

Institutional Diversity and Settlement Patterns in the Karst Highlands of China: A Typological Study Based on 1,093 Villages

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Article

Keywords: Traditional village, Settlement morphology, Karst uplands, Institutional diversity, Hierarchical clustering, Mountain rural studies

Posted Date: October 22nd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11045776/v1>

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Additional Declarations: No competing interests reported.

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Abstract

Settlement morphology in nonhomogeneous terrain regions reflects both geomorphological constraints and cultural adaptations, yet the interaction between these two dimensions has rarely been examined through a unified analytical framework. This study investigates 1,093 traditional villages in Guizhou, China, a karst upland area at the northern edge of Zomia, where fragmented arable land coexists with multiple ethnic institutional traditions. We constructed a three dimensional classification integrating settlement form, site selection, and size class. Ward hierarchical clustering on standardized feature vectors yielded three village groups: a basin intensive group confined to continuous flatlands, a high adaptation group distributed across gentle slopes and valley terraces, and a mountain fragmented group restricted to steep slopes and peak cluster depressions. Kernel density estimation showed that these groups correspond to Guizhou's three main geomorphological divisions. Within each group, the karst environment defines feasible locations and maximum settlement sizes, while internal spatial organization is shaped by four institutional systems, the Ming and Qing garrison system, the Dong Kuan system, the Miao Gu system, and the Tusi system. These institutions produce distinct morphological configurations under similar geomorphological conditions. We propose a sequential framework linking site selection, capacity anchoring, and form consolidation, modulated by culturally specific institutions. This framework may inform rural settlement studies in other nonhomogeneous terrain settings, such as loess hills, deep cut valleys, and Andean landscapes.

Keywords: Traditional village; Settlement morphology; Karst uplands; Institutional diversity; Hierarchical clustering; Mountain rural studies

1. Introduction

Traditional villages represent material and cultural complexes shaped by the long term coevolution of human societies and natural environments. Their spatial configurations not only reflect adaptive strategies employed by specific ethnic groups in response to local biophysical conditions but also encode institutional transformations and evolving social organizational structures. Against the backdrop of global rural restructuring and persistent outmigration from non-urban areas (Andreas et al.,2021), traditional villages in multiethnic settlements across the mountainous southwest of China face converging challenges including demographic hollowing, morphological homogenization, and the erosion of intangible and tangible heritage values (Xie et al.,2026). Yet, the regional knowledge systems embedded in their spatial forms remain undertheorized and insufficiently deconstructed. Moreover, prevailing classification frameworks exhibit limited regional applicability and theoretical robustness particularly in the karst landscapes of southwest China. As a globally representative karst geomorphic region and the northern frontier of Zomia, a zone characterized by ethnic intermingling and sociopolitical autonomy (Eric,2021) this area offers a critical empirical setting for investigating how heterogeneous landforms interact with multiethnic institutional logics to shape settlement formation.

Settlement morphology typology has developed robust theoretical foundations over decades of scholarship. Conzen's urban plan analysis and Muratori's operational typology remain foundational

paradigms, anchoring morphological inquiry in systematic fieldwork and formal logic(Conzen,1960). Rapoport advanced the framework by demonstrating through cultural anthropological analysis how residential practices and symbolic systems actively shape settlement form(Rapoport,1969) thereby shifting typology from descriptive morphology toward interpretive cultural geography. Hillier's space syntax theory further transformed the field by establishing quantifiable, empirically testable links between spatial configuration and patterns of social interaction(Hillier,1984. In recent years, typological approaches have undergone multidimensional expansion not only in data diversity but also in analytical scale and temporal resolution (Trebsche et al.,2025; Akio, 2021; Matthias et al.,2023; Friesen et al.,2020). At the archaeological scale, Rodríguez reconstructed household field spatial organization by integrating soil suitability modeling with terrace morphology analysis(Rodríguez,2026). At the metropolitan suburban scale, Babkin et al. uncovered polycentric functional structures and localized morphological heterogeneity using high resolution commuting flow networks(Babkin et al.,2026). In high latitude cold regions, Carioli et al. traced multidecadal settlement dynamics through synchronized analysis of long term built up area grids and gridded population time series (Carioli et al.,2026). Collectively, these advances affirm the enduring theoretical adaptability of typology for analyzing complex, processual human settlement systems and critically strengthen the empirical testability of the triadic relationship among settlement pattern, environmental adaptation, and historical trajectory. Nevertheless, geographic coverage remains uneven: heterogeneous geomorphological contexts particularly karst landscapes continue to be underrepresented in both methodological development and empirical application.

In recent years, Chinese scholarship has generated a substantial and systematically accumulated body of research on settlement morphology typology. Drawing on 25 years of empirical work in urban morphology, Wu Zhihong and Yang Jian argue that typological inquiry is undergoing from static morphological classification toward dynamic "morphology–performance" correlation analysis, and from unidirectional interpretation toward bidirectional "analysis–generation" integration(Wu and Yang,2026). Li Huaxu et al. developed a multidimensional morphometric indicator system encompassing centrality, boundary complexity, enclosure rate, and spatial sequence entropy, enabling systematic matching evaluation of courtyard prototypes grounded in general architectural typology(Li et al.,2025) Jiang Ziyang et al. performed parametric induction of patio spaces in traditional dwellings of Jingzhou, extracting modeling controllable variables including modular scale, aspect ratio, and opening azimuth, that support generative design applications(Jiang et al.,2024) At the regional scale, Yang Hui and Nie Sen combined GIS based spatial analysis with institutional historical textual analysis to identify four archetypal Tunpu settlement patterns in Anshun and elucidate their governing constraints(Yang and Nie,2025). Liu Peng et al. integrated spatial gene identification with morphological typology to implement hierarchical deconstruction of historic district forms and nested identification of morphological elements across multiple scales(Liu et al.,2026) Collectively, these contributions have significantly strengthened the theoretical grounding, methodological toolkit, and regionally embedded knowledge base of typology within the Chinese context. Nevertheless, gaps persist in current research particularly concerning the intersection of heterogeneous geomorphological settings and multiethnic institutional stratification, where empirical investigation and theoretical conceptualization remain notably scarce. First, sample coverage remains largely confined to county level administrative units or ethnically homogeneous settlements; a provincially representative (Sun

and Ning,2025; LI et al.,2026) large sample morphological database has yet to be established. Second, classification dimensions remain fragmented: planimetric form, site selection logic, and scalar hierarchy are frequently analyzed in isolation(Xie et al.,2023), lacking a unified, weight balanced feature vector framework that synthesizes them into comparable morphological signatures. Third, explanatory mechanisms are often underdeveloped. The prevailing natural constraint cultural adaptation framework remains insufficiently theorized(Cheng et al.,2025), it fails to explicitly articulate how landforms govern settlement siting and maximum viable scale through quantifiable mediators(Wu et al.,2025), such as topographic accessibility and slope stability, and neglects to differentiate how distinct ethnic institutions generate divergent spatial responses under shared geomorphic constraints.

To address the gaps identified above, this study employs a full sample dataset of 1,093 traditional villages across Guizhou Province and establishes a three dimensional collaborative analysis framework integrating planimetric morphology, site selection logic, and scalar hierarchy. The analytical workflow proceeds as follows: (1) Using the boundary shape index (S) and aspect ratio (λ), we develop a quantitative classification system distinguishing six planimetric morphological types; (2) For each morphological type, we compute co-occurrence frequencies across five site selection categories and three scale levels; these frequencies are assembled into an equal weight feature vector, standardized via Z-score transformation, aggregated using Ward's hierarchical clustering algorithm, and validated for optimal cluster count using the silhouette coefficient yielding three empirically robust settlement groups, each exhibiting distinct geographical differentiation patterns and functional spatial connotations; (3) Kernel density estimation and spatial overlay analysis are applied to quantify the spatial coupling between each settlement group's distribution and the karst geomorphological zoning map; (4) Guided by the causal sequence of geomorphological constraint, site selection filtering, carrying capacity anchoring, morphological solidification, we reconstruct the collaborative evolution mechanism underlying these patterns and systematically assess the differentiated regulatory roles of four historically embedded institutional systems the Ming and Qing garrison system, the Dong and Miao self governance system, and the Tusi system in shaping intra settlement spatial organization. This study thus advances a globally applicable, empirically testable framework that jointly operationalizes geomorphological feasibility and institutional regulation for settlement morphology research in heterogeneous landscapes and provides morphologically grounded evidence to inform categorized conservation strategies and differentiated planning interventions for traditional villages in karst mountainous regions.

