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Structural Decoding of Lijiang's Historical Cultural Space: Cultural–Ecological Continuity and Land Governance

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Abstract

Long-standing studies of historical cultural spaces have primarily focused on the preservation of heritage objects and landscapes, while insufficient attention has been paid to the structural relationships, land-use transformations, and cultural–ecological processes that sustain their long-term continuity. Taking the World Heritage site of Lijiang as a case, this study develops a three-dimensional structural decoding framework composed of spatial base, spatial network, and spatial entity, together with an analytical pathway of "Identification–Interpretation–Evaluation–Synthesis–Practice." By integrating qualitative and quantitative approaches with multi-source data, the study establishes an evidence chain linking historical processes and contemporary conditions to examine the formation mechanisms, continuity, and contemporary deviations of Lijiang's historical cultural space. The results show that terrain–habitat adaptability, water system coupling, and environmental risk avoidance shaped environmental adaptation; historical corridors, landscape perception, and core node associations organized spatial networks; and functional diversity, cultural capital agglomeration, and spatial-scale compatibility supported entity-based spatial practices. Although tourism development, urban expansion, and land-use transformation have not completely dismantled these historical relationships, they have caused localized deviations in ecological boundaries, path continuity, visual connections, functional vitality, and spatial scale. This study argues that the governance of historical cultural spaces should shift from preserving isolated heritage objects to sustaining cultural–ecological relationships that support memory, identity, spatial practice, and adaptive land governance.

Keywords: historical cultural space; cultural–ecological continuity; structural relationships; relational continuity; land governance; spatial transformation; Lijiang

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1. Introduction

Historical cultural spaces are not merely material carriers of collective memory [1], but living spatial systems shaped through the long-term co-evolution of culture and environment. Their meaning extends beyond isolated urban relics to encompass multi-scalar spatial systems composed of natural habitats, livelihood practices, and regional settlements [2,3]. These spaces record regional historical trajectories and continue to shape landscape patterns, movement paths, social practices, and local identity. They therefore have structural, processual, and continuous characteristics [4–6]. Studies on the Historic Urban Landscape (HUL) [7], territorial heritage systems [8], cultural landscapes [9,10], and social–ecological systems [11,12] have moved heritage studies beyond the protection

of isolated objects. Increasing attention has been paid to regional human–environment relationships, spatial processes, and the management of change [13–16].

Existing research has contributed to heritage identification, morphological analysis, and value assessment [17–20]. However, how environment, perception, social organization, and everyday practices jointly sustain heritage continuity remains insufficiently explained. When these relationships are overlooked, historical cultural spaces can be divided into separate heritage objects, making their continuity, relationality, and long-term adaptability difficult to understand [21,22]. This problem becomes more evident under rapid urbanization and tourism development. Historic towns may retain visible forms while losing the cultural–ecological relationships that support local memory, identity, and spatial practice [23–25]. The key challenge is therefore not only to identify which heritage objects should be preserved, but also to recognize the structural relationships that sustain long-term evolution and resilience [26–30].

Cultural ecology provides a useful lens for addressing this problem because it emphasizes long-term adaptation between culture and the environment [31–35]. Yet many studies still discuss cultural–ecological processes mainly in qualitative terms or treat the environment as a general background. A clear pathway is still needed to translate these processes into spatial relationships that can be identified and evaluated. This study therefore adopts a structural decoding perspective. From this perspective, historical cultural space records environmental adaptation, local governance, and cultural identity [36,37]. It also continues to shape spatial activities through boundaries, paths, nodes, visual relationships, functions, and scale [38,39]. Space therefore has both representational and operational attributes [40–42].

Accordingly, the study develops a three-dimensional framework composed of a spatial base, spatial network, and spatial entity. The spatial base refers to environmental conditions that shape habitat selection and spatial stability, including terrain, water systems, and ecological risks. The spatial network refers to organizational relationships formed by historical corridors, transport connections, landscape visibility, and core nodes. The spatial entity refers to the material and functional expression of historical cultural space, including settlement texture, cultural facilities, functional organization, and building scale. Together, these three dimensions provide a way to examine how cultural–ecological processes are expressed in spatial structures.

The study follows an analytical pathway of "Identification–Interpretation–Evaluation–Synthesis–Practice." It first identifies historical cultural resources and spatial units. It then interprets their formation mechanisms through the spatial base, spatial network, and spatial entity. It further evaluates the continuity and deviation of these relationships under contemporary transformation. On this basis, the study synthesizes relatively persistent structural relationships and discusses their implications for land and heritage governance.

Empirically, the study focuses on Lijiang, a World Heritage site in southwestern China where cultural, natural, and memory heritage are closely intertwined. Lijiang's historical cultural space was shaped by mountain–valley environments, basin water systems, trade routes, multi-ethnic exchanges, and local beliefs [43]. Under contemporary urbanization and tourism development, Lijiang provides a useful case for examining how the spatial relationships of historical cultural spaces continue, deviate, or transform through land-use change and spatial restructuring.

This study addresses three questions. First, how did cultural–ecological processes shape the spatial structure of Lijiang's historical cultural space? Second, to what extent do these structural relationships continue or deviate under contemporary urbanization and tourism development? Third, how can relatively persistent structural relationships inform land and heritage governance? By answering these questions, this study contributes to

historical cultural space research by linking cultural–ecological interpretation with spatial evaluation and by shifting attention from isolated heritage objects to relational continuity.

2. Materials and Methods

2.1. Study Area

This study focuses on Lijiang in northwestern Yunnan Province, China, located in the Hengduan Mountains between the Qinghai–Tibet Plateau and the Yunnan–Guizhou Plateau. Its elevation ranges from Yulong Snow Mountain (5596 m) to the Jinsha River valley (1015 m). The region contains snow mountains, glaciers, plateau lakes, valleys, meadows, and basin plains. This heterogeneous environment has shaped settlement selection, resource use, and spatial organization (Figure 1).

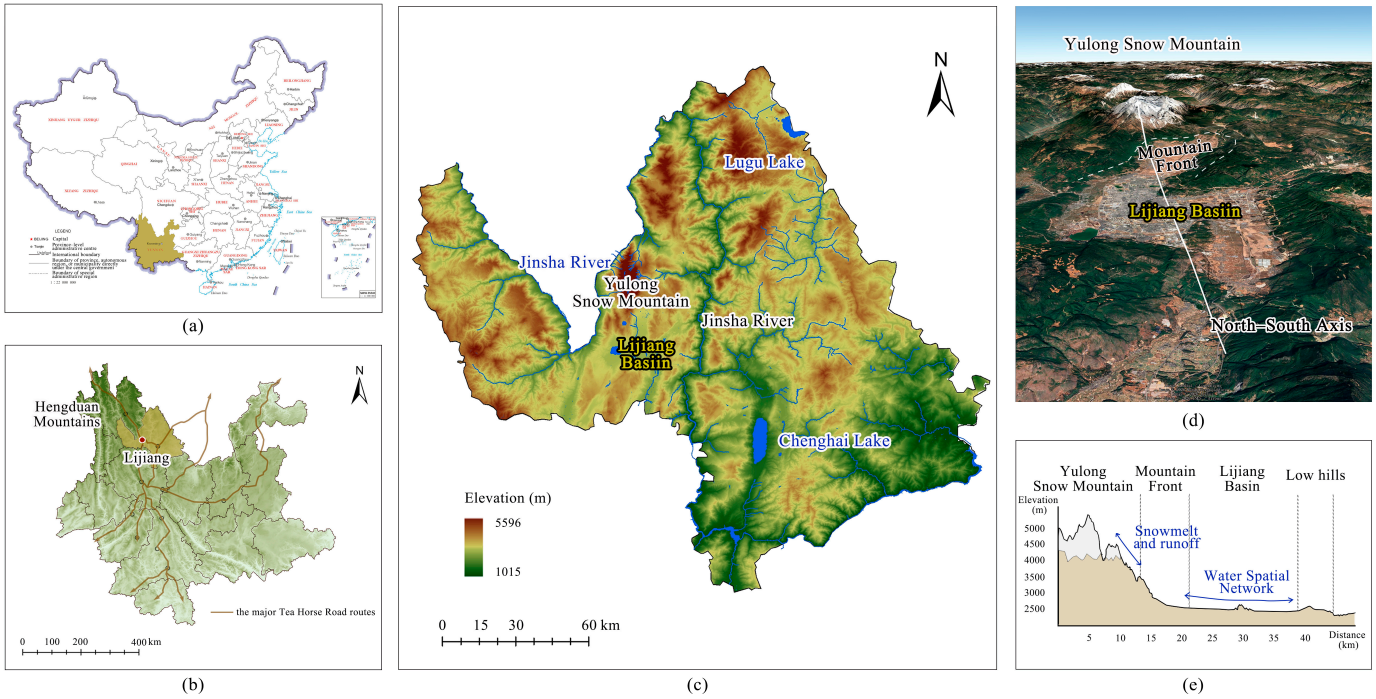

Figure 1. Geographical and environmental context of Lijiang historical cultural space. (**a**) Location of Yunnan Province in China; (**b**) Topographic setting and major Tea Horse Road corridors in Yunnan Province; (**c**) Topography and hydraulic network of Lijiang; (**d**) Three-dimensional geomorphological structure of the Lijiang Basin; (**e**) Topographic profile from Yulong Snow Mountain to the Lijiang Basin.

