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Spatial Configuration and Urban Resilience in the Historic Core of Kermanshah: A Space Syntax Diagnosis

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Abstract

In the historic urban fabrics of Iranian cities (e.g. Kermanshah), the street networks are organic and maze-like and building-level data are often not available. In these cases, resilience may depend upon spatial configuration rather than individual building attributes. The current study aims to investigate the relationship between spatial configuration and urban resilience in the historic core of Kermanshah using Space Syntax analysis and the composite index of Spatial Resilience (SRI). Using DepthmapX, configurational indices were computed at local (R3) and global (Rn) scales. A composite SRI was constructed and validated through Cronbach's alpha. Pearson correlation and ANOVA were used to analyze the correlation between the indices and resilience potential. SRI has a high positive correlation with Local Integration (r = 0.825) and Connectivity (r = 0.824). ANOVA confirmed significant SRI differences among the spatial zones suggesting the resilience potential is centered in the bazaar and main arteries, but peripheral areas still are vulnerable. Global intelligibility remains weak (R^2=0.25), but neighborhood scale correlations indicate relative legibility. The SRI allows a quantitative assessment of resilience for historic fabrics when building-level data are unavailable. It was found that integration and connectivity were important configurational predictors.

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INTRODUCTION

Historic urban fabrics in Iranian cities, including the historic-cultural core of Kermanshah, face specific physical resilience challenges due to their organic and labyrinthine street networks. In these contexts, building typologies and construction materials are relatively homogeneous, and the diversity of structural types is limited (Shamaei et al., 2019). Consequently, variations in resilience capacity may be explained not by individual building characteristics but by the spatial configuration and organizational structure of the street network. This issue becomes particularly critical during crises such as earthquakes, fires, or climate-related hazards, where the efficiency of access and rescue networks directly determines the performance and survival of the fabric (Law et al., 2019; Sharifi, 2020).

Understanding the spatial and morphological structure of urban neighborhoods - especially historic and deteriorated areas - can thus be considered an effective tool for future urban development programs (Lorzangeneh et al., 2024). However, the existing literature suffers from a clearly defined research gap: while spatial configuration is recognized as important, empirical studies on Iranian historic fabrics rarely quantify its relationship with resilience. Moreover, a major practical challenge in Iran is the scarcity of precise, local-scale building and technical data, resulting from a fragmented and sectoral planning system where no integrated database exists (Barakpour & Asadie, 2022; Zamani & Arefi, 2013). Previous research has shown that old urban neighborhoods in Iran have significantly lower physical resilience compared to other urban textures (Meshkini et al., 2024). Nevertheless, most studies rely on building-level data that is often unavailable or unreliable, leaving a methodological gap for assessing resilience in data-scarce historic contexts.

To address this gap, Space Syntax analysis offers an optimal alternative method. It is independent of detailed building-level data and focuses on movement patterns, accessibility, and spatial legibility (Hillier & Hanson, 1989;

Hillier et al., 1993; Hillier, 2007; Fu et al., 2025). Unlike conventional approaches, Space Syntax enables the assessment of relative resilience based purely on configurational indices such as integration, choice, control, and connectivity at both local and global scales. It is worth noting that some studies suggest that spatial configuration alone may not be a significant predictor of pedestrian movement in certain Iranian historic fabrics without considering social parameters (Mirzakhani et al., 2023). However, for the specific purpose of physical resilience - particularly in terms of accessibility, legibility, and network efficiency during crises - spatial configuration remains a valid and robust proxy.

Therefore, this study focuses on the spatial configuration analysis of the street network in Kermanshah's historic core to assess its physical resilience capacity. This study examines the relationship between spatial configuration and urban resilience in the historic core of Kermanshah by: (1) computing Space Syntax configurational indices (integration, connectivity, choice, and control) at both local and global scales; (2) constructing a composite Spatial Resilience Index (SRI) to quantitatively aggregate these indices into a single measure of resilience potential; and (3) analyzing the spatial distribution of SRI values to identify patterns of resilience and vulnerability across the historic fabric. By doing so, this study provides a quantitative, replicable methodology for assessing resilience in data-scarce historic contexts. The main research question is: "To what extent can Space Syntax configurational indices serve as reliable quantitative proxies for assessing physical resilience capacity in Kermanshah's historic fabric, and what spatial patterns of resilience potential and vulnerability does a composite Spatial Resilience Index (SRI) reveal?" Accordingly, it is hypothesized that: (1) higher values of configurational indices (integration, connectivity, choice, and control) are positively associated with higher SRI values; (2) areas with high SRI values are spatially concentrated in the historic core (bazaar and main arteries); and (3) peripheral areas and cul-de-sacs exhibit significantly lower SRI values, indicating vulnerability. These hypotheses are tested quantitatively through the construction of the SRI and subsequent statistical analysis. The expected contribution of this study is to demonstrate that, even in the absence of comprehensive building-level data, spatial configuration analysis can provide a reliable and valid measure of a fabric's capacity for resistance, stability, and recovery during crises. In doing so, this research re-conceptualizes the historic fabric of Kermanshah not only as a set of buildings but as a spatial-functional system whose survival is determined by the quality of its connective network.

LITERATURE REVIEW

Spatial Configuration

Space Syntax models urban space as a network of open spaces, visual or movement axes, and calculates indicators such as Integration (accessibility), Choice (through-movement potential), Connectivity, Control, and Intelligibility. The most widely used tool for computing these indices is DepthmapX (latest version), which is applicable at both neighborhood and morphological scales (depthMapX Space Syntax – Online Training Platform, n.d.; Meng & Zhang, 2025). In many studies, spatial configuration has been conceptualized as the invisible infrastructure of movement, accessibility, and functional performance in urban networks. Also, the underlying structure dictates the efficiency of routes in crisis scenarios, identifies potential rescue or evacuation nodes, and highlights areas that are more vulnerable due to dead-ends or insufficient connectivity. For instance, Hillier & Iida (2005) and later Karimi (2012) demonstrated that Integration and Choice indices can effectively predict movement flows and accessibility under both ordinary and emergency conditions. Similarly, Figueiredo & Amorim (2005) showed that Space Syntax indices can effectively identify areas with increased vulnerability regarding emergency access. Moreover, numerous studies confirm that spatial configuration analyses—including integration and choice—can significantly predict street network behavior, which is useful during crisis scenarios and for understanding their impact on emergency accessibility (Giuliani et al., 2020). Additionally, these analyses have clarified the relationships between pedestrian accessibility and connectivity indexes (Nag et al., 2022). Furthermore, utilizing these spatial configuration indices allows for the identification of vulnerable areas based exclusively on the assessment of these metrics (Pezzica et al., 2019). Soltani et al. (2022), in their research on Shiraz's historic fabric, were able to prioritize the retrofitting of main routes using only integration and choice analyses.