2. Study Area, Data Sources, and Methodological Framework

2.1 Study Area

This study encompasses the entire administrative territory of Guizhou Province (24°37'N–29°13'N, 103°36'E–109°35'E), covering approximately 176,000 km²(Yin and An,2020) (Figure1). Situated on the eastern flank of the Yunnan–Guizhou Plateau, the province exhibits a pronounced west to east topographic gradient. Karst landforms characterized by soluble carbonate bedrock, sinkholes, and underground drainage networks outcrop across approximately 61.9% of its surface area(Dai et al.,2023). Mountains dominate the landscape, occupying 87% of the total area, whereas basins constitute merely 3%. With an average slope angle of 21.52°, the terrain is highly fragmented and deeply dissected, featuring a complex mosaic of valleys, intermontane basins, and steep hillslopes(Guizhou Provincial Local Chronicles Compilation Committee, 2019). Consequently,

developable land is both severely limited and spatially dispersed, compelling traditional villages to adapt through morphologically diverse embedding strategies within the natural substrate.



Figure1 The location of the study area

From a socio-institutional perspective, Guizhou ranks among China's most densely multiethnic provinces. Eighteen ethnic groups including the Miao, Dong, Buyi, Tujia, Gelao, Yao ethnic groups and Tunbao people have maintained continuous residence for centuries, forming a settlement pattern characterized by large scale mixed habitation with small scale ethnic clustering(Guizhou Provincial Local Chronicles Compilation Committee,2020). In the long term historical process, these groups have left institutional heritages such as the Ming and Qing garrison system, the Dong and Miao self governance system and the policy of replacing hereditary local chieftains with centrally appointed officials(Zhang et al.,2025), which have shaped the village spatial organization logic of different ethnic groups.

2.2 Data Sources and Processing

The research samples were selected from the Catalogue of Chinese Traditional Villages, the Catalogue of Guizhou Provincial Traditional Villages and the Catalogue of Characteristic Villages of Ethnic Minorities. After cross validation and duplicate removal, 1093 traditional villages were identified, covering 9 prefecture level cities (autonomous prefectures) and 88 counties (county level cities, districts) across the whole province. The data processing procedure is presented as follows: (1) Vectorization of built up area boundaries and morphometric parameter extraction. Built up area boundaries were delineated through manual visual interpretation of high resolution historical satellite imagery from Google Earth Pro (acquisition period: 2015–2024; predominant year: 2020). To mitigate classification errors induced by seasonal vegetation cover, cloud occlusion, or image artifacts, ambiguous cases underwent cross validation using Bing Maps Aerial Imagery and China's Tianditu Geospatial Platform. All vector layers were geometrically corrected and registered to the CGCS2000 coordinate system within QGIS 3.x and ArcGIS 10.8 environments. A built up area is operationally defined as the contiguous spatial unit formed by building footprints, interconnected courtyards, and functionally integrated public open spaces including threshing grounds, drum tower plazas, and ancestral hall squares. Excluded are modern peripheral expansions detached from the historic core, isolated agricultural structures (e.g., barns, sheds), and abandoned homesteads with no active residential or communal use.

(2) Attribute annotation of site selection typology and scalar classification. Topographic variables including elevation, slope gradient, and profile curvature were derived from the ALOS PALSAR RTC digital elevation model(12.5m resolution). Integrated with multisource satellite imagery

interpretation, each village was assigned to one of five site selection categories: mountaintop, hillside, foothill, basin, or waterfront. Village scale was classified into three tiers based on built up area extent: small (≤ 2 ha), medium (2–5 ha), and large (≥ 5 ha). All attributes were systematically encoded in the GIS attribute table.

(3) Field survey and empirical validation. Between 2019 and 2024, systematic field surveys were conducted across 196 strategically selected sample villages, documenting on site conditions via geotagged photography and GPS positioning. Unmanned aerial vehicle(UAV) photogrammetry was deployed to resolve ambiguities in satellite based boundary delineation particularly for distinguishing historically coherent built up fabric from recent, non-integrated expansions. Boundary consistency between field validated and imagery derived polygons reached 92.3%; discrepancies primarily stemmed from dense vegetation canopy or construction completed after 2020, and were resolved through manual revision prior to final dataset assembly. Additionally, dominant ethnic affiliation and cultural attribution were determined through triangulation of local ethnographic records, official traditional village nomination dossiers, and semi-structured interviews with village elders and cultural custodians.

According to the currently effective Measures for Ethical Review of Biomedical Research Involving Human Subjects¹ in China and established academic conventions, this research project involves only the acquisition of public knowledge and anonymized interviews, presents no physiological or psychological risks, and contains no sensitive data, and therefore falls within the category of exemption from ethical review.

2.3 Morphological Classification and Cluster Analysis

This study adopts an integrated approach of morphometrics and hierarchical clustering to conduct three dimensional feature extraction and group division for 1,093 traditional villages. The specific methodology is described as follows.

Planimetric morphological classification: Using the boundary shape index (S) and aspect ratio (λ)(Pu,2012), villages are classified into six discrete planimetric types: clustered unit, clustered contiguous, linearly extended, linearly stacked, scattered point, and freely combined. The calculation formulas of S and λ as well as the derivation process of classification thresholds are detailed in Table 1.

Site selection and scale co-occurrence profiling: For each morphological type, we compute its co-occurrence frequency across five site selection categories and three scale tiers, yielding an 8 dimensional feature vector per type.

Hierarchical group identification: Standardized feature vectors undergo Ward's hierarchical clustering. The silhouette coefficient at k=3 is 0.339, lower than those at k=4 (0.410) and k=5 (0.447). However, the grouping at k=3 shows the clearest spatial correspondence with Guizhou's three major geomorphological divisions (mid-low mountain hills, hill-basin plains, deeply incised mountains and peak-cluster depressions). Therefore, k=3 was adopted based on theoretical expectation, while k=4 and k=5 were retained for sensitivity testing (Figure2). Consequently, the six morphological types are aggregated into three empirically grounded settlement groups: the High Adaptation Equilibrium Group, the Basin Intensive Group, and the Mountainous Fragmentation Group.

¹For specific details, please refer to the website:

<https://www.nhc.gov.cn/qjjys/c100016/202302/6b6e447b3edc4338856c9a652a85f44b.shtml>
https://www.gov.cn/zhengce/202303/content_6760498.htm

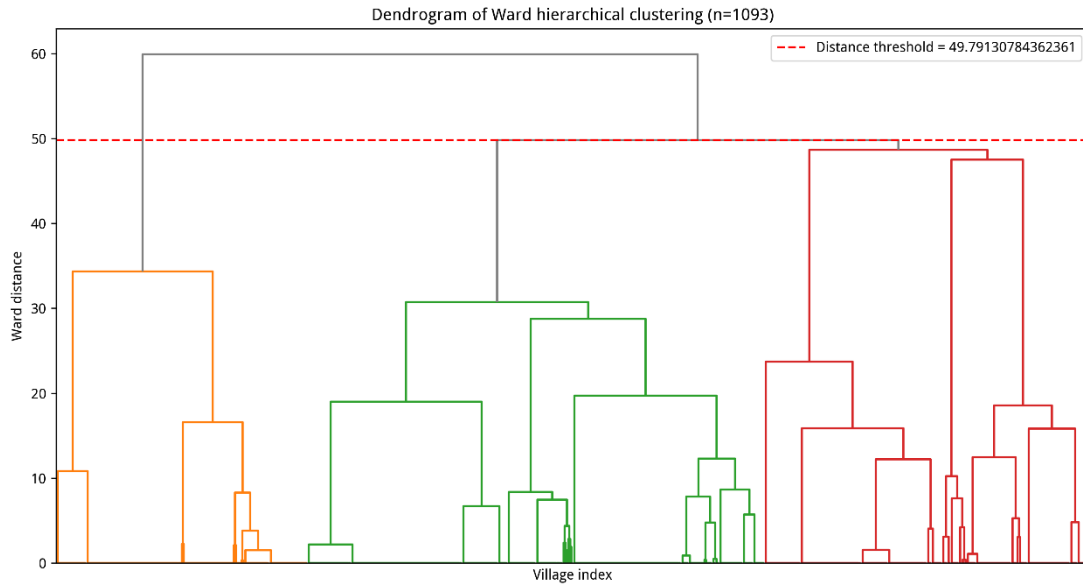


Figure2 Dendrogram of hierarchical clustering

Spatial distribution pattern analysis: Kernel density estimation is applied to map the spatial concentration gradients of each group, revealing distinct geographical patterning. Furthermore, this study integrates quantitative morphometric classification with qualitative institutional tracing to explicate the regulatory mechanisms through which four historically grounded governance systems namely the Ming and Qing garrison system, the Dong Kuan system, the Miao Gu system, and the Tusi system shape settlement morphology. This analysis draws systematically on local gazetteers, ethnographic monographs, and field survey records.