Historically, Lijiang developed as a complex human–environment system shaped by multi-ethnic coexistence, trade networks, and local governance. The region has long been a meeting place for Han, Naxi, Yi, Lisu, Bai, and other ethnic groups. It was also a key node along the Southern Silk Road and the Tea Horse Road, supporting regional trade and cultural exchange. Since the Ming and Qing dynasties, changes in local institutions and regional governance have further influenced the formation of urban systems and spatial order. Its historical spatial pattern therefore reflects adaptation among environmental constraints, social organization, and cultural practices, rather than large-scale engineering intervention alone.

Lijiang contains multiple layers of heritage. These include the Old Town of Lijiang World Cultural Heritage Site, the Three Parallel Rivers World Natural Heritage Site, and the Dongba manuscripts on the Memory of the World Register. With the Old Town of Lijiang, Yulong Snow Mountain, Lugu Lake, and Naxi culture as major attractions, Lijiang has become an important international tourism destination [44,45]. While tourism has

promoted cultural revitalization and economic growth, it has also intensified spatial expansion, functional restructuring, and heritage commodification [46–48]. These conditions make Lijiang a suitable case for examining the formation mechanisms, structural continuity, and contemporary deviations of historical cultural spaces across regional, basin, and local scales [49].

2.2. Analytical Framework and Indicator Operationalization

To connect the conceptual framework proposed in the Introduction with the empirical analysis, this study translates the structural decoding perspective into a research procedure of "Identification–Interpretation–Evaluation–Synthesis–Practice" (Figure 2).

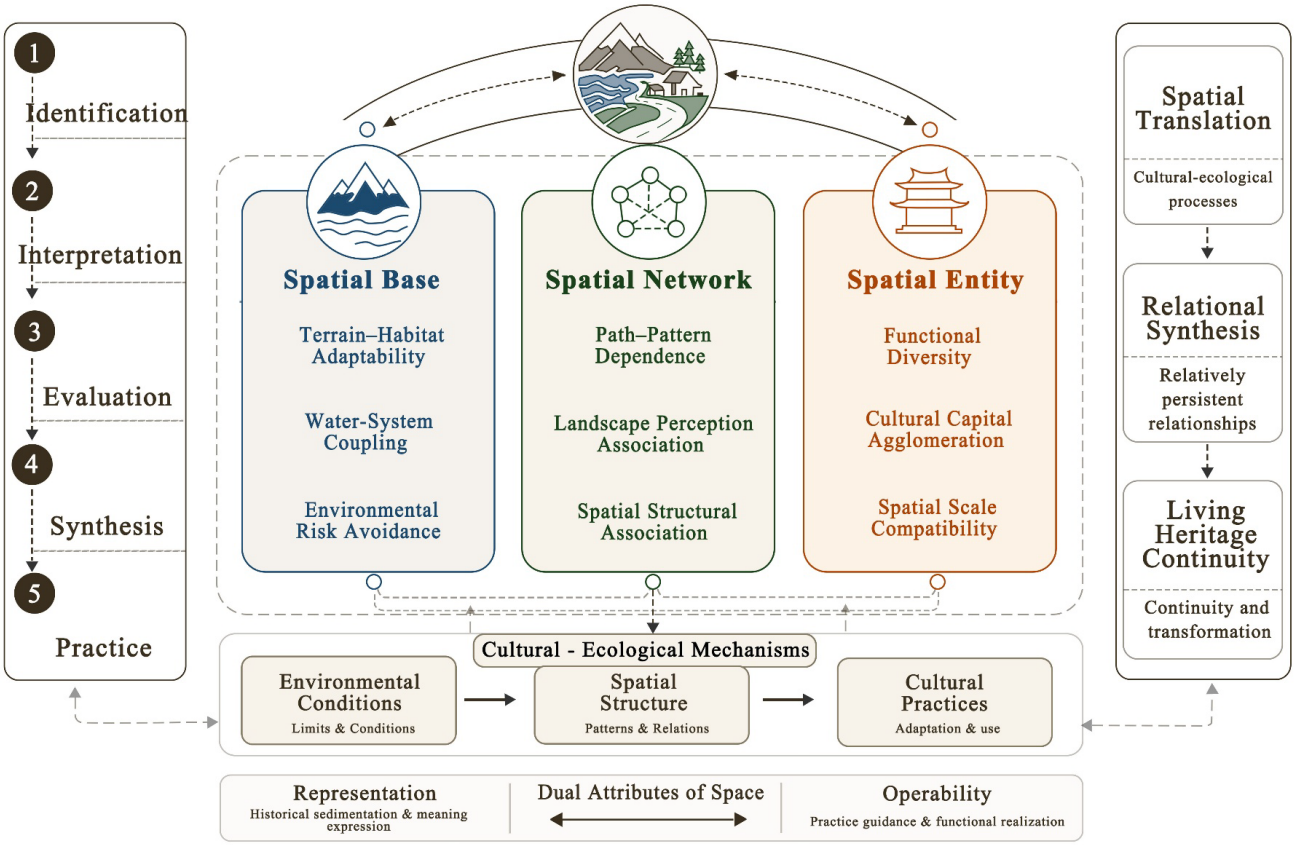

Figure 2. Analytical framework.

In the identification stage, the study builds a unified spatial database covering historical cultural resources, environmental conditions, and contemporary spatial elements. In the interpretation and evaluation stages, the framework is operationalized into an indicator system with three dimensions: spatial base, spatial network, and spatial entity. This system supports mechanism interpretation by examining how culture–environment interactions are embedded in spatial structures. It also supports evaluation by assessing the continuity, weakening, and displacement of these relationships under contemporary transformation. Given the discontinuity of long-term historical data, the study uses verifiable historical cultural resources for mechanism interpretation and combines them with contemporary spatial data to evaluate present-day continuity and deviation (Table 1).

Table 1. Indicator system for structural decoding of Lijiang historical cultural space.

Structural Dimension	Indicator	Definition	Interpretation: Mechanism Role	Evaluation: Diagnostic Role
Base	A1 Terrain–Habitat Adaptability	Measures the distribution of habitat sites across terrain niches.	Reveals how terrain conditions shaped settlement adaptation and spatial stability.	Evaluates whether contemporary construction continues or departs from historical terrain-selection logic.
	A2 Water Systems Coupling	Measures the spatial proximity and coupling between habitat sites and water systems.	Reveals how water systems supported settlement organization and cultural spatial continuity.	Evaluates whether the current spatial organization maintains or disrupts historical water-related structures.
	A3 Environmental Risk Avoidance	Measures the relationship between habitat distribution and environmental risk zones.	Reveals how spatial structures adapt to and avoid environmental risks.	Evaluates whether contemporary construction respects ecological safety boundaries or generates structural risk.
Network	B1 Path–Pattern Dependence	Measures the dependence between historical corridors and spatial pattern.	Reveals how historical routes organized spatial connection and network evolution.	Evaluates the inheritance or deviation of contemporary roads from historical corridor structures.
	B2 Landscape Perception Association	Measures the association between visual perception, sacred landmarks, and spatial organization.	Reveals how landscape visibility maintained spatial cognition and cultural orientation.	Evaluates the integrity or obstruction of historical visual relationships under contemporary development.
	B3 Spatial Structural Association	Measures structural relationships among core spatial units and key elements.	Reveals how geometric alignment, functional coupling, and hierarchical connection maintained spatial order.	Evaluates the continuity, weakening, or dissolution of core structural relationships.
Entity	C1 Functional Diversity	Measures the composite organization and spatial association of different social functional elements.	Reveals how ritual, political, and livelihood functions formed a historical entity organization.	Evaluates the functional mix and vitality transformation of contemporary spatial entities.
	C2 Cultural Capital Agglomeration	Measures the spatial concentration of historical cultural resources.	Reveals the spatial sedimentation and anchoring of cultural elements over time.	Evaluates the coupling or deviation between historical cultural value and contemporary functional vitality.
	C3 Spatial Scale Compatibility	Measures the compatibility between building scale and historical spatial scale.	Reveals how scale control maintained spatial order and landscape coordination.	Evaluates whether contemporary construction is compatible with historical scale and spatial perception.

