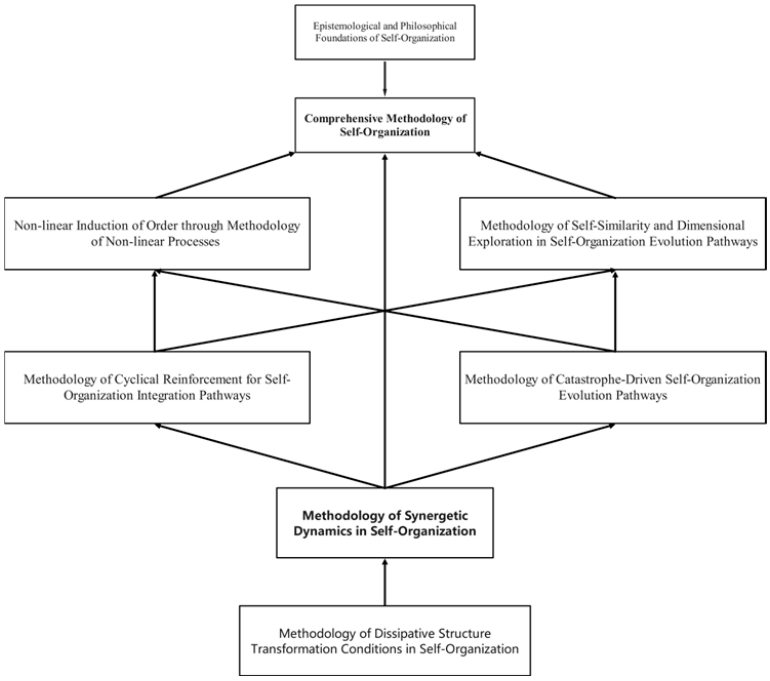


Figure A1. Diagram illustrating the relationships between theories in the self-organization methodology.

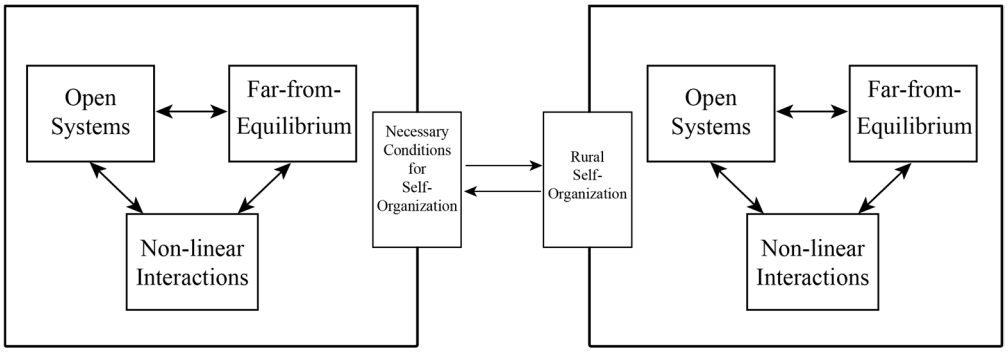


Figure A2. Evolution model of rural self-organization in open systems.

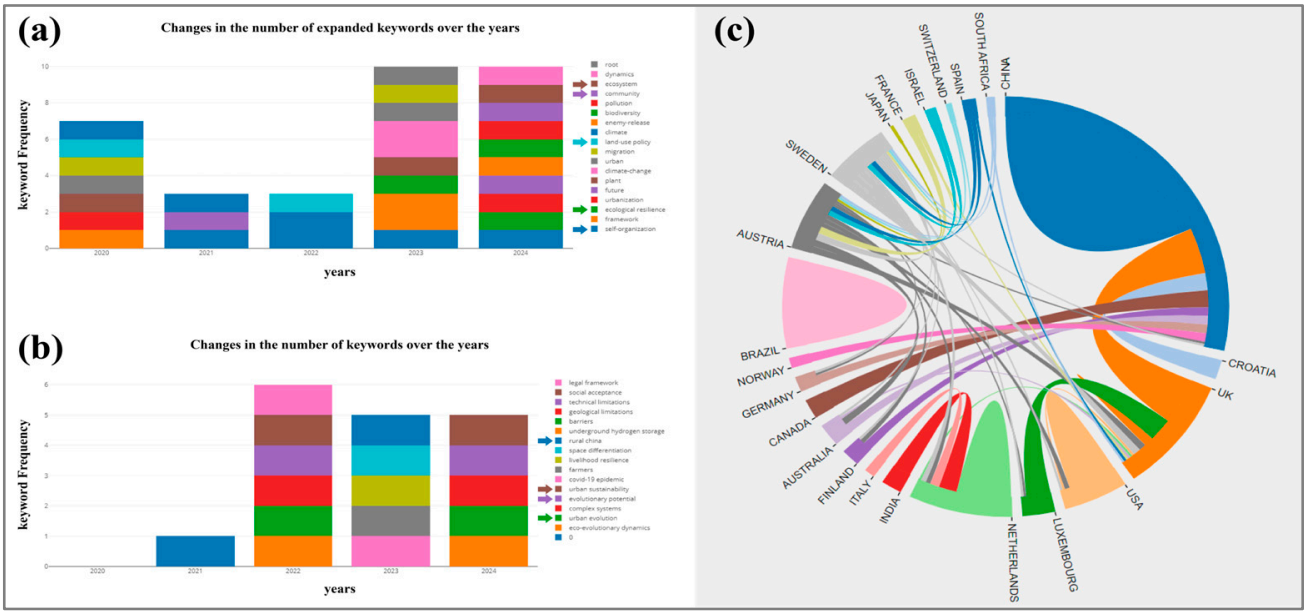


Figure A3. (**a**). Changes in keywords related to the expansion of self-organization theory. (**b**). Changes in keywords related to self-organization theory. (**c**). Relevance of research on self-organization theory.

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