Table 1 Quantitative Classification Rules for Settlement Planimetric Types

Morphological Type	Aspect Ratio(λ)	Shape Index (S)	Area (ha)	Additional Criteria
Clustered Unit	$\lambda < 2.0$	$S \leq 1.8$	> 1	Single compact patch, moderate size
Clustered Contiguous	$\lambda < 2.0$	$S \leq 1.5$	≥ 5	Large compact patch, continuous flatland
Linearly Extended	$\lambda \geq 2.0$	$S \leq 2.0$	Any	Elongated along valley floor or transport route, no stepped layering
Linearly Stacked	$\lambda \geq 2.0$	$S > 2.0$	Any	Elongated along contour lines, stepped arrangement visible
Scattered Point	> 3.0	> 2.5	≤ 1	Multiple discrete small patches
Freely Combined	Mixed	Mixed	Any	Composite morphology not fitting single type above

Shape Index: $S = P / (2\sqrt{\pi A})$, where P= perimeter, A= area. S=1 indicates a perfect circle; larger values indicate increasingly irregular boundaries.

Aspect Ratio: $\lambda = L/W$, where L= length of minimum bounding rectangle, W= width. Values close to 1 indicate square or circular shapes; higher values indicate linear elongation.

Table 2 Comparison of Silhouette Coefficients for Different Candidate Clustering Schemes

Number of candidate clusters k	Average Silhouette Coefficient	Explain
2	0.283	Binary structure, insufficient compactness within clusters
3	0.339	Three part structure with optimal inter cluster

separation		
4	0.410	Three clusters with blurred boundaries appear.
5	0.447	Excessive subdivision leads to increased noise.

3. Results

3.1 Morphological Type Classification

Among the six planimetric morphological types, the clustered unit type is the most prevalent (31.13%), followed by the linearly extended type (24.33%), the linearly stacked type (14.69%), the freely combined type (11.57%), the clustered contiguous type (10.19%), and the scattered point type (8.08%). Aggregated types comprising both clustered and linear configurations collectively account for 80.34% of the sample, establishing aggregation as the dominant spatial logic across Guizhou's traditional villages. In contrast, the scattered point type constitutes only 8.08%, confirming that fully dispersed settlement patterns are marginal in karst mountainous terrain. This overwhelming prevalence of aggregated forms whether compact or linearly organized reflects an adaptive response to the island like spatial distribution of developable land in karst landscapes: dispersed layouts incur prohibitive costs in terms of public service accessibility, collective defense, and infrastructural connectivity(Lin et al., 2023), rendering aggregation a structurally necessary and functionally superior survival strategy.

Site selection distribution exhibits pronounced spatial stratification. The foothill category dominates at 42.98%, followed by hillside(24.33%), basin(19.93%), waterfront(13.59%), and mountaintop(2.39%). Together, foothill and hillside settlements constitute 67.31% of the total corroborating the historically documented site selection principle: “settle near mountains but avoid occupying arable land; settle near water but avoid flood risk”(Li,2011). This pattern reflects a deliberate land use hierarchy: high quality basins are preserved for intensive agriculture, while residential functions are strategically located on geomorphologically stable yet accessible slopes balancing topographic safety, resource access, and agricultural sustainability.

Village scale distribution reveals the constraining force of terrain fragmentation. Small scale villages constitute the majority(56.72%), medium scale account for 30.15%, and large scale represent only 13.13%. This pyramidal size structure directly mirrors the extreme scarcity and spatial discontiguity of developable land in karst environments where contiguous buildable patches are rare, small, and topographically isolated. Consequently, village growth remains inherently bounded, with expansion constrained not by demographic limits but by the physical availability and geometric coherence of suitable land.

3.2 Hierarchical Cluster Analysis of Morphological Types

3.2.1 Results of Cluster Grouping

As shown in Table 3, the interpretation of cluster groups is provided below based on varied site selection preferences and scale distributions.

(1) The High Adaptation Equilibrium Group (n=606;55.46% of total) comprises the clustered unit and linearly extended types. It exhibits near uniform distribution across all five site selection categories, with strong representation in medium and large scales. Its morphological versatility evidenced by independence from any single terrain class and high functional redundancy reflects exceptional environmental adaptability and structural resilience under variable geomorphic constraints.

(2) The Basin Intensive Group(n=111;10.19% of total) consists exclusively of the clustered

contiguous type. It is overwhelmingly concentrated in basin terrain(92.8% of its members), dominated by large scale settlements(73.0%), and characterized by highly centripetal, compact morphology. This pattern signifies intensive, high efficiency utilization of scarce flat land where spatial consolidation maximizes agricultural proximity, infrastructural connectivity, and communal coherence.

(3) The Mountainous Fragmentation Group(n=375;34.34% of total) integrates the linearly stacked, scattered point, and freely combined types. It is predominantly located on hillsides(48.3%), mountaintops(19.2%), and fragmented peak cluster zones(22.1%), with small and medium scales dominating(86.4%). Its morphology is structurally constrained by steep, dissected topography manifesting as spatial discontinuity, low contiguity, and functional compartmentalization thereby embodying the direct imprint of karst terrain fragmentation on settlement organization.

Table 3 The Results of Cluster Grouping

Cluster group	Including morphology	Clustering distance threshold	sample size	Percentage (%)	Silhouette coefficient range
The High Adaptation Equilibrium Group	Clustered Unit, Linearly Extended	3.8	606	55.46%	0.43—0.58
The Basin Intensive Group	Clustered Contiguous	3.8	111	10.19%	0.51—0.64
The Mountainous Fragmentation Group	Linearly Stacked, Freely Combined, and Scattered Point	3.8	375	34.34%	0.37—0.53

3.2.2 Site Selection and Scalar Profiles of the Three Settlement Groups

The spatial distribution and scale composition of the three settlement groups exhibit distinct, morphologically grounded patterns:

The High Adaptation Equilibrium Group demonstrates broad site selection flexibility, with dominant concentrations in foothill(13.87% of group members) and basin(9.27%) settings. Its clustered unit subtype shows co-occurrence rates of 13.87%(foothill), 9.27%(basin), 6.15%(waterfront), 5.05%(hillside), and 0.83%(mountaintop); its linearly extended subtype exhibits 13.04%(foothill), 5.60%(basin), 4.50%(waterfront), 3.76%(hillside), and 0.28%(mountaintop). Scalarly, this group is predominantly medium and large scale: clustered unit units are 47% medium sized and 45% large sized(8% small); linearly extended units are 48% medium sized and 41% large sized(11% small).

The Basin Intensive Group is overwhelmingly concentrated in basin terrain(5.23% of total sample; 92.8% of group members), with secondary presence in foothill settings(4.68%; 42.3% of group members). Its scale structure is strongly skewed toward large scale settlements(71%), followed by medium scale(26%) and small scale(3%).

The Mountainous Fragmentation Group displays terrain constrained heterogeneity across its constituent morphological subtypes. The linearly stacked subtype concentrates on hillsides(9.18%; 48.3% of group members), with minor representation in foothill(3.03%), waterfront(1.47%), basin (0.73%), and mountaintop(0.55%) locations. The scattered point subtype shows relatively diffuse distribution 3.12%(foothill), 2.94%(hillside), 1.38%(basin), 0.92%(waterfront), and 0.28%(mountaintop). The freely combined subtype peaks at foothill(5.23%; 47.0% of group members), followed by basin(3.58%), hillside(2.66%), waterfront(1.29%), and

mountaintop(0.18%). Scalarly, linearly stacked units are predominantly medium sized(70%), with modest large(16%) and small scale(14%) representation; scattered point units are overwhelmingly small scale(82%), with minor medium(17%) and negligible large scale(1%) presence; freely combined units are split between small(59%) and medium scale(38%), with only 3% large scale. Collectively, the co-occurrence rate(Figure3) reveals three robust spatial morphological couplings:(1) the clustered contiguous type exhibits significantly higher basin affinity than any other site selection category;(2) the linearly stacked type shows pronounced hillside specialization; and (3) the scattered point type displays near uniform distribution across all five terrain settings indicating minimal topographic selectivity. As shown in Figure4, scale morphology location interdependencies are systematic: large scale settlements occur almost exclusively within clustered contiguous and clustered unit configurations; medium scale settlements dominate linearly stacked, linearly extended, and clustered unit forms; and small scale settlements prevail in scattered point and freely combined morphologies. Critically, both the scale distribution of a given morphological type and the scale carrying capacity of a given terrain setting vary significantly across morphological configurations, confirming that terrain does not impose uniform constraints but interacts differentially with morphological logic to produce context specific settlement outcomes.