In the synthesis stage, the study summarizes the results from the three dimensions and examines whether historically formed spatial relationships remain continuous, weakened, shifted, or functionally changed under contemporary conditions. A spatial relationship is summarized as a relatively persistent structural relationship when it has a formation basis in historical documents, old maps, or related studies; shows spatial correspondence in the distribution of extant historical cultural resources; and shows a consistent association in the indicator analysis.

In the practice stage, the synthesized findings are translated into implications for land and heritage governance, including environmental constraints, historical path continuity, visual corridor protection, cultural resource agglomeration, functional vitality renewal, and historical scale coordination.

2.3. Data Sources, Selection, and Preprocessing

This study integrates historical materials, cultural resource inventory data, environmental data, remote sensing imagery, and contemporary spatial data to build a unified spatial database. The point-based analysis used 184 historical cultural resource points from the Lijiang Territorial Spatial Master Plan. These points include extant remains and official heritage records with identifiable historical attributes and verifiable spatial locations. The inventory covers World Cultural Heritage, World Natural Heritage, historical cultural cities, historical cultural blocks and villages, and protected cultural relic units. It also includes Chinese traditional villages, cultural landscape scenic areas, and ethnic traditional cultural–ecological protection areas. Protected cultural relic units include ancient buildings, ancient sites, ancient tombs, cave temples, stone carvings, and important modern historical sites and representative buildings.

For the spatial base analysis, 117 historical habitat sites were selected from the 184 points. This subset includes historical cultural villages, ancient buildings within protected cultural relic units, Chinese traditional villages, and ethnic traditional cultural–ecological protection areas. These sites were used to examine historical habitat formation in relation to terrain, water systems, and environmental risk.

Historical materials include *Lijiang Fuzhi Lüe* from the Qing Qianlong period and historical maps. They also include literature on the Ancient Tea Horse Road, Naxi settlements, and regional transportation. These materials were used to verify historical background, functional meanings, and major spatial relationships. Records without identifiable spatial locations were used only for supplementary interpretation.

Contemporary geospatial data include DEM, land use, water systems, road networks, geological hazards, active faults, building footprints, POI data, and remote-sensing images. DEM data were obtained from ASTER GDEM V3 at 30 m resolution. Land-use data were obtained from a 30 m land-use remote sensing monitoring dataset. This dataset was released by the Resource and Environment Science and Data Center of the Chinese Academy of Sciences in 2025. Water systems, road networks, and building footprints were derived mainly from OpenStreetMap (OSM, 2025) and checked against Google Earth imagery. Geological hazard data were obtained from the China Resource and Environmental Science Data Platform, including 852 hazard points from 1978 to 2020. These include unstable slopes, landslides, debris flows, collapses, and ground collapses. Active fault data were taken from the China Active Fault Database 2023 (CAFDv2023) [50]. Slope and flow accumulation were derived from the ASTER GDEM V3 DEM.

For visibility analysis, the DEM was used as the terrain surface. The DSM was generated by adding available OSM building height attributes to the DEM. Where height information was unavailable, no additional height was added. The DSM was used to diagnose present-day building obstruction rather than to reconstruct historical visibility.

Contemporary functional data were collected from the Amap web-based platform (accessed in 2025) through category-based POI crawling. Duplicate points, invalid coordinates, and points outside the study area were removed. The remaining POIs were reclassified into six categories: shopping, daily life services, catering, scenic spots, public services, and accommodation.

2.4. Data Analysis Methods

This section describes the analytical methods and parameter settings for the indicators listed in Table 1. The methods are organized by spatial base, spatial network, and spatial entity. Historical cultural resources support mechanism interpretation, while contemporary spatial data support continuity evaluation.

For the spatial base, A1 Terrain–Habitat Adaptability, A2 Water System Coupling, and A3 Environmental Risk Avoidance were used to compare 117 historical habitat sites with current built-up land. Terrain adaptability was measured by the Terrain Niche Index (TNI), calculated from elevation and slope:

$$T = \log\left[\left(\frac{E}{\overline{E}} + 1\right) \times \left(\frac{S}{\overline{S}} + 1\right)\right]$$

where T is the terrain niche index; E and $\overline{E}$ denote the elevation of a spatial unit and the mean elevation of the study area. S and $\overline{S}$ denote the slope of a spatial unit and the mean slope of the study area.

Water system coupling was measured by Euclidean distance to water systems. Distance distributions were calculated for both historical habitat sites and current built-up land patches.

Environmental risk avoidance was assessed through a weighted overlay of four factors: slope, flow accumulation, distance to active faults, and distance to known geological hazard points. For each factor, the original raster values were reclassified into five relative risk scores using the natural breaks method. The scores ranged from 1 to 5, where 1 indicated the lowest relative risk and 5 indicated the highest relative risk. The final risk index was calculated as follows:

$$R = 0.30S_r + 0.20F_r + 0.25\ D_f + 0.25D_h$$

where R is the environmental risk index; S_r is the reclassified slope score; F_r is the reclassified flow accumulation score; D_f is the reclassified distance-to-active-fault score; and D_h is the reclassified distance-to-geological-hazard score. The weights were determined through expert judgment according to the relevance of each factor to environmental risk in mountainous settlement environments. This index was used for relative diagnostic comparison within the study area, not as a probabilistic hazard model.

For the spatial network, B1 Path–Pattern Dependence, B2 Landscape Perception Association, and B3 Spatial Structural Association were examined. Historical documents, historical maps, and spatial evidence were used to identify the Tea Horse Road and regional transport axes. Buffer analysis and distance classification were used to evaluate the spatial association between historical cultural resource points and these corridors. The distance bands were set as 0–100 m, 100–500 m, 500–2000 m, 2000–5000 m, and more than 5000 m. These bands were exploratory intervals for describing corridor association, not fixed historical thresholds. The results were compared with current road networks to assess inheritance or deviation.

Viewshed analysis was conducted with Yulong Snow Mountain as the visual target. The target point was set at the summit of Yulong Snow Mountain, with an elevation

of 5596 m. Historical cultural resource points were used as observation points, with an observer height of 1.6 m. The analysis was conducted within the study area boundary. DEM-based viewshed analysis first identified potential visibility under terrain conditions. A second viewshed analysis used the DSM, generated by adding available OSM building height attributes to the DEM, to diagnose current obstruction effects.

For the spatial entity, C1 Functional Diversity, C2 Cultural Capital Agglomeration, and C3 Spatial Scale Compatibility were analyzed. Historical functional entities were classified according to their dominant historical functions into ritual–spiritual centers, power administrative cores, and livelihood residential nodes. KDE was used to identify the agglomeration patterns of historical cultural resource points and contemporary POIs. The analysis was conducted in ArcMap 10.8.2, with a search radius of 5 km and an output cell size of 30 m. Contemporary functional diversity was calculated from the six POI categories over 1 km × 1 km grids. KDE overlays of historical cultural resource points and POIs were used to diagnose the relationship between cultural resource agglomeration and present-day functional vitality. Spatial scale compatibility was assessed through building footprints, remote sensing images, and typical spatial scenes. This part considered settlement texture, street–water relationships, visual enclosure, and the coordination between built form and landscape perception.

3. Results

3.1. Structural Identification of Lijiang Historical Cultural Space

Lijiang's historical cultural space is rooted in a composite mountain–water landscape of mountains, river valleys, lakes, and basin plains. Mountain ranges such as Yulong Snow Mountain form the regional geomorphological framework, while the Jinsha River functions as a major valley corridor and hydrological linkage. Plateau lakes such as Chenghai and Lugu Lake, together with 56 scattered basin plains, provide key water nodes and settlement habitats. Among them, the Lijiang Basin serves as the core platform linking mountains, valleys, and lakes, forming the spatial foundation of the historical cultural landscape (Figure 3a). At the network level, Lijiang is organized around basin plains, connected through river valleys, and structured by the Tea Horse Road and related historical routes (Figure 3b). At the entity level, core settlements such as Dayan, Baisha, and Shuhe are concentrated within the Lijiang Basin, while peripheral resources extend along the Jinsha River, lake areas, and historical transport corridors in linear and nodal patterns (Figure 3c).