Physical/Morphological Resilience

In contemporary literature, physical resilience (Table 1) includes various qualities or capacities: robustness, redundancy, recoverability, adaptability, and functional diversity. It should be noted that each of these can be assessed through a range of spatial and infrastructural indicators. Recent studies emphasize the necessity of a spatial-indicator framework for assessing physical resilience (Parizi et al., 2024).

Table 1. Urban Resilience/Morphological Indicators

Dimension of Resilience	Definition	Relation to Spatial Indices	References
Robustness	Functional resistance of the network against disruption	High global integration enables faster emergency access	(Parizi et al., 2024; Sharifi & Yamagata, 2016)
Redundancy	Presence of alternative routes/options	High choice values → alternative routes and reduced bottlenecks	(Sharifi & Yamagata, 2016)
Recoverability	Speed of return to normal function	High local integration + intelligibility → faster recovery	(Parizi et al., 2024)
Adaptive Capacity	Ability to adjust to changing conditions	High connectivity → flexibility of route change	(Ibrahim et al., 2025; Meerow & Newell, 2019)
Functional Stability	Maintaining core functions during crises	High control value → regulation of movement flows	(Sharifi & Yamagata, 2016)

Linking Spatial Configuration and Resilience

Recent studies demonstrate the effective role of spatial configuration in operational capacities during crises, encompassing emergency access, evacuation, risk dispersion, and functional recovery. In fact, spatial configuration - particularly the connectivity and accessibility of streets and pathways - plays a key role in these capacities. Consequently, several studies have suggested incorporating Space Syntax factors into broader resilience assessment frameworks, allowing for the simultaneous evaluation of both structural (objective) and spatial-perceptual (subjective) dimensions (Li et al., 2025).

Table 2. Spatial Configuration Indicators and Their Relationship with Urban Resilience

Spatial Index	Definition	Corresponding Dimension of Physical Resilience	References
Global Integration (Rn)	Degree of accessibility of a street/space to the entire network	Robustness (functional strength & emergency access)	(B. Hillier & Iida, 2005; Karimi, 2012)
Local Integration (R3, R5)	Relative accessibility at neighborhood scale	Recoverability (neighborhood-level recovery)	(B. Hillier et al., 1993; B. Hillier, 2007; B. Hillier & Hanson, 1989)
Choice (Segment/Angular)	Probability of a segment being selected in overall movement	Redundancy (alternative route options)	(Sharifi & Yamagata, 2016; Turner, 2007)
Connectivity	Number of direct links to adjacent spaces	Adaptive Capacity (network flexibility)	(B. Hillier, 2007; Ibrahim et al., 2025)
Control Value	Ability of a space to regulate access to neighboring spaces	Functional Stability (maintaining essential functions)	(B. Hillier, 2007)
Intelligibility	Correlation between connectivity and integration (spatial legibility)	Recoverability + user confidence	(B. Hillier & Hanson, 1989; Ibrahim et al., 2025)

However, it should be noted that most previous studies have applied Space Syntax mainly in regular or planned urban grids. A key debate in the literature is whether Space Syntax indices perform similarly in organic, maze-like historic fabrics such as those found in many Iranian cities. Some researchers argue that in these contexts, social and cultural parameters may interfere with the predictive power of purely configurational indices (Mirzakhani et al., 2023). Nevertheless, for physical resilience - specifically emergency access, evacuation, and network legibility - the spatial configuration remains a valid starting point, especially when building-level data is unavailable.

METHODS

Data Preparation and Preprocessing

In the first step, the boundary of Kermanshah's historic–cultural fabric was extracted from the comprehensive plan of the metropolis in order to enable a focused analysis of its spatial structure. Following the delineation of this boundary, the process of block subdivision was carried out, and the entire network of primary and secondary streets was identified. This reconstructed network served as the basis for preparing the data for input into the DepthmapX software.

Subsequently, the extracted map was converted into DXF format and imported into the software. The axial mapping process was then conducted. To ensure transparency in preprocessing, it should be noted that the reduction to a minimal line representation followed the standard "least-line" principle proposed by Hillier (2007), where only the longest and fewest lines that fully cover all public accessible spaces are retained. In practice, dangling lines, isolated segments, and dead-end alleys with no connection to the main network were manually removed, while all routes essential for spatial connectivity were retained .The final axial map consisted of 1204 lines covering the entire historic fabric.

Multiscalar Graph Generation and Index Calculation

Based on these data, the spatial graph of the historic fabric was generated at both local and global scales. Regarding the choice of radii, Radius 3 (R3) was selected for local analysis because it represents approximately a 5–7-minute walking distance (400–600 meters) in the context of Kermanshah's historic fabric, which corresponds to the typical scale of neighborhood-level movement and emergency response. Radius n (Rn) was used for global analysis to capture city-wide accessibility patterns. A commonly used alternative, Radius 5 (R5), was not applied because the pilot analysis showed minimal difference between R3 and R5 in this specific organic fabric, and R3 provided a more conservative estimate of local resilience capacities. From this analysis, spatial configuration indices - including Integration at both scales, as well as Control and Connectivity - were derived.

For a more detailed analysis of movement paths and the distribution of spatial load, in addition to the axial map, a segment graph and an angular graph were also produced. This step enabled the calculation of the Choice index at various scales, which is particularly important for assessing redundancy of routes and the role of alternative pathways within the historic network.

Development of the Spatial Resilience Index (SRI)

To go beyond descriptive reporting and quantitatively explore the relationship between spatial configuration and resilience capacity, this study constructed a composite Spatial Resilience Index (SRI) using the methodological approach developed by Alawneh and Rashid (2022). This approach combines a number of configurational indices into a single and interpretable measure of resilience potential for each axial line (Alawneh & Rashid, 2022).

Step 1: Normalization of Data

First, each of the six spatial indices (Connectivity, Integration (Rn), Integration (R3), Choice (Rn), Choice (R3), and Control) was scaled to 0–1 by min-max normalization:

$Z_i = (x_i - x_{min}) / (x_{max} - x_{min})$

where Z_i is the normalized value of index i for each axial line, x_i is the raw value, and x_{min}, x_{max} are the minimum and maximum values in the whole network of 1204 axial lines. This normalization makes sure that all indices have the same importance in the composite index, no matter the scale of the original indices (Alawneh & Rashid, 2022).