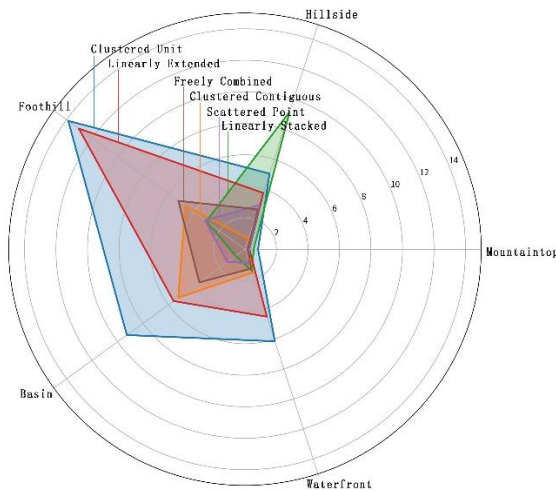


Figure3 Co-occurrence Rate of Morphology and Site Selection

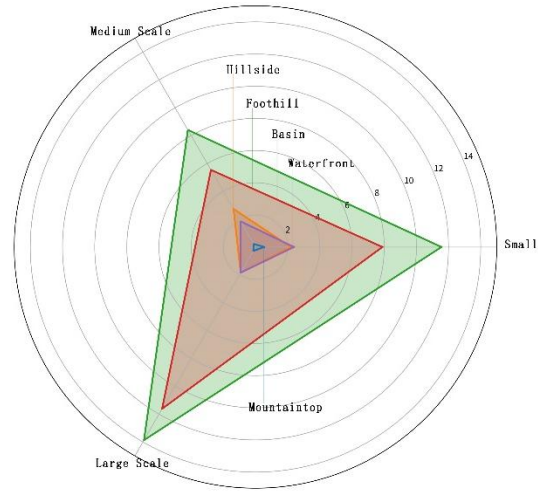


Figure4 Co-occurrence Rate of Site Selection and Scale

3.2.3 Spatial Distribution Patterns of the Three Settlement Groups

Kernel density estimation reveals a strong spatial correspondence between the distribution of the three empirically derived settlement groups and Guizhou's major geomorphological zones(Figure 5, Figure 6, Figure 7).

The High Adaptation Equilibrium Group exhibits province wide dispersion with two statistically significant high density cores. The first core spans the medium to low mountain and hilly terrain of southeastern Guizhou centered on Leigong Mountain and encompassing Taijiang, Jianhe, Rongjiang, and Liping counties with a kernel density of 143–235 villages per 100 km². This zone lies at elevations of 800–1500 m, features average slopes of 18–25°, and is underlain predominantly by slate and sandstone bedrock; its developable land consists of interconnected gentle slope patches and alluvial valley terraces. The second core occupies the central Guizhou hilly plateau basin complex focused on Pingba, Anshun, Huaxi, and Guiyang with a kernel density of 58–85 villages per 100 km². This region is characterized by karst corrosion deposition landforms, where residual hills and solution basins form an interlaced mosaic.

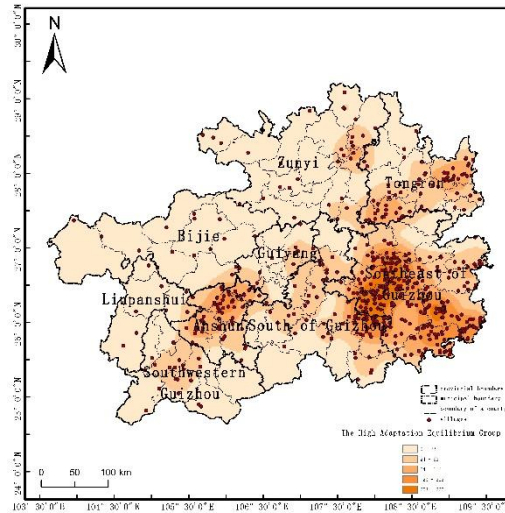


Figure5 Kernel density distribution plot of the High Adaptation Equilibrium Group

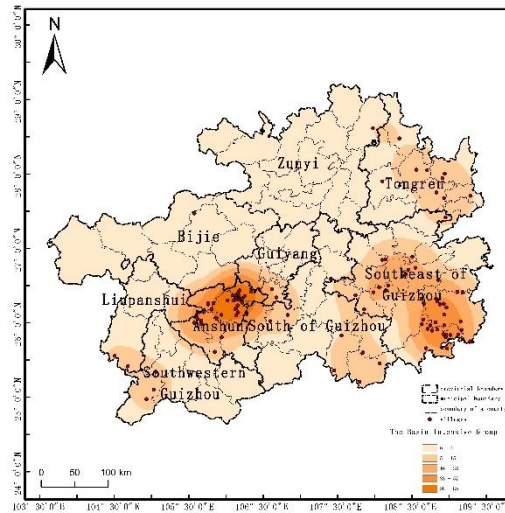


Figure6 Kernel density distribution plot of the Basin Intensive Group

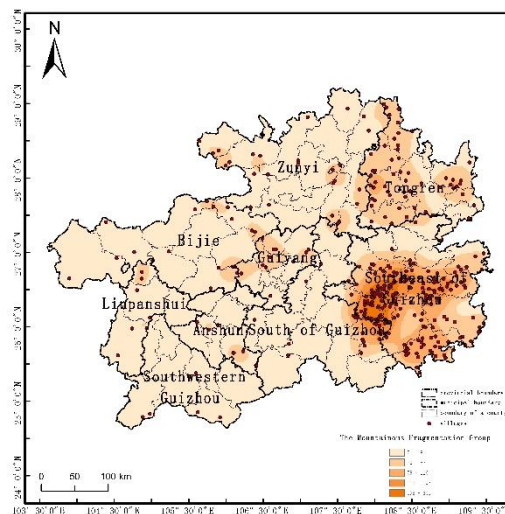


Figure7 Kernel density distribution plot of the Mountainous Fragmentation Group

- 315 The Basin Intensive Group displays highly localized, island like high density clusters predominantly
 316 concentrated in the Pingba–Anshun karst basin core (peak density: 58–85 villages per 100 km²).

Secondary clusters occur sporadically in valley floor basins of southeastern Guizhou (Liping, Congjiang) and southern Guizhou (Duyun, Dushan). Critically, all high density occurrences fall strictly within mapped karst dam extents confirming their exclusive dependence on flat, alluvial floodplain terrain.

The Mountainous Fragmentation Group manifests two distinct spatial modes. Its linearly stacked subtype forms a narrow, topographically constrained band across deeply incised medium mountains flanking Fanjing Mountain (Northeastern Guizhou) and Leigong Mountain (Southeastern Guizhou), with densities of 20–40 villages per 100 km². This zone reaches elevations of 1200–1900 m, exhibits relative relief of 600–1000 m, slopes >25°, and displays stepped erosion corrosion platforms shaped by differential weathering. In contrast, its scattered point and freely combined subtypes appear as isolated, low density points across karst peak cluster depression zones primarily in southern Guizhou(Ziyun, Luodian), southwestern Guizhou(Xingyi, Zhenfeng), and parts of Bijie where densities remain below 15 villages per 100 km². Here, closed depressions(<0.5 km² each) and residual peaks interlace to produce fragmented, island like patches of developable land. Notably, elevated densities occur along high altitude border corridors particularly at the Guizhou–Guangxi and Guizhou–Yunnan administrative boundaries reflecting cross regional ethnic mobility and shared institutional legacies.

Collectively, the spatial differentiation of the three groups aligns precisely with Guizhou’s primary geomorphological divisions: medium to low mountain hilly terrain, hilly plateau basin complexes, deeply incised medium mountains, and karst peak cluster depression systems.