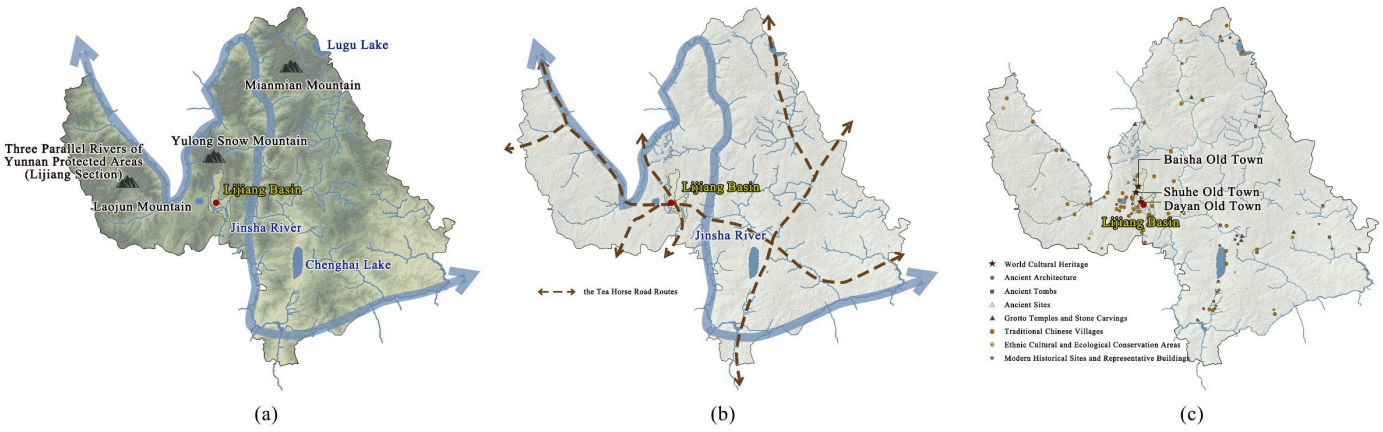

Figure 3. Multi-dimensional structural identification of Lijiang historical cultural space. (**a**) Spatial base structure; (**b**) Spatial network structure; (**c**) Spatial entity distribution.

From a long-term evolutionary perspective, Lijiang's historical cultural space shifted from dispersed and mobile settlement patterns to corridor-based networks and reinforced

core nodes. Early activities were mainly distributed along river valleys, water systems, mountain edges, and basin plains. After the Tang and Song dynasties, regional connectivity promoted agricultural settlements, religious spaces, and trade nodes along major valleys and historical routes. During the Yuan, Ming, and Qing periods, the Lijiang Basin became the core carrier of regional spatial organization, with towns, settlements, water systems, and transport networks forming a more stable hierarchical structure. Since the modern period, traditional settlements, water spaces, and built-up areas have become increasingly superimposed, creating a composite landscape where historical structures and modern functions coexist (Figure 4).

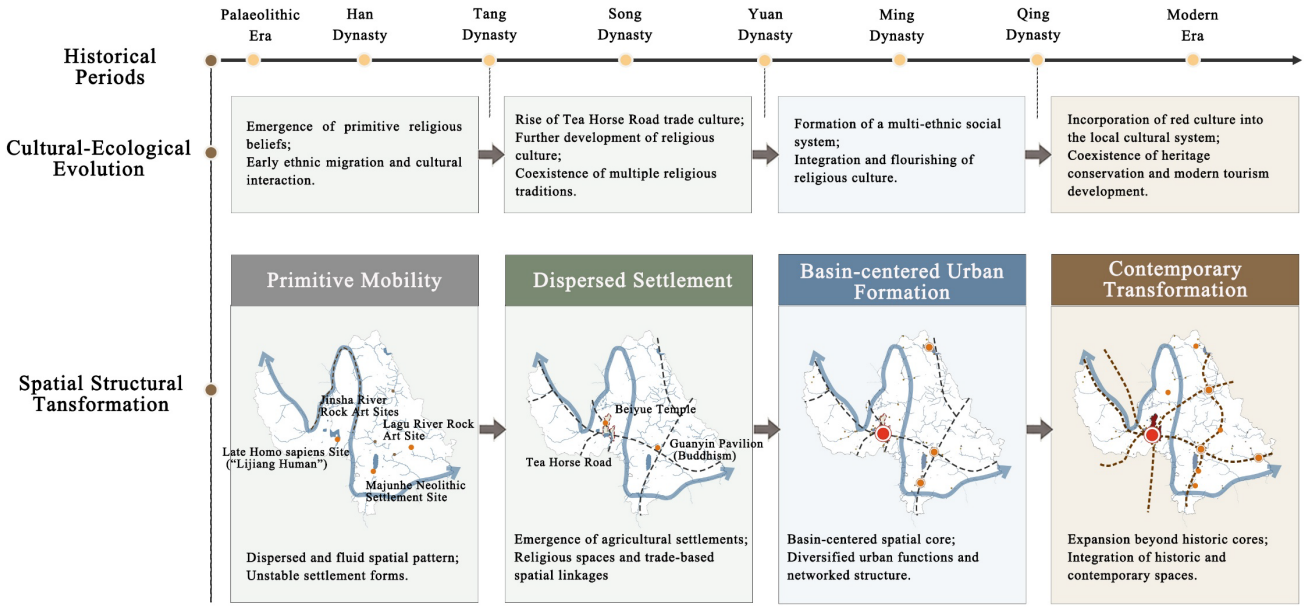

Figure 4. Historical evolution of the spatial structure of Lijiang historical cultural space. The brown dashed lines in the spatial structure panels indicate the main transportation routes in different historical periods.

3.2. Formation Mechanisms of Cultural–Ecological Spatial Structures

3.2.1. Spatial Base: Environmental Adaptation and Habitat Selection

The Terrain Niche Index (TNI) shows that historical habitat sites are mainly concentrated within the 0.30–0.45 range, indicating a preference for low- and medium-terrain niches, while a small number of higher-terrain sites correspond to mountain defense spaces (Figure 5a). The distance-to-water analysis shows strong near-water clustering, with the density peak mainly occurring within 0–1000 m from water systems and declining rapidly with distance (Figure 5b). The composite environmental risk analysis further indicates that historical habitat sites were generally concentrated in low- to medium-risk zones, mostly within the 1.8–2.6 range, with a mean value of approximately 2.30; only a few sites had risk values above 3.0 (Figure 5c).

Together, these results suggest that Lijiang's historical habitat sites were shaped by a composite habitat strategy. Low- and medium-terrain areas, near-water locations, and relatively safe zones provided favorable conditions for agriculture, daily life, settlement stability, and spatial connectivity. Some higher-terrain or higher-risk sites also remained important for route control, defense, and regional management. Overall, Yulong Snow Mountain, the Jinsha River, lake systems, and the Lijiang Basin formed a "high mountain barrier–valley corridor–water-networked basin" framework for historical settlement and cultural resource distribution.

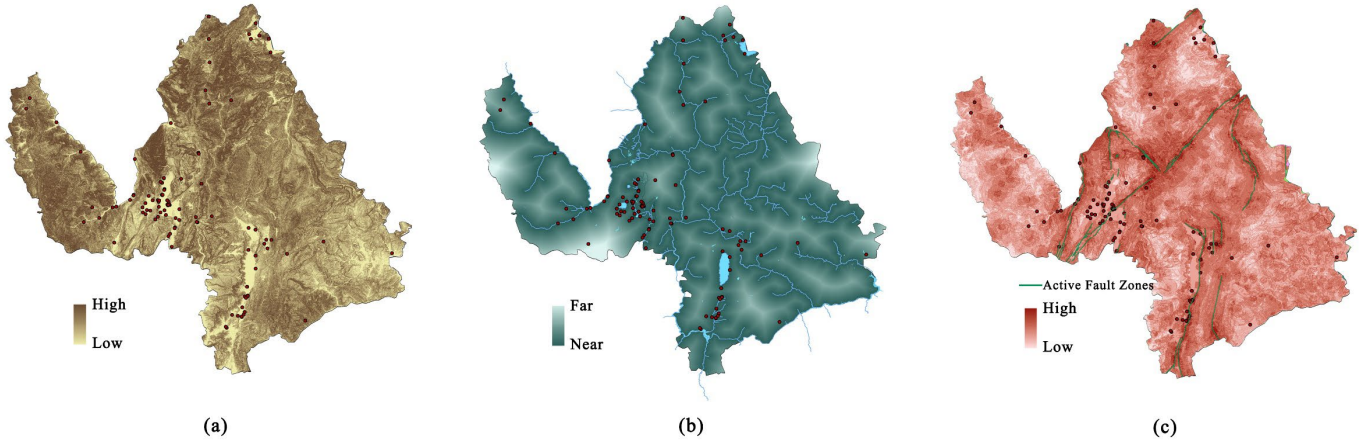

Figure 5. Spatial base mechanisms of Lijiang historical cultural space. (**a**) Terrain habitat adaptation; (**b**) Water system coupling; (**c**) Environmental risk avoidance.