Step 2: Compute the Composite Index

The spatial resilience index (SRI) of each axial line was calculated as the arithmetic mean of the six normalized indices following the approach of the composite index validated in previous resilience studies in Space Syntax (Cutini & Pezzica, 2020; Li et al., 2025):

$SRI=(Z_{Connectivity}+Z_{Integration}-Rn+Z_{Integration}-R3+Z_{Choice}-Rn+Z_{Choice}-R3+Z_{Control})/6$

This composite index is a relative "resilience potential" index of each axial line, whereby higher SRI values indicate the spatial configurations that are theoretically associated with higher physical resilience including robustness, redundancy, adaptive capacity and functional stability according to the theoretical framework developed in the literature review (see Table 2).

Step 3: Reliability Assessment

Internal consistency of the composite SRI was evaluated using Cronbach's alpha (α) in SPSS (version 22). Consistent with Alawneh and Rashid (2022), a Cronbach's alpha value greater than 0.70 was deemed acceptable, indicating that the six spatial indices consistently measure the underlying construct of spatial resilience (Alawneh & Rashid, 2022). The Item-Total Statistics were examined to see if any index was decreasing overall reliability.

Step 4: Spatial Classification

To facilitate the spatial analysis of the distribution of resilience, the SRI values were classified into four quartiles (Alawneh & Rashid, 2022; Cutini & Pezzica, 2020):
a. Q3 (Top 25%): High potential for resilience
b. Q2 (25-50%): Moderate high resilience potential
c. Q1 (Bottom 25%): Low potential for resilience

Such classification allows for the identification of spatial clusters of resilience and vulnerability in the historic fabric, thus providing an answer to the research question regarding the spatial relation between the configurational structure and resilience capacity (Cutini & Pezzica, 2020; Li et al., 2025).

Intelligibility Assessment

In order to evaluate the level of clarity and legibility of the fabric, scatterplots were generated to examine the correlation between Connectivity and Integration, and the coefficients of determination (R^2) were calculated. This analysis allowed for the assessment of the degree of spatial intelligibility of Kermanshah's historic fabric at both local and global scales. It should be noted that while alternative metrics for intelligibility exist (e.g., mean depth or entropy-based measures), R^2 was selected because it remains the most widely used and comparable metric in Space Syntax literature (Hillier & Hanson, 1989; Karimi, 2012), and it allows direct comparison with previous studies on Iranian historic fabrics.

Limitations and Data Quality

A limitation of this methodology is the absence of a formal sensitivity analysis or robustness check, which is typically difficult to perform in Space Syntax studies of organic fabrics due to the lack of ground-truth movement data. However, to ensure map accuracy, the extracted street network was cross-checked against the most recent satellite imagery (2024) and the official municipality map of Kermanshah. No major discrepancies were found. Nevertheless, future research could enhance validity by incorporating on-site movement observations or GPS tracking.

Final Analytical Framework

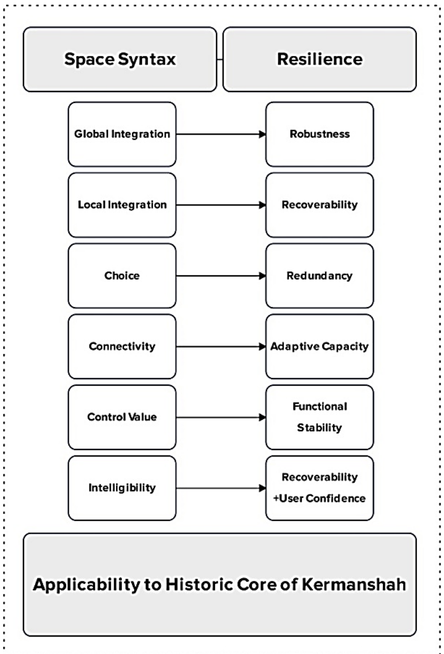

Fig. 1. Conceptual diagram of the research

Finally, all extracted indices were aligned with the dimensions of urban resilience (see Fig.1), and the results were analyzed and interpreted in an integrated manner. In this way, the relationship between the spatial structure of the historic fabric and its resilience capacities - particularly in the physical–spatial dimension - was revealed.

Case Study

The city of Kermanshah derives its cultural vitality and identity from its historic fabric. Due to the irregular growth pattern of the city, the historic core is located in the southern part of Kermanshah. Possessing high cultural values, this area constitutes an integral part of the city's identity and national heritage Kermanshah is administratively organized into eight municipal districts. Moreover, the historic fabric of Kermanshah is situated in Districts 2, 3, and 4. Obviously, it has a specific character of its own. Furthermore, the detailed plan for the historic fabric defines the area into sixteen distinct neighborhoods.

Situated in western Iran, Kermanshah is one of the region's historically significant cities, featuring an extensive historic fabric and numerous long, covered commercial streets (bazaar corridors). Due to its location along one of the most important trade routes connecting the western to the eastern Zagros Mountains, the main bazaar also developed along this corridor. Prior to its division during the Pahlavi I period with the creation of Sepah Street (currently Modarres Street), Kermanshah's bazaar was considered the longest continuous bazaar corridor in the Middle East (Hashemi, 2013). The establishment of this street divided the bazaar into two main sections, each comprising multiple subsidiary corridors. (Fig.2)