4. Discussion

4.1 Collaborative Evolution Mechanism of Morphology, Site Selection, and Scale

4.1.1 Hierarchical Coupling Under Karst Geomorphic Constraints

The planimetric morphology, microsite selection, and scalar hierarchy of traditional villages in Guizhou are interdependent dimensions of a single human land coupling process. Their covariation follows a causal sequence: geomorphic constraint, site selection filtering, carrying capacity anchoring, morphological solidification (Figure 8).

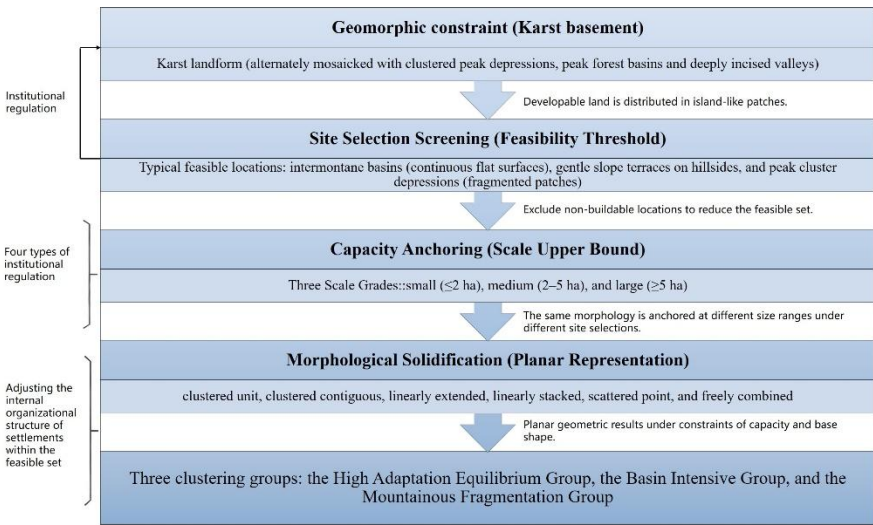


Figure8 Collaborative Evolution Mechanism of Morphology, Site Selection and Scale

In Guizhou’s karst landscape, peak cluster depressions, peak fin basins, and deeply incised valleys form a spatially fragmented mosaic resulting in an island like distribution of developable land

patches(Chen et al.,2025a). Under this fundamental geomorphic constraint, site selection is governed primarily by engineering feasibility: gentle slopes at foothills and moderate hillslopes offer the broadest applicability due to their relatively low gradient, minimal rock exposure, and reduced excavation requirements. Although basin areas are scarce, they constitute the sole terrain class capable of supporting large, contiguous settlements owing to their continuous flatness, favorable drainage, and proximity to arable land(Gao and Xiao,2025). In contrast, peak cluster depressions characterized by poor surface drainage, thin soil cover, and high spatial discontinuity can only sustain small scale, spatially discrete settlements. This physical fragmentation directly conditions the spatial coupling between morphology and site selection(Harrower et al.,2022): integrated clustered forms dominate basins; cascaded linear stacked forms extend stepwise along contour lines on hillslopes; and scattered point forms embed passively within topographically isolated pockets.

Once site selection is fixed, carrying capacity becomes the decisive scalar filter. Settlement scale varies systematically across terrain classes even for identical morphological types(Carlos,2020): clustered unit settlements reach >5ha in foothill or basin edge locations but remain predominantly small to medium in fragmented terrain; linear stacked settlements are constrained by slope width and vertical interval, rarely exceeding medium scale; and scattered point settlements limited by the minute area of individual karst patches are almost invariably <2ha. Thus, the observed pyramidal scale distribution is not demographic but structural: it reflects the progressive spatial filtering of construction capacity imposed by karst landform geometry.

Morphological organization logic represents the sociospatial translation of institutional and functional demands into planimetric configuration mediated by two inseparable constraints(Teresa,2020; Peter and James,2020): environmental carrying capacity and substrate geometry. Where capacity is high and substrate flat, morphology consolidates into centripetal, integrated forms; where capacity is moderate and substrate sloped, morphology organizes into layered, contour following cascades; where capacity is low and substrate fragmented, morphology disperses into point based or collage like configurations; and where substrate aligns with linear corridors such as river terraces or historic transport routes at foothills enhanced accessibility relaxes both capacity and connectivity constraints, enabling linearly extended morphologies along axial frameworks.

4.1.2 Institutional Regulation of Settlement Morphology

While karst landforms define the feasibility envelope for settlement layout, the precise location, internal configuration, and functional articulation of villages are actively shaped by layered institutional frameworks and culturally embedded governance logics(Meador,2019). As Rapoport observed, homogeneous natural environments can host heterogeneous spatial outcomes differences that arise not from ecology alone but from divergent institutional prescriptions governing group size thresholds, administrative reach, and territorial security perimeters(Maraud et al.,2026). Situated at the northern frontier of Zomia and functioning as a long standing interface of multi ethnic interaction, Guizhou's settlement morphology emerges from the co-constitutive superposition of centralized state authority, localized autonomy traditions, and highland strategies of state evasion all operating upon the same karst substrate.

The Ming and Qing garrison system institutionalized a tripartite framework integrating military household registration, clan based ritual governance, and state mandated tax and corvée obligations (Lu and Lin, 2021). Its spatial imperatives controllability, defensibility, and cultivability were

materially realized in karst basins(Du et al.,2025): continuous flat terrain was institutionally consolidated into centripetal, compact agglomerations anchored by ancestral temples and market squares(Chen et al.,2026); streets and lanes followed orthogonal grids; and perimeter walls were constructed from locally quarried stone. This institutional logic directly produces the clustered contiguous morphology evident in the Basin Intensive Group where spatial order manifests the active territorial embedding of imperial power into karst lowlands.

The Dong Kuan system, a polycentric, indigenous model of collective resource governance organized communities through alliances formalized in Kuan covenants and federated networks of large and small Kuan units (Guizhou Provincial Local Chronicles Compilation Committee,2003; Kikuchi, 2020). Drum towers functioned simultaneously as civic assembly spaces and nodes for managing shared resources: Kuan conventions codified water allocation for terraced fields, regulated timber harvesting in fengshui forests, and prescribed sanctions for violations. This system achieved highest spatial efficacy in the foothill basin transition zone: settlements extended to basin edges to secure arable land while drawing upon foothill forests for communal resource supply yielding a clustered unit morphology characterized by drum tower centered nodal aggregation and polycentric spatial juxtaposition. Critically, the typical Kuan unit comprising over one hundred households aligns precisely with the upper threshold of the medium scale category within this morphological type.

The Miao Gu system anchored social organization in patrilineal descent and integrated the Yilang customary legal code with a vertically structured livelihood system combining terraced agriculture and woodland management(Chen et al.,2025b). To evade incorporation into the lowland state's household registration and conscription apparatus(Fan,1983), Miao communities deliberately occupied topographically inaccessible zones peak clusters and deeply incised medium mountains and vertically integrated terraced fields, water sources, woodlands, and settlements along elevation gradients. Settlement layout including platform foundations, stilted architecture, and ridge aligned orientation was strictly governed by Yilang defined property boundaries for terraced plots and water use rights(Huang,1995). This confirms that highland ethnic groups actively sustain institutional autonomy not through isolation, but through strategic terrain selection and vertical socio spatial integration.

In marginal river valleys and plateau platforms along the Guizhou–Guangxi and Guizhou–Yunnan borders, the imperial court implemented an indirect governance regime centered on hereditary Tusi authority and customary tax quotas(Tian et al.,2006). This fostered multi wave immigrant cohabitation under loose military oversight and a mixed subsistence economy of farming, forestry, and pastoralism. Settlements here adopt a collage like morphology stitched together across fragmented resource patches reflecting the spatial juxtaposition of ethnically and institutionally heterogeneous groups within single valley units. This pattern constitutes the tangible spatial interface between centralized state jurisdiction and indigenous governance in Zomia's peripheral zones.

Collectively, these findings extend the proposition that institutional diversity underpins the resilience of mountain settlements. Unlike the institutional convergence observed in lowland plains, Guizhou demonstrates that in ecologically constrained, land scarce environments like karst regions, institutional plurality is not incidental, it is adaptive necessity. The militarized agrarian order of the garrison system, the egalitarian resource autonomy of the Dong Kuan system, the vertically integrated highland livelihood of the Miao Gu system, and the delegated sovereignty of the Tusi

system collectively constitute distinct, context specific expressions of rurality each materially inscribed upon, and reciprocally shaping, the same karst geomorphological substrate.