3.2.2. Spatial Network: Path Dependence and Landscape Cognition

Approximately 17.4% of historical cultural resource points are located within 500 m of the Tea Horse Road, including 3.3% within 100 m, while 26.6% are distributed within 500–2000 m and 21.2% within 2000–5000 m (Figure 6a). Overall, resources extend in a belt-like pattern along ancient routes and valley corridors, while more distant sites are mainly associated with livelihood, defense, and religious functions in peripheral mountain areas. DEM-based viewshed analysis shows that the visible areas of Yulong Snow Mountain are mainly concentrated in the Lijiang Basin, valley corridors, and piedmont zones. A total of 74 historical cultural resource points fall within the terrain-based visible range (Figure 6b). This suggests a spatial association between landscape visibility, settlement distribution, and transport corridors. The spatial relationships among Yulong Snow Mountain, Beiyue Temple, Black Dragon Pool, Dayan Old Town, and Qiutang Pass further reveal a hierarchical network linking sacred mountains, water systems, settlements, religious sites, and transport routes (Figure 6c,d). As the sacred mountain of the Naxi "Sanduo" belief system, Yulong Snow Mountain functioned as an important spatial reference for religious worship, landscape perception, and regional identity.

Overall, the Tea Horse Road, valley corridors, water systems, religious centers, and settlements jointly shaped a networked pattern of historical cultural resources. The visibility and symbolic meaning of Yulong Snow Mountain further strengthened spiritual orientation and regional identity.

3.2.3. Spatial Entity: Functional Organization and Cultural Sedimentation

Historical functional entities show a differentiated but coupled distribution. Political administrative centers are concentrated in the central basin, with Dayan Old Town as the main core. Ritual-spiritual centers are mainly distributed around the southern foothills of Yulong Snow Mountain and major settlement nodes, while livelihood residential nodes extend along valleys, water systems, and transport corridors (Figure 7a). Their combined distribution forms a pattern of cultural capital agglomeration, with core concentration around Dayan Old Town and the Baisha–Shuhe area and corridor-based extension along north–south valley routes (Figure 7b). In terms of spatial scale, Dayan Old Town preserves a small-scale, low-rise, and high-density settlement texture organized by water systems, terrain, small hills, Sifang Square, bridges, and wells (Figure 7c–e) [51].

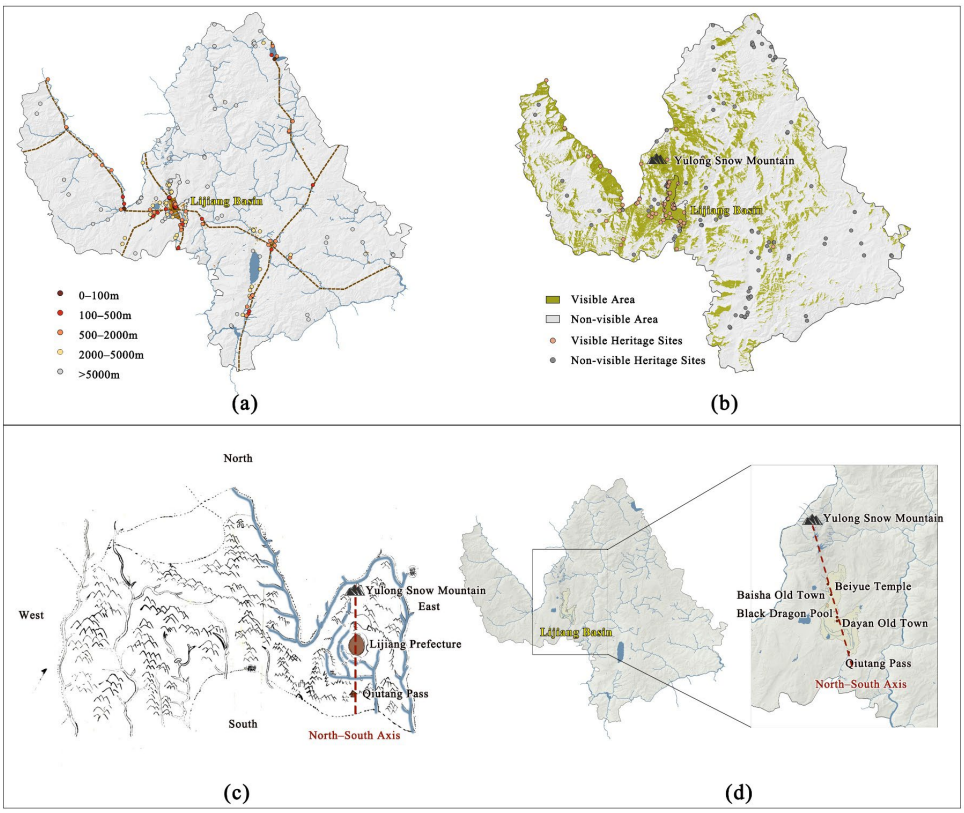

Figure 6. Spatial network mechanisms of Lijiang historical cultural space. (**a**) Historical corridor dependence; (**b**) Visibility relationship with Yulong Snow Mountain; (**c**) Spatial cognition in historical maps, source: *Lijiang Fuzhi Lüe* (Qianlong Period of the Qing Dynasty); (**d**) Spatial axis of Lijiang Basin area.

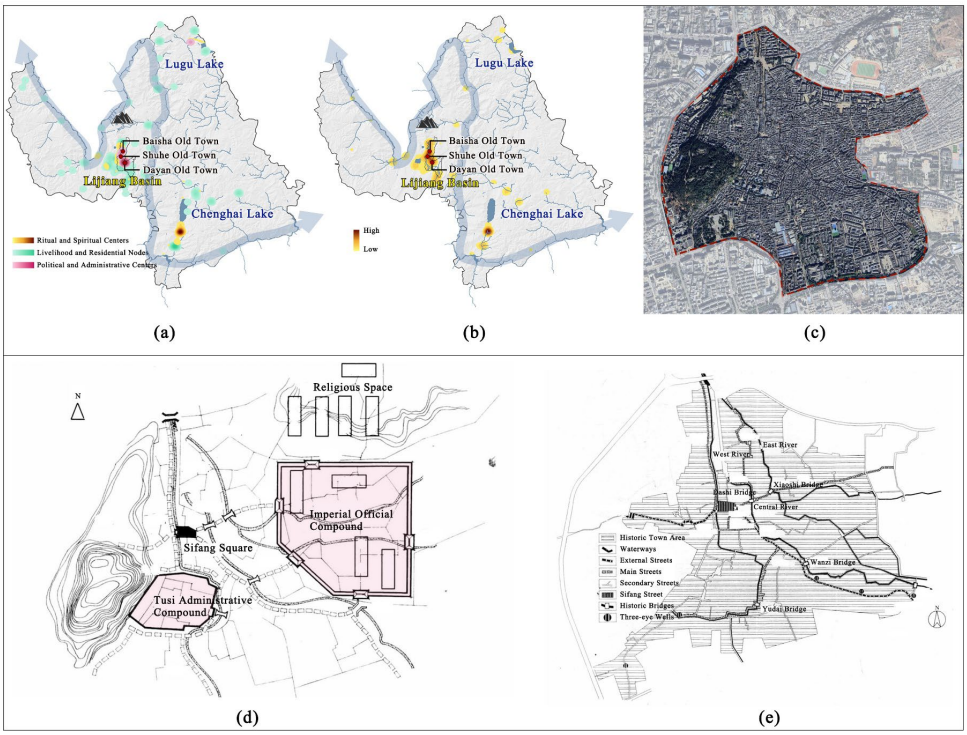

Figure 7. Spatial entity mechanisms of Lijiang historical cultural space. (**a**) Distribution of ritual, political, and livelihood centers; (**b**) Kernel density distribution of historical cultural heritage resources; (**c**) Spatial texture of Dayan Old Town; (**d**) Historical administrative structure of Lijiang, source: Ref. [51]. (**e**) Historical street–water spatial system of Dayan Old Town, source: Ref. [51].

Together, these results indicate that Lijiang's spatial entities were organized around a basin-centered functional structure. The basin core, especially Dayan, Baisha, and Shuhe, concentrated cultural resources, everyday activities, and symbolic meanings, while peripheral lake areas, valley corridors, and mountain settlements supported route control, livelihood production, and localized cultural connections. In Dayan Old Town, small-scale streets, water networks, public spaces, and compact building forms further linked settlement texture with everyday practice.

3.3. Evaluation of Spatial Continuity and Land-Use Deviation

3.3.1. Spatial Base: Habitat Continuity and Environmental Deviation

To evaluate the continuity and deviation of the spatial base under contemporary urban expansion, current built-up land (CBL) was compared with historical habitat sites (HHS) (Figure 8a,b). The TNI distribution shows that HHS are mainly concentrated in low- and medium-terrain niches, while CBL is more strongly concentrated in flat basin areas and low-terrain niches, with some built-up areas extending into higher terrain zones (Figure 8c). The distance-to-water analysis shows that HHS retain a stronger near-water clustering pattern, whereas CBL extends more widely toward medium- and long-distance zones from water systems (Figure 8d). In terms of environmental risk, risk values were first extracted from the weighted risk raster for both HHS and CBL. The 1.8–2.6 range was then identified as the main concentration interval of HHS based on the frequency distribution of the extracted values. HHS decline sharply after about 3.0, while CBL is more dispersed and extends into some relatively higher-risk zones (Figure 8e).