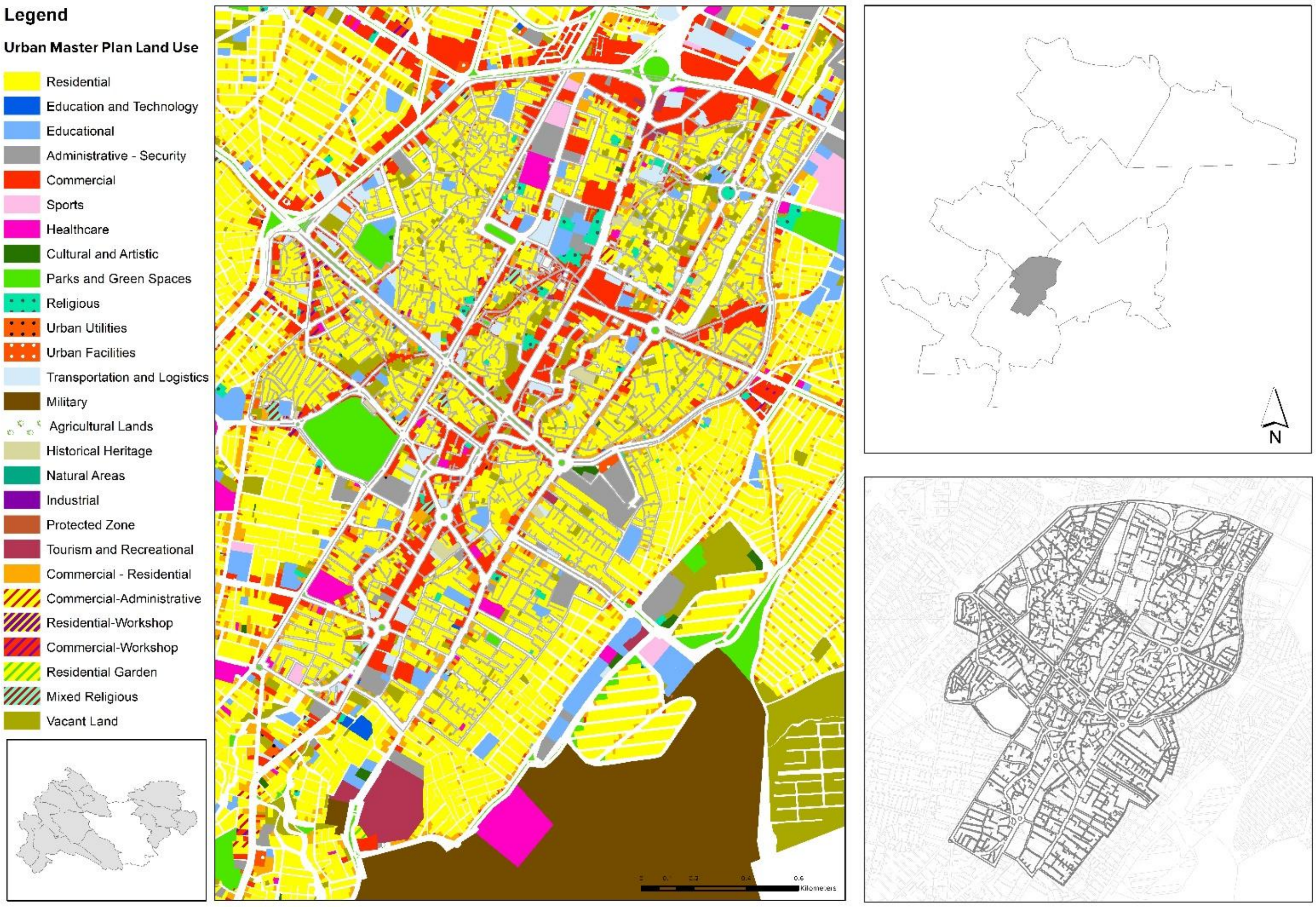

Fig. 2. Left map: Location of Kermanshah County within the provincial administrative divisions. Top-right map: The metropolis of Kermanshah and its eight urban districts. Bottom-right map: Location of the historic-cultural fabric of Kermanshah within the city
(Source: author)

RESULTS AND DISCUSSION

Connectivity: Descriptive Findings and Their Interpretation

The Connectivity index represents the number of lines or segments directly connected to a given line, making it a strictly local measure. In numerical interpretations, values above 5 or 6 are typically associated with arterial streets or grid networks, whereas values of 1 or 2 are linked to cul-de-sacs or minor local routes. Thus, Connectivity is inherently a relative-scale measure, primarily used for intra-system comparisons (e.g., between historic and modern fabrics) (Hillier, 2007; Hillier & Hanson, 1989). Upon evaluating the extent of spatial connectivity within the historical fabric of Kermanshah, the center regions offer more advantageous conditions and superior spatial experiences for pedestrians and local inhabitants. As shown in Fig.3, the connectivity patterns in the core—characterized by cross-shaped street layouts (Modarres Street, Motahari Street, Mahdieh Street, and Kouhsari Street)—are relatively suitable. Although such street layouts, introduced during the Pahlavi I era, disrupted the continuity of Kermanshah's historic fabric, they simultaneously created spatial openings in the central areas that have contributed to spatial dynamism. Quantitatively, as shown in Table 5, the mean spatial connectivity of the historical fabric (4.08) is lower than values reported in previous studies on more regular grids. Nonetheless, within the direct connectivity range above 5, the situation is evaluated as favorable. Connectivity is higher along the bazaar and primary passageways compared to other parts of the fabric (Fu et al., 2025; Yang et al., 2025).

Interpreted from a resilience perspective, these spatial indices reveal both strengths and vulnerabilities. Higher connectivity in the bazaar and main axes suggests that these areas are more likely to maintain movement flows during crises. However, connectivity alone does not guarantee resilience, as highly connected nodes may also become bottlenecks if not supported by redundant routes.

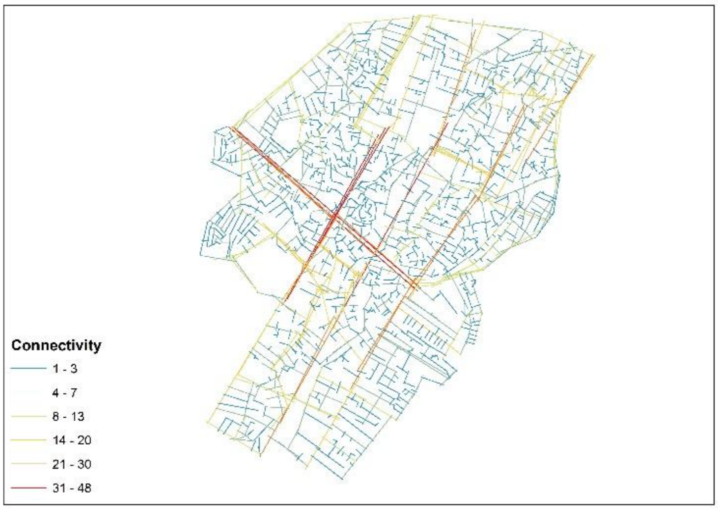

Fig. 3. Map of spatial connectivity in the historic fabric of Kermanshah

Integration and Control: Global and Local Cohesion

Using the integration map, efforts were made to examine both the global structure of the city (Centrality, with radius Rn) and the local logic of neighborhoods (Neighborhood logic, with radius R3). The combined interpretation of these scales allows for the assessment of spatial intelligibility through pairwise comparisons of connectivity and integration at both global and local levels. At the global scale, integration reflects the degree of accessibility of a space within the entire system. In the case of Kermanshah’s historic fabric, the central areas demonstrate favorable levels of global integration. At the local scale, accessibility relative to immediate surroundings is measured. Following the earlier discussion, higher cohesion is found in the central areas and at spatial openings than in the inner fabric and cul-de-sacs. The historic bazaar has raised the global integration index to an average value above 1.28. At the local scale, the index exceeds 1.84, highlighting relatively strong spatial cohesion at the neighborhood level. (Fig. 4-5). In other words, Integration reflects the central identity of the urban fabric (B. Hillier, 2007; W. R. G. Hillier et al., 2012; Liao et al., 2025).