4.2 Typological Classification of Traditional Villages in Guizhou

Existing typological studies of settlement morphology have established diverse reference frameworks anchored in distinct environmental regimes. Conzen’s plan analysis of Alnwick, UK, introduced the “plan unit” concept (Conzen, 1960), a foundational analytical construct for urban morphological research. Extending this approach to environmentally constrained settings, subsequent scholarship has generated context specific typologies: K.D.S. et al., studying Jakhol Village in Uttarakhand, India, documented the vertical stratification and systematic scale miniaturization characteristic of Himalayan high altitude settlements (Shahi et al., 2021); Najim et al., examining southern Iraqi marshlands, identified a discrete point embedding strategy where settlements articulate with dense hydrological networks through spatially isolated, reed based nodes (Najim et al., 2021); Yilmaz et al., analyzing cold climate settlements, demonstrated how thermal performance differentially constrains morphological choice validating that dispersed configurations outperform grid layouts in minimizing heat loss under sub-zero conditions (Yilmaz et al., 2025). Collectively, these studies map onto three archetypal environmental regimes lowland plains, alpine steep slope terrain, and lacustrine palustrine wetlands thereby enriching the global typological repertoire with empirically grounded, process-oriented models.

This study conducts a cross regional comparative analysis of Guizhou’s three settlement groups against globally documented cases examining convergence and divergence in settlement morphology under analogous topographic conditions through the lens of environmental constraint morphological response coupling (Tables 4, Tables 5, Tables 6).

Table 4 Comparison of Intensive Settlements on Flat Terrain

Comparison Dimensions	Guizhou Basin Intensive Group	European Plain Nuclear Village
Environmental Constraint	Karst basins, with scarce continuous flat surfaces	Alluvial plain with extensive, continuous flat areas
Plane Modality	Clumped and patchy, with dense central concentration	Clustered nucleated villages, gathered around public spaces
Scale Characteristics	Large, constrained by the maximum area of the dam basin	Medium to large, constrained by open field supply
Driving Mechanism	The garrison system, along with military defense requirements	Feudal manorial economy, open field system, and lordship system
Core Spatial Elements	Ancestral hall, settlement walls, and grid-like streets and alleys	Church, square, estate boundary

Table 5 Comparison of Steep Slope Vertical Stratified Settlements

Comparison Dimensions	Guizhou Mountainous Fragment Group	Himalayan Highland Settlement
Environmental Constraint	Steep slopes on karst hillsides (15°–35°), weathered by dissolution	High mountains, steep slopes, glaciers ice water type fragmentation
Plane Modality	Linear stacking, unfolded layer by layer along contour lines	Linear stacked, vertically distributed bands
Scale Characteristics	Medium sized, limited by slope width	Small, limited by high altitude cold conditions
Driving Mechanism	the Miao Gu system and dryland terraced farming	Cold climate, glacial landforms, and mixed farming and pastoral livelihoods
Core Spatial Elements	Stilt houses, terraced fields, and feng shui forests	Temples, prayer paths, and stone built houses

Table 6 Comparison of Discrete Settlements in Fragmented Environments

Comparison Dimensions	Guizhou Mountainous Fragment Group	Marshland settlements in Iraq
Environmental Constraint	Karst peak clusters and depressions, with highly fragmented land	Wetland marsh with seasonal water level fluctuations
Plane Modality	Scattered distribution, with no continuous built up boundary	Discrete, scattered across elevated areas of wetlands
Scale Characteristics	Small, confined to small patch environments	Small and unstable, fluctuating dynamically with water levels
Driving Mechanism	Land fragmentation and the transition from shifting cultivation to settled farming	Seasonal water level fluctuations, fishing, and reed harvesting
Core Spatial Elements	No fixed center, local materials, permanent structures	Reed Chapel, lightweight and removable structure

Three universal patterns emerge:(1) flat terrain consistently favors centripetal, agglomerated morphologies;(2) steep slopes systematically generate linearly stratified configurations; and(3) fragmented landscapes invariably produce discrete, point based distributions. These recurrent correspondences confirm that topography functions as a foundational biophysical filter imposing strong directional pressure on spatial organization and that human societies converge upon functionally equivalent morphological solutions when confronting comparable geomorphic constraints.

Yet beneath this structural convergence lies profound institutional and cultural divergence. Under flat land conditions: Guizhou's Basin Intensive Group reflects the garrison system, its centripetal form anchored by ancestral halls and bounded by stone garrison walls, materializing dual imperatives of military defense and lineage based governance. In contrast, European nuclear villages evolved from feudal manorial economies and open field agricultural traditions, with churches and communal squares serving as spatial cores embodying ecclesiastical authority and collective land stewardship. Under steep slope conditions: Guizhou's linearly stacked settlements integrate dry terrace agriculture with the Miao Gu system, exhibiting vertical elevation gradients exceeding 100m and embedding production, residence, and ritual within a single integrated altitudinal zone. Himalayan alpine settlements, shaped by glacial landforms and extreme cold, prioritize thermal insulation yielding smaller, lower density clusters whose spatial layout is calibrated to microclimatic shelter rather than vertical integration. Under fragmented terrain conditions: Guizhou's scattered point settlements deploy locally quarried stone and timber to achieve permanent, fixed occupation, a passive adaptation to the extreme patchiness of karst peak cluster depressions. Iraqi Mesopotamian marsh settlements, by contrast, utilize woven reed architecture enabling rapid assembly and seasonal mobility constituting an active, hydrologically responsive strategy to annual flooding cycles. These contrasts demonstrate unequivocally that social institutions, cultural schemas, and livelihood logics do not merely overlay but actively recalibrate morphological responses to shared physical constraints(Willett,2026).

Guizhou's distinctiveness arises from the co-occurrence of two exceptional conditions within a single province:(1) extreme heterogeneity of karst landforms including basins, deeply incised mountains, and peak cluster depressions and(2) layered coexistence of multi ethnic institutional systems the garrison order, the Dong and Miao vertical governance, and the Tusi system. This synergy enables the several settlement groups to emerge, differentiate, and persist on the same geological substrate. Crucially, while karst basins constitute only 3% of Guizhou's territory, they

host the majority of large scale settlements precisely because their rare flatness was institutionally amplified into high capacity settlement nodes. Thus, Guizhou does not merely replicate global typologies; it extends them by revealing how institutional diversity transforms scarce geomorphic opportunities into differentiated spatial outcomes. Its traditional villages therefore constitute not a marginal case, but a critical supplementary archetype for mountain settlement theory offering a karst specific model of institutional geomorphic coproduction.

4.3 Research Limitations

This study acknowledges three methodological and analytical limitations pertaining to temporal resolution, morphological classification boundaries, and cultural quantification that warrant explicit recognition and targeted refinement in future work.

First, the dataset is temporally static. Village morphology data derive primarily from high resolution satellite imagery and contemporaneous field surveys, capturing a decadal snapshot of Guizhou's traditional villages. While robust for cross sectional spatial analysis, this design precludes reconstruction of diachronic morphological trajectories(Andrzej and Monika,2020; Fedorov and Kuznetsova,2022): transitional forms between historical typologies remain unobserved, and the dynamic drivers such as infrastructural investment, demographic shifts, or policy interventions that mediate morphological change over time cannot be modeled. Consequently, the current typology reflects structural endpoints rather than evolutionary pathways.

Second, morphological classification boundaries exhibit inherent ambiguity. Although quantitative classification using the boundary shape index (S) and aspect ratio (λ) minimizes subjective bias, the six morphological categories represent idealized end members within a continuous morphometric spectrum. Villages occupying intermediate positions particularly those straddling the clustered unit/linearly stacked or clustered contiguous/scattered point boundaries pose persistent classification challenges. Manual verification mitigates but does not eliminate uncertainty.

Third, cultural factors remain under quantified. Ethnic affiliation serves solely as a contextual covariate in morphological analysis, while institutional frameworks are treated qualitatively. No direct metrics capture their scalar influence or spatial imprint. This asymmetry results in stronger empirical grounding for geomorphic constraints where terrain metrics are directly integrated into clustering algorithms than for sociocultural drivers, limiting the capacity to model their relative weighting in morphological formation.