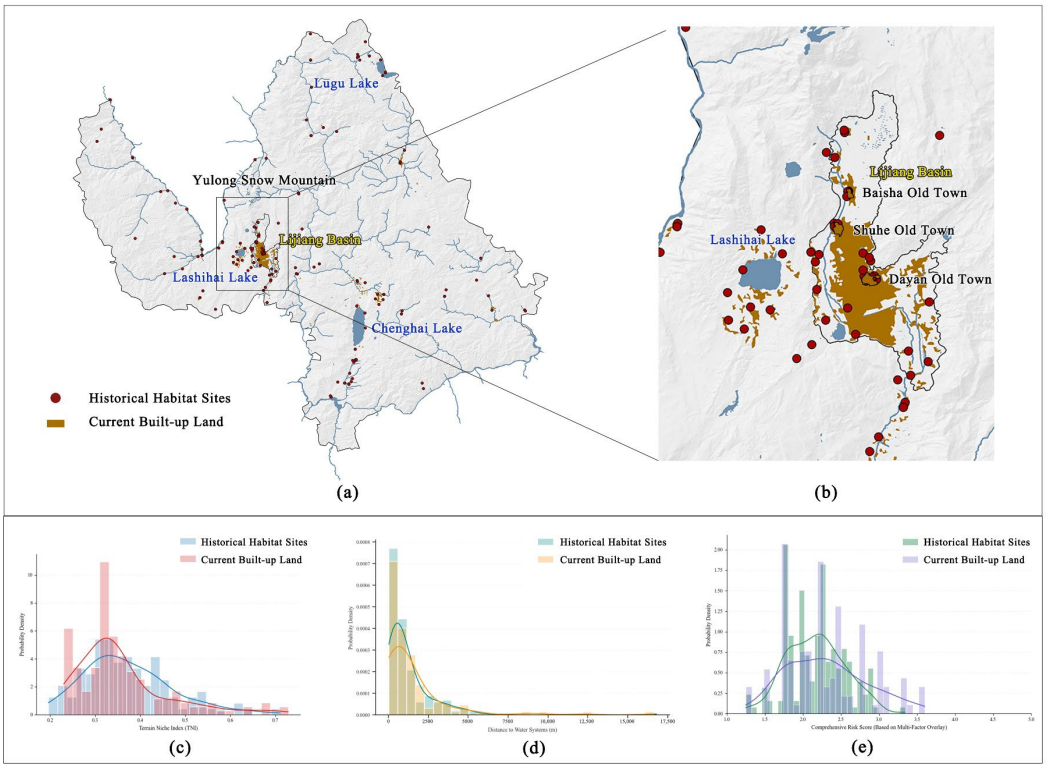

Figure 8. Evaluation of spatial base continuity and structural deviation of Lijiang historical cultural space. (**a**) Spatial distribution of Historical Habitat Sites (HHS) and Current Built-up Land (CBL); (**b**) Expansion of current built-up land in the Lijiang Basin; (**c**) Terrain niche index (TNI) comparison between HHS and CBL; (**d**) Distance-to-water distribution comparison between HHS and CBL; (**e**) Comprehensive environmental risk comparison between HHS and CBL.

These results indicate that current built-up land still partly overlaps with the historical habitat base, but its distribution is more dispersed across terrain, water distance, and risk gradients. Compared with HHS, CBL shows partial deviation from the historical pattern of terrain adaptation, water dependence, and risk avoidance.

3.3.2. Spatial Network: Network Continuity and Visual Connectivity Change

The results show that the historical framework formed by the Tea Horse Road and valley corridors still partly persists in the contemporary road network (Figure 9a). The Baisha–Shuhe–Dayan axis remains an important linkage within the Lijiang Basin. In terms of landscape visibility, 60 historical cultural resource points remain visible after the current building height is incorporated into the DSM. Compared with the DEM-based terrain-only baseline, 14 previously visible points become invisible under present-day building height conditions, including Qiutang Pass, an important Tea Horse Road node (Figure 9b). This indicates that some terrain-based visual connections are obstructed by present-day building height.

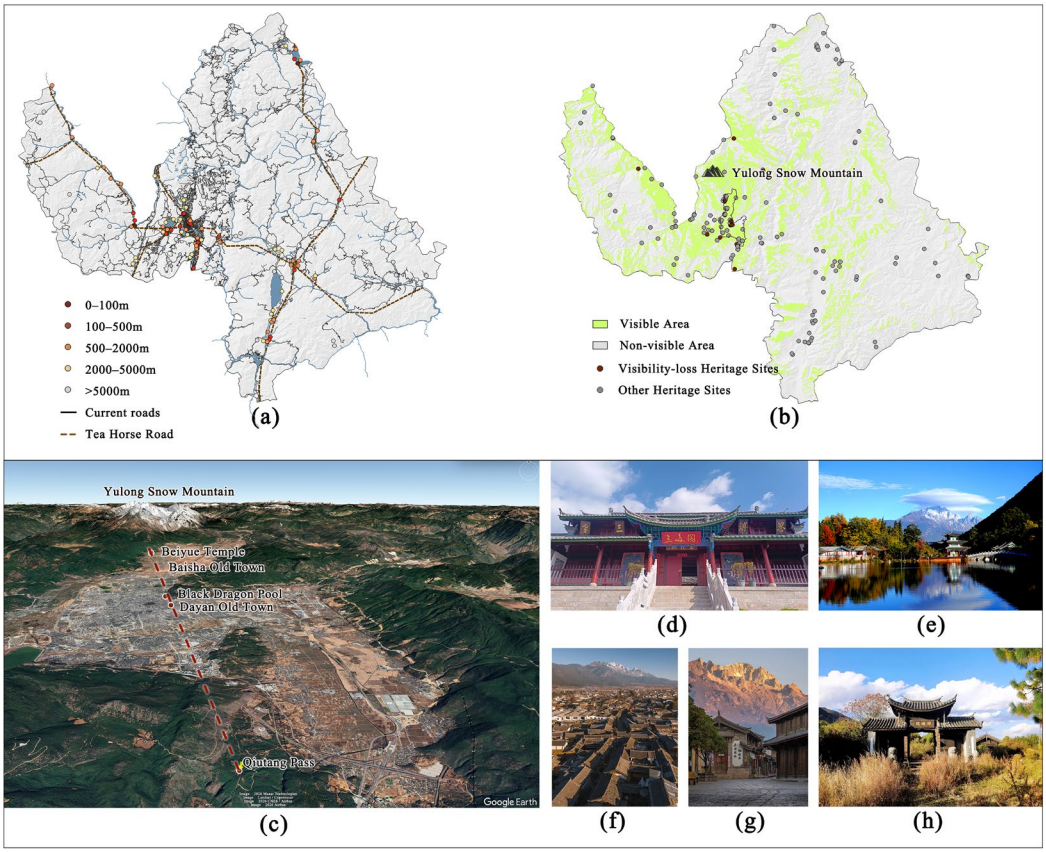

Figure 9. Evaluation of spatial network continuity and structural deviation of Lijiang historical cultural space. (**a**) Dependence between contemporary roads, historical habitat sites, and the Tea Horse Road; (**b**) Visibility change of heritage sites under contemporary built-up conditions; (**c**) Three-dimensional spatial corridor of the Lijiang Basin; (**d**) Beiyue Temple, source: Official WeChat account of Lijiang Museum; (**e**) Black Dragon Pool, source: Official WeChat account of Lijiang Release, photographed by He Lao; (**f**,**g**) Baisha Old Town, source: Official WeChat account of Yunnan Tourism Promotion Officer; (**h**) Qiutang Pass, source: Official WeChat account of Ancient Town Cultural Tourism.

Meanwhile, Baisha Old Town, Beiyue Temple, Black Dragon Pool, Dayan Old Town, and Qiutang Pass still present a relatively clear spatial sequence along the visual axis of Yulong Snow Mountain and the valley transport direction (Figure 9c). Overall, the spatial network shows partial continuity in corridor connection and key-node sequence, while

road restructuring, urban expansion, and building height have changed some visibility and corridor relationships.