Regarding the interpretation of the Control value, some mistakenly assume it is the inverse of Connectivity. In fact, this index evaluates the extent to which a line exerts dominance over its directly connected lines. Thus, if a line constitutes the only access to several others, its control value is high. Accordingly, in Kermanshah’s historic fabric, the main thoroughfares and movement bottlenecks exhibit high control values, with numerical values exceeding 2, as these are the obligatory passages for movement. (Fig. 6). The mean Controllability index—essentially a normalized measure of control—stands at 0.29, indicating that even in cul-de-sacs, relatively favorable conditions exist within the inner parts of the historic neighborhoods (Fig. 7) (Fu et al., 2025; B. Hillier & Hanson, 1989; Penn et al., 1998).

The significance of these results for resilience lies in the configuration of the central axes. High control values along main thoroughfares imply that these routes are essential for any emergency response. However, this also creates vulnerability: if these routes are blocked (e.g., by debris or fire), large portions of the fabric may become inaccessible. This is a point where the findings diverge from more optimistic interpretations in previous studies.

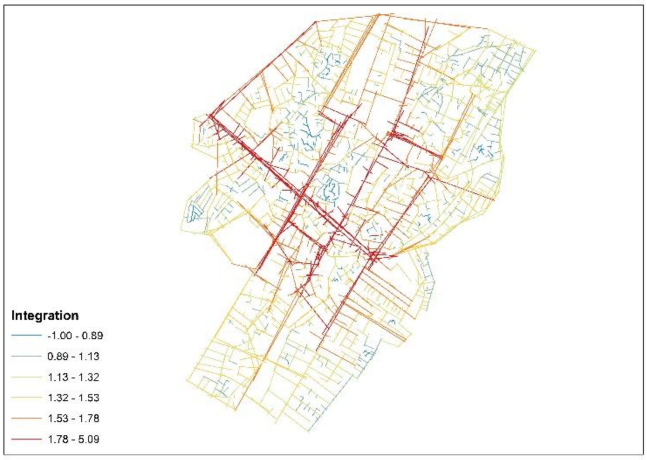

Fig. 4. Map of global integration

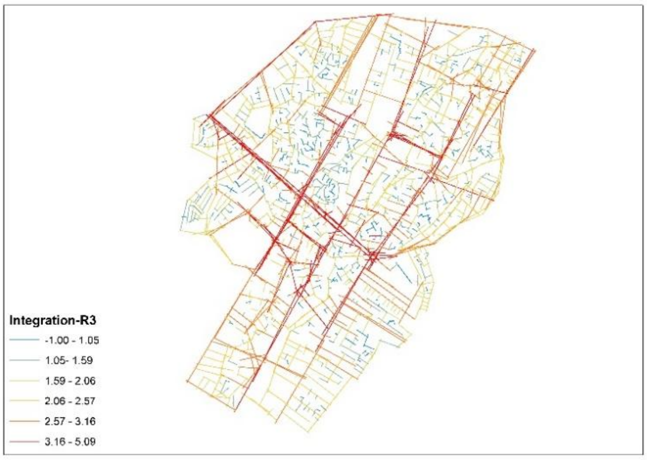

Fig. 5. Map of local integration

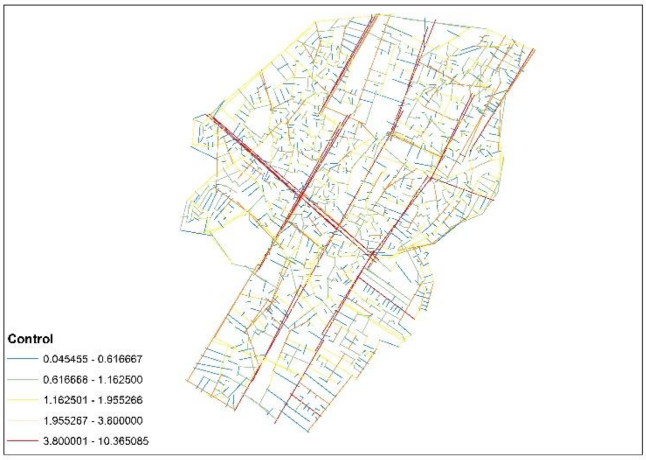

Fig. 6. Map of control

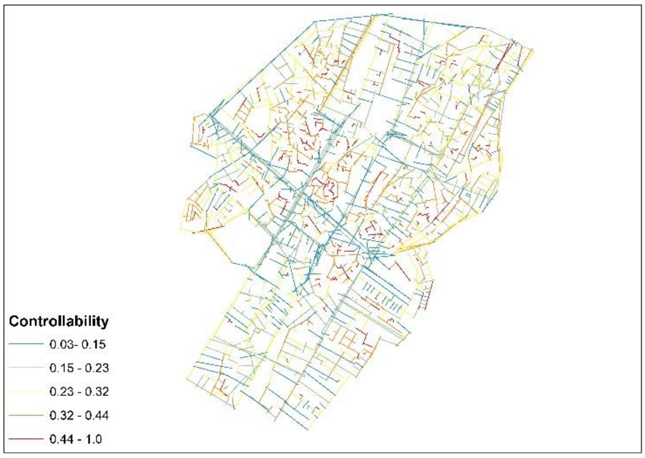

Fig. 7. Map of controllability

Choice and Redundancy

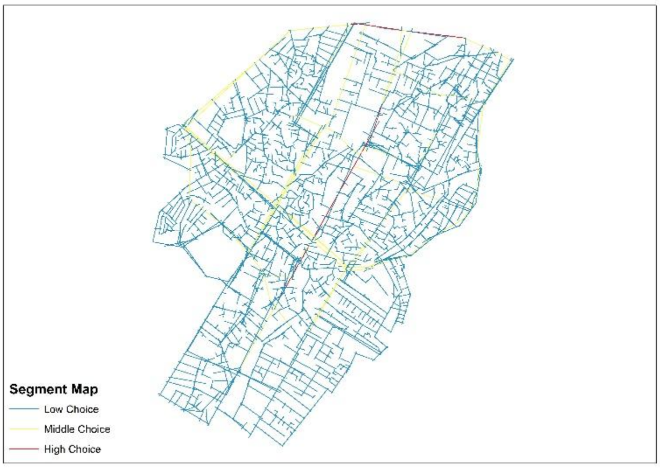

Fig. 8. Segment map (distribution of high- and low-choice areas) in the historic fabric of Kermanshah

Choice corresponds to Betweenness Centrality in Space Syntax theory (Fig. 9-10). Similar to Intelligibility, this measure was initially described qualitatively and later operationalized with quantitative thresholds. Hillier et al. (2012) emphasize that comparisons of Choice become meaningful only after normalization (e.g., dividing by the number of possible pairs or through logarithmic distribution). In the present study, the Choice values were log-transformed and subsequently classified using percentiles (P20/P80). Accordingly, the top 10–20% of segments with high Choice values were identified as the primary backbone routes, characterized by high redundancy, whereas the bottom 20% of segments with low Choice values, mainly cul-de-sacs or minor local routes, were classified as having low redundancy within the street network of the historic fabric. As shown in (Fig. 8), the central areas—including main thoroughfares and the historic bazaar—exhibit the highest Choice values and consequently serve as routes of significant redundancy (Hillier et al., 2012; B. Jiang, 2009, 2013; Porta et al., 2006). The consequences of such spatial arrangements for resilience are particularly pronounced in peripheral areas. High Choice values in the central areas indicate good redundancy and multiple alternative routes. Nevertheless, this redundancy is concentrated in the core, while peripheral and inner-fabric areas suffer from low redundancy, making them less resilient to localized disruptions.