5. Conclusion

This study identifies a causal chain linking geomorphic constraint, site selection filtering, carrying capacity anchoring, and morphological solidification the core dimensions of traditional village organization in Guizhou. Karst landforms fragment developable land into discrete, island like patches, rendering site selection the critical bottleneck that mediates between biophysical limits and spatial form. Once site is fixed, carrying capacity becomes the decisive scalar filter: the observed pyramidal scale distribution is a direct outcome of karst terrain's layered filtration of construction potential. Morphology, in turn, emerges as the socio-spatial translation of institutional and functional demands into planimetric configuration constrained simultaneously by available capacity and substrate geometry. Crucially, across this entire chain, four historically embedded governance systems the Ming and Qing garrison system, the Dong Kuan system, the Miao Gu system, and the Tusi system exert differentiated regulatory agency, imprinting distinct spatial logics onto the same karst substrate.

Building on these findings, we propose a two layers interpretive framework: the geomorphic feasibility envelope and institutional agency. In topographically heterogeneous regions, settlement morphology is neither environmentally determined nor culturally arbitrary. Rather, it constitutes a context specific spatial solution generated through institutional negotiation within the biophysically defined feasibility boundaries. This framework transcends Guizhou: it is transferable to other fragmented landscapes including loess tablelands, deeply incised canyon systems, and non-karst mountainous terrains providing a generalizable analytical lens for decoding the diversity of mountain human settlements.

Practically, the empirically derived three groups typology offers a morphologically grounded basis for differentiated conservation and planning interventions. For the High Adaptation Equilibrium Group, conservation strategies must prioritize adaptive flexibility safeguarding its inherent morphological plurality and functional redundancy against homogenizing pressures. For the Basin Intensive Group, intervention should focus on containing urban and infrastructural encroachment into basin floor land preserving the integrity of its centripetal, large scale agglomerations. For the Mountainous Fragmentation Group, priority lies in upgrading transport connectivity and livelihood infrastructure to mitigate hollowing, induced disintegration while respecting its terrain constrained, point based logic.

Data Availability

All data supporting the findings of this study are available within the paper and its Supplementary Information.

References

- Akio, 2021 Y. Akio. Typological Study of Oya Stone Buildings and Townscapes: A Case Study of Nishine District, Tokujirou Town, Utsunomiya City. *Japan Architectural Review* 4(2) (2021),pp.332–342. doi:10.1002/2475-8876.12194.
- Andreas *et al.*, 2021 K. Andreas, B. Bernd, M. Michael, and N. Matthias. The Cultural Political Economy of Rural Governance: Regional Development in Hesse (Germany). *Journal of Rural Studies* 87(2021),pp.327–337. doi:10.1016/J.JRURSTUD.2021.09.017.
- Andrzej *et al.*, 2020 R. Andrzej , W. Monika. Deagrarianisation of the Economic Structure and the Evolution of Rural Settlement Patterns in Poland. *Land* 9(12)(2020),pp.523. doi:10.3390/LAND9120523.
- Babkin *et al.*, 2026 R. A. Babkin, A. N. Berezhnysky, and A. G. Makhrova. Polycentric Suburban Zone of a Monocentric Agglomeration: Settlement Pattern Structure in the Moscow Environment. *Regional Research of Russia* 16(1)(2026),pp.37–49. doi:10.1134/S2079970525600970.
- Carioli *et al.*, 2026 A. Carioli, J. H. Uhl, L. Maffenini, M. Schiavina, and K. K. dębska. Human Settlement Dynamics of the Arctic: Insights from Remote Sensing and Census Observations. *Applied Geography* 189(2026),pp.103922. doi:10.1016/J.APGEOG.2026.103922.
- Carlos, 2020 T. G. Carlos Settlement Patterns in Inland Gallaecia between the End of the Roman Empire and the Early Middle Ages: New Data, New Proposals. *STUDIA HISTORICA-HISTORIA MEDIEVAL* 38(2)(2020),pp.155–187. doi:10.14201/SHHME2020382155187.
- Chen *et al.*, 2026 H. Chen, Y. Liang, D. Xiao, M. Chen, W. Niu, and X. Luo From Military Defense to Cultural Continuity: The Spatial Transformation of Tunpu Settlements in Central Guizhou,

- China. *Journal of Asian Architecture and Building Engineering*(2026),pp.1–18.
doi:<https://doi.org/10.1080/13467581.2026.2653287>.
- Chen *et al.*,2025a H. Chen, D. Xiao, and Y. Liu Spatial Morphology and Influencing Factors of
Tunpu Traditional Villages in Anshun: A Comprehensive Study. *Journal of Asian Architecture
and Building Engineering* 24(5)(2025),pp.3457–3470. doi:10.1080/13467581.2024.2396624.
- Chen *et al.*,2025b H. Chen, D. Xiao, J. Li, and Y. Liu Study on the Distribution Characteristics and
Formation Mechanism of Traditional Village Names in Southeast Guizhou. *npj Heritage
Science* 13(1) (2025),pp.263. doi:10.1038/S40494-025-01830-8.
- Cheng *et al.*, 2025 Z. Cheng, M. Wang, and A. Huang Spatial Distribution Characteristics and
Influencing Factors of Traditional Villages in Guizhou. *Journal of Human Settlements in West
China* 40(05)(2025),pp.222–229. doi:10.13791/j.cnki.hsfwest.20240119002.
- Conzen,1960 M. R. G. Conzen Alnwick, Northumberland: A Study in Town-Plan Analysis. In
London: George Philip(1960),pp.1–122.
- Dai *et al.*,2023 B. Dai, T. Peng, X. Zhang, X. Mo, and S. Wang Major Types and Formation
Mechanism of Karst Hill in Plateau and Discussion on Karst Landform Zoning in Guizhou,
China. *Mountain Research* 41(2)(2023),pp.155–168. doi:10.16089/j.cnki.1008-2786.000738.
- Du *et al.*, 2025 J. Du, Y. Yu, and J. An Research on the Preservation of Ming Dynasty Southwest
Weicheng Based on Spatial Gene Theory: Taking Guizhou Pu'an Fortress as an Example.
Industrial Construction 55(10)(2025),pp.136 ~ 145.
- Fan,1983 T. Fan The Collapse of the Chieftain System of Ethnic Groups in Southwest China and
the Bureaucratization of Native Chieftaindoms in the Early Qing Dynasty. *Guizhou Social
Sciences* (2)(1983),pp.73–80.
- Fedorov *et al.*,2022 G. M. Fedorov and T. Yu. Kuznetsova Rural Population Change and Settlement
Patterns in the Kaliningrad Region in 1991 – 2021. *Vestnik of Saint Petersburg University.
Earth Sciences* 67(4)(2022). doi:10.21638/SPBU07.2022.410.
- Friesen *et al.*,2020 J. Friesen, V. Friesen, I. Dietrich, and F. P. Peter Slums, Space, and State of
Health—A Link between Settlement Morphology and Health Data. *International Journal of
Environmental Research and Public Health* 17(6)(2020),pp.2022.
doi:10.3390/ijerph17062022.
- Gao and Xiao, 2025 P. Gao and Y. Xiao Study on the Natural Ecological Adaptation of Traditional
Miao Dwellings in Qiandongnan Region. *Architectural Journal* (S1)(2025),pp.112 ~ 117.
- Guizhou Provincial Local Chronicles Compilation Committee,2003 Guizhou Provincial Local
Chronicles Compilation Committee Guizhou Provincial Chronicles: Cultural Relics Volume.
In Guiyang: Guizhou People's Publishing House, (2003),pp.215.
- Guizhou Provincial Local Chronicles Compilation Committee, 2019 Guizhou Provincial Local
Chronicles Compilation Committee Guizhou Province Gazetteer (1978–2010): Forestry. In
Guiyang: Guizhou People's Publishing House(2019),pp.415.
- Guizhou Provincial Local Chronicles Compilation Committee,2020 Guizhou Provincial Local
Chronicles Compilation Committee Guizhou Province Gazetteer. In Guiyang: Guizhou
People's Publishing House(2020).
- Harrower *et al.*,2022 M. J. Harrower, J. C. Mazzariello, D. Catherine A., S. Nathan, and H. M.
Taddesse Aksumite Settlement Patterns: Site Size Hierarchies and Spatial Clustering. *Journal
of Archaeological Research* 31(1)(2022),pp.1–44. doi:10.1007/S10814-021-09172-2.
- Hillier,1984 B. Hillier The Social Logic of Space. In New York: Cambridge University Press,(1984).