3.3.3. Spatial Entity: Functional Transformation and Scale Compatibility

The results show that areas with high functional diversity follow a pattern of "core concentration–corridor extension–nodal distribution." They are mainly concentrated in Dayan, Baisha, and Shuhe, and extend along the main transport axes of the Lijiang Basin (Figure 10a). Secondary clusters also appear around county centers, key towns, the Jinsha River corridor, and tourism areas such as Lugu Lake and Chenghai. Cultural capital agglomeration and functional vitality show "high–high coordination" in the Lijiang Basin and surrounding areas (Figure 10b,c). These areas contain both cultural resource clusters and tourism, commercial, and public-service functions. However, some areas along the Jinsha River and around Chenghai show mismatches between cultural resources and functional vitality.

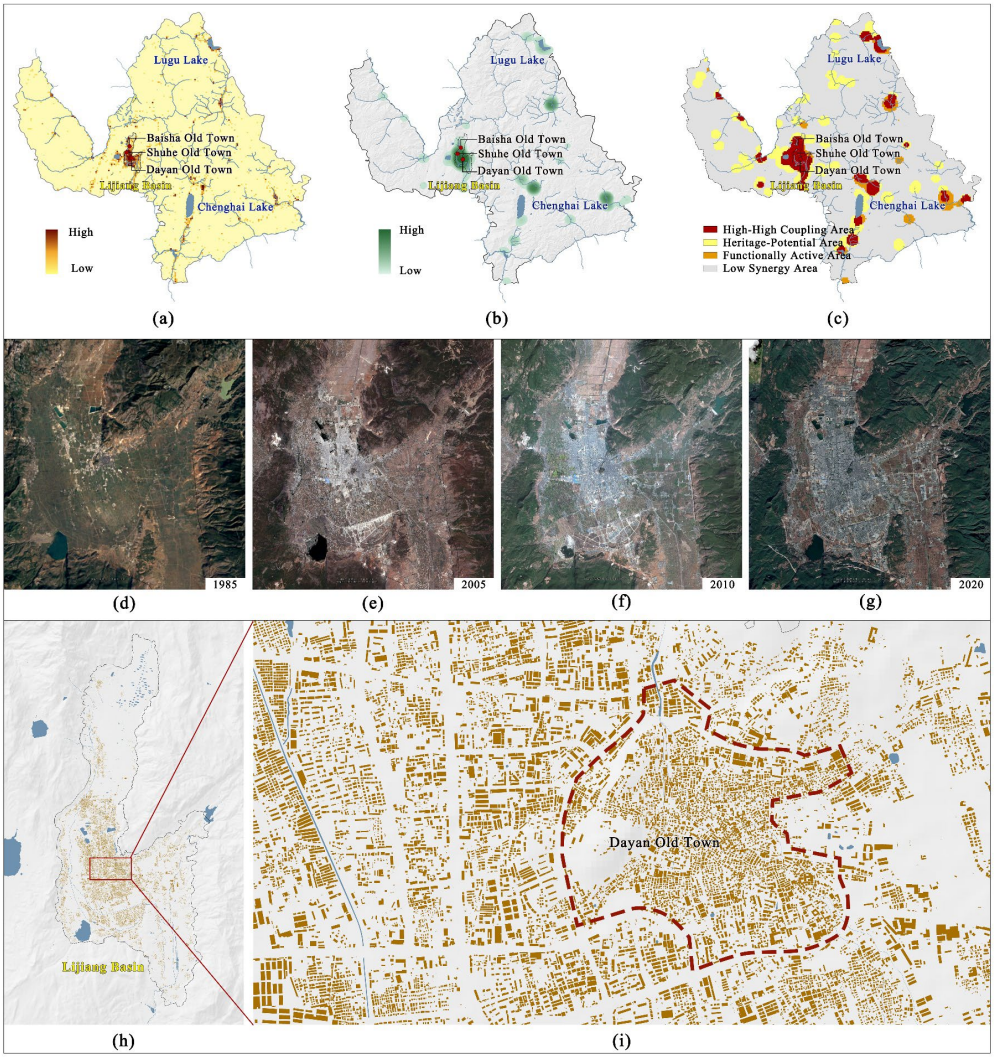

Figure 10. Evaluation of spatial entity continuity and functional transformation of Lijiang historical cultural space. (**a**) Contemporary functional agglomeration pattern based on POI types; (**b**) Kernel density distribution of contemporary functional POIs; (**c**) Spatial coupling relationship between historical cultural resources and contemporary functional activities; (**d**–**g**) Urban expansion and spatial transformation of the Lijiang Basin from 1985 to 2020, derived from historical satellite imagery in Google Earth Pro; (**h**) Distribution of contemporary building footprints in the Lijiang Basin; (**i**) Spatial texture continuity and contemporary construction expansion in Dayan Old Town.

In terms of spatial scale, Dayan Old Town still preserves a small-scale, high-density texture organized by water systems and terrain. By contrast, built-up space in the Lijiang Basin has shifted from dispersed point-like growth toward continuous urban expansion and district-scale development (Figure 10d–i). These results indicate that historical settlement cores and cultural resource clusters still overlap with areas of contemporary functional vitality, especially in Dayan, Baisha, and Shuhe. However, this overlap is uneven, and traditional settlement texture faces pressure from continuous expansion and larger-scale construction.

3.4. Relational Synthesis of Living Heritage Continuity

Based on the preceding interpretation and evaluation, this section examines the continuity and transformation of Lijiang's historical spatial relationships. The analysis follows the three dimensions of spatial base, spatial network, and spatial entity, and integrates spatial indicators, historical interpretation, existing frameworks, and expert judgment.

At the level of spatial base, the evidence shows a relationship among terrain adaptation, water proximity, and risk avoidance. Historical habitat sites are mainly concentrated in low- and medium-terrain niches, near water systems, and in low- to medium-risk zones. TNI values are mostly within 0.30–0.45, water distance density peaks within 0–1000 m, and risk values are mainly within 1.8–2.6. Current built-up land still partly overlaps with this habitat base, especially in the Lijiang Basin. However, it also extends farther from water systems and into some higher-terrain and higher-risk zones. This indicates both continuity and deviation from the historical pattern of habitat selection.

At the level of the spatial network, the evidence shows a relationship among historical routes, valley corridors, sacred mountain visibility, and key nodes. About 17.4% of historical cultural resource points are located within 500 m of the Tea Horse Road. The Baisha–Shuhe–Dayan axis also remains an important linkage within the contemporary road system. In terms of visibility, 74 points fall within the DEM-based visible range of Yulong Snow Mountain, while 60 remain visible after the current building height is incorporated into the DSM. The sequence of Yulong Snow Mountain, Beiyue Temple, Black Dragon Pool, Dayan Old Town, and Qiutang Pass remains partly recognizable. However, some corridor and visibility relationships have changed under contemporary development.

At the level of spatial entity, the evidence shows an overlap among cultural-resource clusters, functional vitality, and traditional settlement texture. High functional diversity is mainly concentrated in Dayan, Baisha, and Shuhe, and extends along the main transport axes of the Lijiang Basin. However, some areas along the Jinsha River and around Chenghai show weaker coordination between cultural resources and functional vitality. Continuous urban expansion and larger building scales in the Lijiang Basin also place pressure on traditional settlement texture.

Overall, Lijiang's living heritage continuity depends not only on individual heritage objects but also on relationships among habitat conditions, water systems, historical routes, sacred landscapes, settlement texture, and everyday spatial practices. These relationships have not disappeared, but they have been unevenly reshaped by contemporary development. The main governance challenge is to maintain these connections while accommodating necessary urban and functional transformation.

3.5. Optimization Strategies for Land and Heritage Governance

Based on the preceding analysis, optimization strategies should focus on maintaining Lijiang's cultural–ecological relationships under contemporary transformation. The following strategies are organized around spatial base, spatial network, and spatial entity.

Within the spatial base, governance needs to maintain the habitat boundaries formed through terrain adaptation, water dependence, and environmental risk avoidance. The Lijiang Basin, water networks, piedmont gentle slopes, and low- to medium-risk areas can continue to guide urban expansion and land-use control. Development toward areas farther from water systems, higher terrain positions, and steeper valley zones should be carefully limited. Water systems such as Black Dragon Pool and the waterways of Dayan Old Town should be treated not only as landscape elements, but also as eco-cultural structures linking settlement organization, public space, and cultural memory.

The continuity of the spatial network depends on maintaining relationships among historical routes, sacred landscapes, and core nodes. The Tea Horse Road can be managed as a regional corridor system linking routes, ferries, bridges, passes, settlements, religious spaces, and defensive nodes. The Baisha–Shuhe–Dayan corridor can also function as both a historical movement axis and a contemporary public-space corridor. Meanwhile, the visibility of Yulong Snow Mountain needs to be incorporated into spatial management through coordinated control of building height, development intensity, and open space around key corridors and nodes.