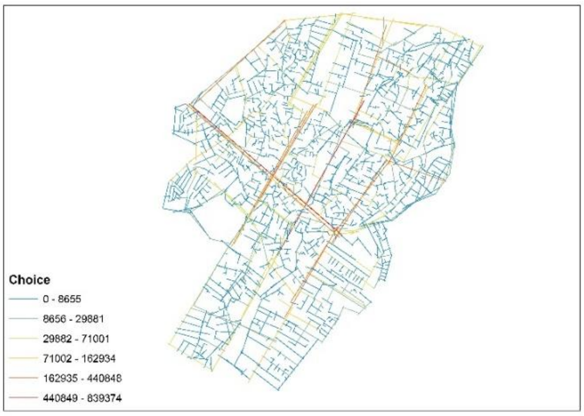

Fig. 9. Map of global choice

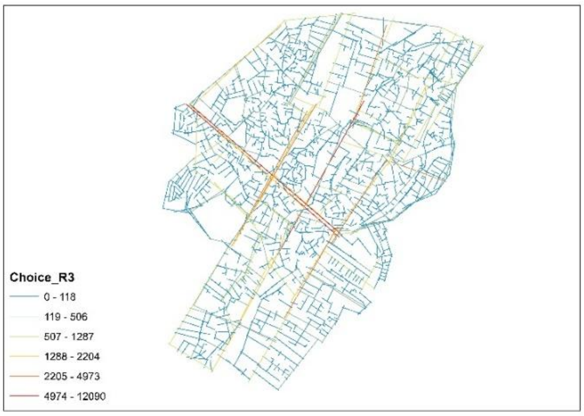

Fig. 10. Map of local choice

Integibility: Global vs. Local Legibility

In contrast to Integration or Choice, which are computed for each individual line or segment, Intelligibility serves as a singular global metric for the entire network. This index is derived from a linear regression between integration and connectivity. At the global scale (Fig. 11), the historical fabric of Kermanshah records an R^2 of 0.25, indicating that the overall system is not easily understood from local connectivity values alone. However, at the local scale (Fig. 12), the value rises to $R^2 = 0.48$, suggesting that residents possess a relatively coherent understanding of the system at the neighborhood level. This aligns with the observed spatial dynamism across most neighborhoods within Kermanshah's historic-cultural core. The Intelligibility index was initially proposed by Hillier and Hanson in 1984 and subsequently expanded by Hillier in 1996. Subsequent research has established quantitative limits for interpretation: $R^2 < 0.3$ signifies an unintelligible system, 0.3–0.7 denotes a moderately intelligible system, and > 0.7 represents a highly intelligible system.(Karimi, 1997; Penn et al., 1998; Psarra, 2009). Accordingly, Kermanshah's historic fabric is moderately intelligible at the local scale but unintelligible at the global scale.

A resilience-based interpretation of these findings highlights how low global intelligibility implies that unfamiliar users (e.g., emergency responders from outside the neighborhood) may struggle to navigate the fabric efficiently. This is a critical vulnerability not often emphasized in Space Syntax studies of historic fabrics.

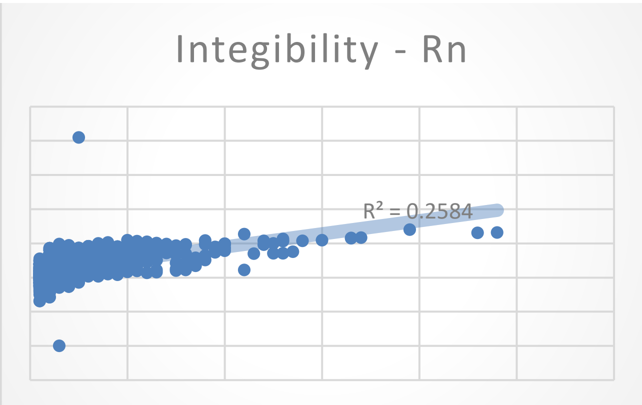

Fig. 11. Graph of spatial intelligibility at the global scale

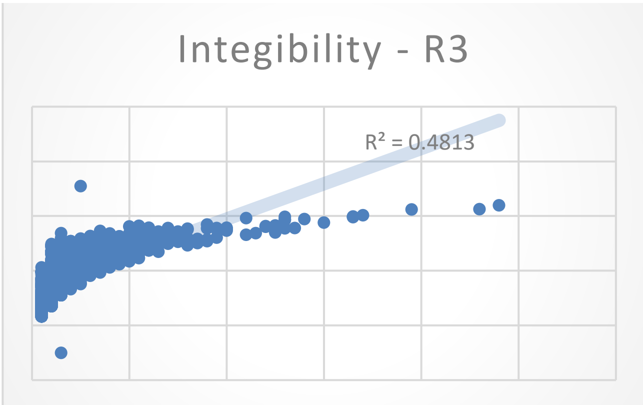

Fig. 12. Graph of spatial intelligibility at the local scale

Spatial Resilience Index (SRI) Results

Reliability Assessment

The reliability analysis of the six spatial indices demonstrated strong internal consistency, with a Cronbach's alpha of α = 0.729. This value is above the acceptable threshold of 0.70 (Alawneh & Rashid, 2022); hence, the six indices measure the latent construct of spatial resilience consistently. The Item-Total Statistics (Table 3) showed that removal of any single index would not substantially improve the alpha value, indicating that all six indices contribute meaningfully to the composite SRI.