- Huang,1995 C. Huang Institutional Culture of Indigenous Ethnic Groups Inhabiting Guizhou. *Guizhou Ethnic Studies* (4),pp.94–106. doi:10.13965/j.cnki.gzmzyj10026959.1995.04.018.
- Jiang *et al.*,2024 Z. Jiang, J. Zheng, and R. Peng A Study on the Spatial Prototype of the Patio of Traditional Residential Houses in Jingzhou Based on Architectural Typology. *Chinese & Overseas Architecture* (02)(2024),pp.129–135. doi:10.19940/j.cnki.1008-0422.2024.02.023.
- Kikuchi *et al.*,2020 M. Kikuchi and T. Okubo Building Cyber Resilience through Polycentric Governance. *Journal of Communications* 15(5)(2020). doi:10.12720/JCM.15.5.390-397.
- Li *et al.*,2026 C. Li, Y. Zhao, Z. He, Z. Li, and F. Fu Research on Spatial Morphology Characteristics of Curved Brook for Drinking and Poetry in Chinese Garden Based on the Typology Theory. *Chinese Landscape Architecture* 42(2)(2026),pp.138–144. doi:10.19775/j.cla.2026.02.0138.
- Li *et al.*,2025 H. Li, Y. Zhu, T. Wang, and W. Ouyang Prototype Translation and Spatial Quantification of the Traditional Chinese Courtyard: Insights from the Perspective of Generalized Architectural Typology. *South Architecture* (10)(2025),pp.76–89.
- Li, 2011 Z. Li Division of Karst Landform in Guizhou. *Guizhou Geology* 28(3)(2011),pp.177-181+234.
- Lin *et al.*,2023 K. Lin, W. Tao, and H. Gu Spatial Form and Spatial Cognition of Traditional Villages Based on Space Syntax: A Case Study of Jiaju Village, Guizhou Province. *Geographical Science* 43(09)(2023),pp.1608–1618. doi:10.13249/j.cnki.sgs.2023.09.011.
- Liu *et al.*,2026 P. Liu, M. Yu, Y. Zhang, and Y. Tian Identification and Transmission Assessment of Space Genes in Historic Districts from the Perspective of Morphological Archaeology: A Case Study of Shibati in Chongqing. *Planners* 42(3)(2026),pp.72–80.
- Lu and Lin, 2021 R. Lu and X. Lin Special Administrative Divisions with Its Ethnic Management and Household Registration in Southwest Minority Area in Yuan Dynasty. *Journal of Nanjing University(Philosophy, Humanities and Social Sciences)* 58(3)(2021),pp.41-49+158-159.
- Maraud *et al.*,2026 S. Maraud, B. Burke, M. W. Devine, J. Thompson, and E. Marty Shaping Society, Building Community. The Role of Mutual Aid in a Pastoral Basque Valley (Xiberoa, France). *Journal of Rural Studies* 126(2026),pp.104301. doi:10.1016/J.JRURSTUD.2026.104301.
- Matthias *et al.*,2023 W. Matthias, W. Simon, S. Marta, and T. Hannes A Structural Catalogue of the Settlement Morphology in Refugee and IDP Camps. *International Journal of Geographical Information Science* 37(6)(2023),pp.1338–1364. doi:10.1080/13658816.2023.2189724.
- Meador,2019 J. E. Meador Reaching Rural: Identifying Implicit Social Networks in Community Development Programmes. *Journal of Rural Studies* 68(2019),pp.285–295. doi:10.1016/j.jrurstud.2018.12.006.
- Najim *et al.*,2021 S. Najim, N. A. Alslam, and I. A. Albazzaz Environmental Influences on the Settlements Patterns of Communities in the Marshes of Iraq. *IJDNE* 16(6)(2021),pp.657–663. doi:10.18280/IJDNE.160606.
- Peter and James, 2020 B. Peter and C. James Influence of Traditional Settlement Patterns on Urban Design and Planning. *Urbani Izziv* 31(2)(2020),pp.66–77.
- Pu, 2012 X. Pu A Study on Quantitative Methods for the Two-Dimensional Overall Form of Traditional Rural Settlements. Zhejiang University(2012).
- Rapoport,1969 A. Rapoport House Form and Culture. In New York: Prentice Hall(1969),pp.56.
- Rodríguez,2026 L. M. S. Rodríguez Agricultural Intensification and Settlement Patterns in Tairona Chiefdoms (AD 100–1600): A Multi-Scalar Study of the House-Lot Model in the Sierra Nevada de Santa Marta. *Journal of Archaeological Science: Reports* 73(2026),pp.105835.

- doi:10.1016/J.JASREP.2026.105835.
- Shahi *et al.*,2021 D. K. Shahi, K. Arun, S.K Gupta, P Padmanaban, et al.. Morphological Characteristics of High Mountain Settlements a Case Study of Jakhol, Uttarkashi. *Academic Discourse* 10(2)(2021),pp.8–19.
- Sun and Ning,2025 Y. Sun and J. Ning Decoding Rural Territorial Heterogeneity: Optimization Pathways via Pole-Field-Area-Net Structure Analysis. *Journal of Rural Studies* 120(2025),pp.103840. doi:10.1016/J.JRURSTUD.2025.103840.
- Tagliacozzo,2021 E. Tagliacozzo History, Zomia, Closure. *The Journal of Asian Studies* 80(2)(2021),pp.423–430. doi:10.1017/S002191182100005X.
- Teresa,2020 C. G. M. Teresa Settlement Pattern and Hypothetical Reconstruction of the One-Room House in the Bolanos Culture. *ARQUEOLOGIA IBEROAMERICANA* 46(2020),pp.54–63.
- Tian *et al.*,2006 Y. Tian, Z. Tian, and D. Hu History of Guizhou Tusi. In Guiyang: Guizhou People's Publishing House(2006),pp.148.
- Trebsche *et al.*,2025 P. Trebsche, M. V. Außerlechner, S. Cereda, H. S. da Fonseca, and M. Staudt A Fluctuating Environment: Micromorphological and Archaeobotanical Investigations of the Early Iron Age Lakeshore Settlement at Traunkirchen (Upper Austria). *Environmental Archaeology* 30(1)(2025),pp.1–21. doi:10.1080/14614103.2023.2176611.
- Willett,2026 J. Willett More than Human Peripheries, Peripheralisation, and the Mattering of Left behind Regions. *Journal of Rural Studies* 126(2026),pp.104289. doi:10.1016/J.JRURSTUD.2026.104289.
- Wu *et al.*,2025 K. Wu, W. Su, S. Ye, S. Luo, and H. Wang Spatial Pattern and Identification of Environmental Factor Influence of Traditional Villages in Guizhou. *Geography and Geo-Information Science* 41(04)(2025),pp.103 ~ 110.
- Wu and Yang,2026 Z. Wu and J. Yang Pathways, Problems, and Prospects: A 25-Year Review of Applied Research in Urban Morphology. *Journal of Human Settlements in West China* (04)(2026),pp.1–8. doi:0.13791/j.cnki.hsfwest.20250805001.
- Xie *et al.*,2023 X. Xie, W. Sun, X. Zhang, and W. Lai Analysis of 'Courtyard Chains' in Traditional Lingnan Gardens Based on Architectural Typology. *New Architecture* (4)(2023),pp.125–130.
- Xie *et al.*,2026 Y. Xie, L. Yang, L. Ma, Y. Zhang, X. Ren, Y. Li, L. Zhou, and X. Wu. Diversity Evolution Pattern of Rural Settlements and Its Driving Mechanism Transition: A Case Study in Southwest China's Karst Mountains. *Journal of Rural Studies* 123(2026),pp.104052. doi:10.1016/J.JRURSTUD.2026.104052.
- Yang and Nie,2025 H. Yang and S. Nie Typological Analysis of the Structural Characteristics and Spatial Genes of Anshun Tunpu Settlement Patterns. *Journal of Guizhou Education University* 41(12)(2025),pp.2–11. doi:10.13391/j.cnki.issn.1674-7798.2025.12.009.
- Yilmaz *et al.*,2025 S. Yilmaz, Y. Menteş, A. Qaid, E. Jamei, and S. N. Angin Urban Form and Thermal Comfort: A Comparative Study of Scattered and Grid Settlement in Cold Climate. *Land* 15(1)(2025),pp.34–34. doi:10.3390/LAND15010034.
- Yin and An, 2020 H. Yin and Y. An Guizhou Geography. In Beijing: Beijing Normal University Press(2020),pp.5.
- Zhang *et al.*,2025 X. Zhang, T. Luo, and J. Lin Constructing State Capacity:A Study on the Guizhou's Centralization Reform in Imperial China. *China Economic Quarterly* 25(6)(2025),pp.1443–1459. doi:10.13821/j.cnki.ceq.2025.06.02.