At the level of spatial entity, governance should strengthen the coordination among functional vitality, cultural capital, and spatial scale. Historical settlements such as Dayan, Baisha, and Shuhe need to maintain a balance among community life, public services, cultural display, and local commerce, while avoiding excessive concentration of tourism-consumption functions. Areas with rich cultural resources but weak vitality, such as the Jinsha River corridor, Chenghai, Lugu Lake, and traditional villages, may be revitalized through cultural interpretation, community services, and small-scale public spaces. Areas with active modern functions but limited cultural support should strengthen their connections with historical routes, local culture, and traditional spatial texture. New development around Dayan Old Town and across the Lijiang Basin should establish gradual transitions in building height, block scale, openness, and spatial form, so as to reduce the decoupling between modern construction and historical spatial relationships.

4. Discussion

4.1. From Object Preservation to Relational Continuity

The Lijiang case shows that living heritage continuity cannot be explained only by the survival of heritage objects, historic districts, or traditional townscapes. Its continuity also depends on whether heritage elements remain connected with mountain–water settings, historical routes, visual references, settlement textures, and everyday practices. This finding extends object-based and morphology-based heritage studies by shifting attention from individual elements to the relationships that keep them active.

This relational perspective is important for mountain heritage regions and multi-ethnic cultural landscapes. In such contexts, heritage value is often distributed across environmental settings, transport routes, religious landscapes, settlement cores, and local practices. A historic town may retain visible forms but lose relational continuity. This may occur through functional homogenization, visual obstruction, scale expansion, or the decline of everyday local life. The Lijiang case therefore suggests that conservation should not only ask whether heritage objects still exist. It should also ask whether habitat conditions, routes, sacred landscapes, spatial texture, and daily activities remain connected.

4.2. Cultural–Ecological Processes as Spatial Relationships

Previous studies on cultural landscapes and historic urban landscapes have emphasized the interaction between nature, culture, and society [52,53]. This study adds a spatial diagnostic perspective by showing how such interactions can be examined through mea-

surable spatial relationships. In Lijiang, terrain niche, distance to water, environmental risk, corridor association, viewshed, POI agglomeration, and spatial texture do not fully explain cultural–ecological continuity by themselves. However, these indicators become more meaningful when interpreted together with historical materials and local cultural meanings. They help reveal how cultural–ecological processes are expressed through spatial base, spatial network, and spatial entity.

The contribution of structural decoding is therefore not to create a new classification of heritage elements, but to provide a way to connect empirical spatial evidence with relational interpretation. Terrain, water systems, and risk conditions help explain habitat selection. Historical routes, valley corridors, and Yulong Snow Mountain visibility help explain regional connection and landscape perception. Cultural-resource clusters, functional vitality, and settlement texture help explain how historical cores continue to support cultural practice and urban life. In this sense, the study differs from approaches that focus mainly on heritage inventories, visual landscape description, or land-use change. It examines how different spatial relationships jointly sustain, modify, or weaken living heritage continuity.

4.3. Contemporary Transformation and Governance Implications

Lijiang's contemporary transformation shows a tension between inherited spatial relationships and new development demands. Current built-up land still partly overlaps with the historical habitat base, and the Baisha–Shuhe–Dayan axis remains an important linkage within the basin. At the same time, urban expansion extends farther from water systems and into some higher-terrain and higher-risk zones. Road restructuring and building height have also changed some corridor and visibility relationships. These changes suggest that contemporary development does not simply follow inherited cultural–ecological relationships, but partly continues, modifies, obstructs, and reorganizes them.

This tension is also reflected in the contrast between heritage cores and their surrounding basin landscape. Within Dayan, Baisha, and Shuhe, historical spatial features are still partly reflected in small-scale streets, compact building forms, water networks, stone-paved paths, and pedestrian-oriented spaces. Outside these cores, dense infill and continuous built-up expansion have compressed the former transition among mountains, water systems, farmland, villages, and town edges. As a result, the visual and ecological setting of the heritage area is no longer shaped only by the protected townscape itself. It is also affected by the changing spatial scale and land-use intensity of the surrounding basin.

This scale contrast is important for living heritage governance. Modernization itself is not the problem. The key issue is whether new construction, tourism functions, and infrastructure development remain connected with the spatial relationships that support heritage continuity. If habitat conditions, historical routes, sacred landscapes, settlement texture, and everyday life become disconnected, heritage may remain visually recognizable but lose part of its relational capacity.

For this reason, heritage governance needs to address not only individual heritage objects but also the relationships that connect them. Land expansion should be guided by terrain, water, and risk conditions. Historical corridors and key visual axes should be protected as part of the broader spatial network. Cultural resource clusters should be coordinated with public services, local life, and small-scale public spaces. Around traditional settlements and across the wider Lijiang Basin, building height, block scale, development intensity, and open-space continuity should be managed. This can reduce pressure on historical texture, mountain–water perception, and the remaining rural landscape.

4.4. Limitations and Future Research

This study has several limitations. First, long-term historical spatial relationships cannot be fully reconstructed from local gazetteers, historical maps, and present-day spatial traces. Some historical processes are therefore interpreted through multiple sources rather than directly measured. Second, the evaluation of contemporary vitality and spatial disturbance mainly relies on POI data, built-up land, viewshed simulation, and spatial morphology. Residents' practices, tourist perceptions, and governance processes are not sufficiently examined. Third, the relational synthesis proposed in this study is based on the Lijiang case. It still needs further testing through expert consultation, participatory mapping, sensitivity analysis, and cross-regional comparison. Future research may apply this framework to other mountain heritage regions and living heritage sites to examine how relational continuity is perceived, used, and managed by different actors.

5. Conclusions

This study examined Lijiang's historical cultural space through the lens of cultural–ecological processes and living heritage continuity. The study developed a three-dimensional framework of spatial base, spatial network, and spatial entity. Following the analytical pathway of "Identification–Interpretation–Evaluation–Synthesis–Practice," it explored how long-term culture–environment interactions are expressed in spatial structures and reshaped under contemporary transformation.

First, the mechanism interpretation shows that Lijiang's historical cultural space was shaped by environmental adaptation, historical networks, and spatial practices. In the spatial base, historical habitat sites were mainly concentrated in low- and medium-terrain niches, near water systems, and low- to medium-risk zones. TNI values were mainly within 0.30–0.45, water distance density peaks appeared within 0–1000 m, and risk values were mostly within 1.8–2.6. In the spatial network, 17.4% of historical cultural resource points were located within 500 m of the Tea Horse Road, and 74 points fell within the terrain-based visible range of Yulong Snow Mountain. In the spatial entity, political–administrative, ritual–spiritual, and livelihood–residential functions were mainly organized around Dayan, Baisha, and Shuhe, with secondary nodes along lake areas, valley corridors, and peripheral mountain settlements.

Second, the evaluation of contemporary conditions shows both continuity and local deviation. Current built-up land still partly overlaps with the historical habitat base, but it also extends farther from water systems and into some higher-terrain and higher-risk zones. The Tea Horse Road framework and the Baisha–Shuhe–Dayan axis still correspond to parts of the contemporary road system. However, 14 terrain-visible resource points were no longer visible after present-day building height was incorporated into the DSM. Areas with high functional diversity remain concentrated in Dayan, Baisha, and Shuhe, while mismatches between cultural resources and functional vitality appear in areas such as the Jinsha River corridor and Chenghai. Continuous urban expansion in the Lijiang Basin also places pressure on traditional settlement texture and spatial scale.

Third, the findings point to three relatively persistent structural relationships. The environmental adaptation relationship links terrain selection, water systems proximity, and risk avoidance. The network-based spatial association links historical routes, sacred mountain visibility, and key nodes. The entity-based spatial practice relationship links cultural resource agglomeration, functional vitality, and settlement texture. These relationships are not independent quantitative indicators, but a synthesis of spatial evidence, historical interpretation, and contemporary evaluation. They show that Lijiang's living heritage continuity depends not only on individual heritage objects. It also depends on the

connections among habitat conditions, water systems, historical routes, sacred landscapes, settlement textures, and everyday spatial practices.

The findings suggest that living heritage conservation should move beyond isolated heritage objects and pay greater attention to relational continuity. For Lijiang, the key challenge is to maintain the cultural–ecological relationships that connect heritage sites, traditional buildings, historic districts, and their wider basin setting. Contemporary development has not completely erased these relationships. Rather, it has reshaped them unevenly through land expansion, building obstruction, functional restructuring, and scale change. The proposed structural decoding framework provides a diagnostic approach for identifying such relationships and may offer a reference for other mountain heritage regions and multi-ethnic cultural landscapes undergoing rapid transformation.

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Abbreviations

The following abbreviations are used in this manuscript:

DEM	Digital Elevation Model
DSM	Digital Surface Model generated by adding available building height attributes to the DEM
CBL	Current Built-up Land
HHS	Historical Habitat Sites
TNI	Terrain Niche Index
POI	Point of Interest

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