Table 3. Spatial Configuration Indicators and Their Relationship with Urban Resilience

Indexes	Cronbach's Alpha if Item Deleted	Corrected Item-Total Correlation	Scale Variance if Item Deleted	Scale Mean if Item Deleted
Choice Rn	1.037794	.087	.295	.703
Choice R3	1.007964	.094	.000	.775
Connectivity	.980996	.058	.781	.538
Control	.954114	.066	.651	.596
Integration Rn	.671712	.080	.544	.657
Integration R3	.580482	.052	.544	.649

Descriptive Statistics of SRI

The SRI values across the 1204 axial lines ranged from 0.18 to 0.79, with a mean of 0.31 (SD =0.05). In addition, the distribution of SRI values showed a clear spatial pattern. In other words, the axial lines in the historic bazaar and main arteries (Modarres Street, Motahari Street, Mahdieh Street, and Kouhsari Street) had the highest SRI values (first quartile, SRI > 0.32), while the peripheral areas and cul-de-sacs had the lowest SRI values (third quartile, SRI < 0.27).

Spatial Distribution of Resilience Potential

It should be noted, the spatial mapping of SRI values (Fig. 13) shows that the potential for resilience is concentrated in the central core, with approximately 40% of axial lines in the top quartile located within the bazaar and main arterial network. However, 60% axial lines in peripheral areas were in the low-resilience category (SRI < Q1). Moreover, this spatial concentration supports the hypothesis of an uneven distribution of resilience potential across the historic fabric. It means that the historic core enjoying higher configurational integration and connectivity.

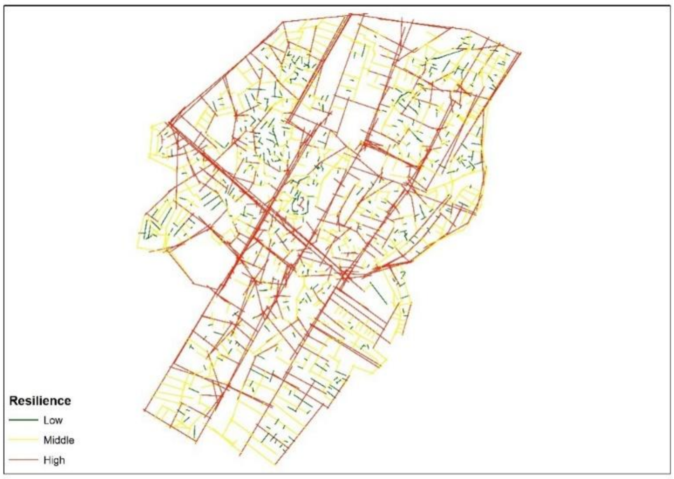

Fig. 13. Graph of Resilience in Historic Core of Kermanshah City

Statistical Comparison Between Zones

A one-way analysis of variance (ANOVA) was performed to statistically test whether SRI values were significantly different across the spatial zones (Table 4). The SRI values were divided into three groups by quartile distribution: Low Resilience (Q1, SRI < 0.18), Moderate Resilience (Q2, 0.28 ≤ SRI ≤ 0.33) and High Resilience (Q3, SRI > 0.33).

In addition, the ANOVA results indicated a “statistically significant difference” in SRI values across the three resilience groups ($F (2, 1688) = 1713.306$, $p < 0.001$). The effect size (Eta squared= $\eta^2 = 0.670$) is 0.670, indicating that approximately 67% of the variance in SRI is accounted for by the group membership. This is considered a “large effect size” (Cohen, 1988).

The high F-value (1713.306) and the very low p-value ($p < 0.001$) are strong evidence of significantly different resilience potentials of Kermanshah’s historic core spatial zones. Moreover, this confirms that the capacity for resilience, measured by SRI, is not evenly spread within the historic fabric but rather concentrated in specific areas (bazaar and main arteries) whilst it is significantly lower in peripheral areas and dead-end streets (cul-de-sacs).

Table 4. Descriptive Statistics of SRI by Spatial Zone

Zone	N (Axial Lines)	Mean SRI	SD	Min	Max
Core (Bazaar/Main Arteries)	326	0.37	0.05	0.33	0.79
Intermediate Neighborhoods	558	0.30	0.01	0.28	0.33
Periphery (Cul-de-sacs)	320	0.26	0.02	0.18	0.28
Total	1204	0.31	0.05	0.18	0.79

Linking Spatial Configuration to Resilience: Beyond Description

Numerous papers assessed urban resilience in urban fabrics at several cities. In particular, in historical core using space syntax is common. Primarily, to analyzing urban resilience at both global and local levels utilizing space syntax metrics. Indices encompassing connectivity, integration, and choice to assess characteristics of resilient urban systems across various worldwide municipalities (J. Jiang et al., 2024; Marcus & Colding, 2023; Kassem, 2021). An interesting thing, some researches focus on evaluating green infrastructure impact on urban resilience or incorporating connectivity and integration at policy and performance levels (V. Marin, 2023) while other studies concentrated on urban resilience to disasters using choice and integration in architectural design informed by space syntax methods (Veddeler et al., 2023). These days, in particular, space syntax has engaged with climate change and associated topics. For instance, employing space syntax rose up to examine human-space interactions, encompassing global-scale heat islands and vegetation management for morphological resilience (Eldesoky, 2023).

Table 5. Statistical Summary of Configuration Metrics

Indexes	Min	Ave	Max
Connectivity	1	4.08	48
Integration Rn	0.31	1.28	5.09
Integration R3	0.33	1.84	5.09
Choice Rn	0	0.01	1.53
Choice R3	0	0.06	1.6
Control	0.04	1	10.36
Controllability	0.03	0.29	1

In the present study, by assessing variables related to the physical resilience of the historic fabric, an initial understanding was sought regarding the current condition of Kermanshah's historic core in the face of hazards and its resilience during crises. The results demonstrate that spatial connectivity within the historic fabric is predominantly focused along the principal thoroughfares and in the central center, characterized by the cross-shaped streets established during the Pahlavi I period. Another structural element of significance is the historic bazaar of Kermanshah, located at the heart of this central area, which has continuously maintained its dynamic and functional role throughout history. A closer look at the extracted spatial configuration indices demonstrates that these very areas feature the strongest spatial connectivity, higher control values at nodal points, elevated levels of global integration in relation to the surrounding modern fabric, and strong local integration in connecting the neighborhoods constituting the historic fabric. Naturally, these areas also record the highest Choice values (Figure 8). The high integration and choice values in the central areas suggest that, under normal conditions, movement flows are efficient and multiple alternative routes exist. This aligns with the redundancy and robustness dimensions of resilience (Sharifi & Yamagata, 2016). In theory, during a crisis such as an earthquake, these central routes could serve as primary access corridors for emergency vehicles and evacuation.

Three critical vulnerabilities emerged that are rarely discussed together in previous studies:

1) Concentration of resilience in the core: The peripheral and inner-fabric areas (especially cul-de-sacs with low connectivity and choice) remain highly vulnerable. A crisis that blocks the central backbone could isolate entire neighborhoods.
2) Low global intelligibility ($R^2 = 0.25$): This means that the overall system is not legible from local conditions. For outside emergency responders unfamiliar with the fabric, navigation becomes difficult, potentially delaying rescue operations.
3) Inferential rather than direct measurement: It must be acknowledged that resilience has been inferred from spatial configuration, rather than measured directly. Factors such as building materials, social capital, and institutional response—all critical to actual resilience—were beyond the scope of this study.

At the same time, the results of this research reaffirm the classical works of ((B. Hillier, 2007; B. Hillier et al., 1993; B. Hillier & Hanson, 1989; B. Hillier & Iida, 2005; Penn et al., 1998)) and once again validate the theory of natural movement and Space Syntax theory. Furthermore, the findings are consistent with more recent scholarly contributions in the field (Askarizad et al., 2024; Fu et al., 2025; Ibrahim et al., 2025; Lorzangeneh et al., 2024; Meng & Zhang, 2025; Refaat, 2025).

A comparison with similar studies on Iranian historic cores reveals both consistencies and differences. Soltani et al. (2022), in their Space Syntax study of Shiraz's historic fabric using axial and segment analysis, found that the bazaar and main axes function as structural backbones, with integration values comparable to those observed in Kermanshah. While their study focused on active mobility to school rather than resilience, the configurational patterns show similarities. Regarding Yazd, Mirzakhani et al. (2023) examined three historic neighborhoods in Gorgan, Qazvin, and Yazd specifically to test the "Natural Movement" theory in Iranian historic fabrics. Their findings suggest that spatial configuration alone may not be a meaningful predictor of pedestrian movement in these contexts, and land use patterns play a more significant role. This aligns with the finding that low global intelligibility ($R^2 = 0.25$) limits the predictive power of spatial configuration in Kermanshah. For Tabriz, Ebrahimi and Mohammdzade (2025) conducted a comprehensive analysis of spatial organization theories applicable to Tabriz's historic fabric, prioritizing integration and choice as key indicators for analyzing complex historic urban structures. However, empirical Space Syntax studies specifically measuring intelligibility values in Tabriz remain limited. Together, this comparison indicates that while Iranian historic fabrics share similar spatial challenges—organic networks, reliance on bazaar axes, and moderate to low intelligibility—the degree of these characteristics varies significantly across cities, affecting their potential resilience capacities.

Correlation of configurational indices with SRI

Pearson correlation analysis was performed on all 1204 axial lines to explore the quantitative relationship between the individual Space Syntax indices and the composite Spatial Resilience Index (SRI). (Table 6) Several significant findings are shown in the results.

Strongest Correlates of SRI

The variables that had the strongest positive correlations with SRI were Local Integration (R3) ($r = 0.825$, $p < 0.001$) and Connectivity ($r = 0.824$, $p < 0.001$). Initially, these findings indicate that axial lines with higher neighborhood-level accessibility and more direct connections to adjacent spaces have significantly higher resilience potential. In addition, the coefficient of determination (R^2) for both indexes was approximately 0.68, indicating that these two configurational variables account for almost 68% of the SRI variance.

Moderate Correlates of SRI

Global Integration (Rn) had a strong positive correlation with SRI ($r = 0.736$, $p < 0.001$), followed by Control ($r = 0.697$, $p < 0.001$). These results confirm that the both the global accessibility and the capacity to control movement flows are meaningful to resilience potential, albeit at a slightly lower level than the local-scale indices.

Weakest Correlates of SRI

The weakest correlations were observed for Normalized Choice at global scale ($r = 0.465$, $p < 0.001$) and Normalized Choice at local scale ($r = 0.147$, $p < 0.001$). The relatively weak association indicates that the existence of alternative routes (Choice) does not necessarily lead to higher resilience potential in the organic maze-like fabric of Kermanshah's historic core. This is in contrast to regular grid networks, where Choice is a strong predictor of flows (Hillier et al., 2012). The complex geometries of historic fabrics may limit the functional utility of alternative paths, particularly in emergency situations where wayfinding is difficult.

Correlation of Configuration Indices

Additional analyses revealed the expected high correlations between theoretically related indices, such as Integration Rn and Integration R3 ($r = 0.827$, $p < 0.001$) and Connectivity and Control ($r = 0.793$, $p < 0.001$). These strong inter-correlations confirm the internal consistency of the Space Syntax measurements and validate the composite SRI approach, as the indices together measure the underlying construct of spatial configuration.

Table 6. Pearson Correlation Matrix of Spatial Configurational Indices and SRI

Variable	Choice Rn	Choice R3	Connectivity	Control	Integration Rn	Integration R3	SRI
Choice Rn	1						
Choice R3	.446**	1					
Connectivity	.223**	-.013	1				
Control	.243**	.273**	.793**	1			
Integration Rn	.094**	-.283**	.508**	.256**	1		
Integration R3	.085**	-.235**	.694**	.407**	.827**	1	
SRI	.465**	.147**	.824**	.697**	.736**	.825**	1

**p < 0.01 (2-tailed), *p < 0.05 (2-tailed)

The correlation analysis provides strong quantitative evidence of the relationship between spatial configuration and resilience potential. This high correlation of SRI with Local Integration ($r = 0.825$) and Connectivity ($r = 0.824$) confirms that the accessibility at the neighborhood scale and direct network links are the most important spatial factors determining resilience capacity in the historic fabric of Kermanshah. This is in line with the theoretical framework developed by Hillier (2007) and Sharifi & Yamagata (2016) which states that local-scale integration allows for a faster recovery and functional continuity during a crisis.

Especially notable is the relatively weak correlation between Choice and SRI ($r = 0.465$ for global, $r = 0.147$ for local). In typical urban grids, Choice is typically associated with redundancy and availability of alternative paths (Turner, 2007). However, the organic and maze-like nature of historic Iranian fabrics may limit the functional use of alternative paths. In such environments, the existence of many paths does not guarantee efficient navigation and evacuation, especially for users who are unfamiliar with the environment (e.g. emergency responders). This result is in line with the claim of Mirzakhani et al. (2023) that without considering the land use and wayfinding factors, the configurational indices alone may have limited predictive power in historic fabrics. Furthermore, the high inter-correlations between the configurational indices (e.g., Integration Rn and Integration R3, $r = 0.827$) confirm the internal consistency of the Space Syntax measurements. Also, it validates the composite SRI approach.

CONCLUSION

The analysis of morphological indicators within the Space Syntax framework reveals a significant relationship between the configurational structure of Kermanshah's old street network and its physical resilience. In fact, this relationship appears to be reciprocal, meaning that the street network not only influences resilience but is also shaped by it. On the one hand, the presence of main arteries and spatial openings introduced during the Pahlavi I period, along with the historic bazaar as the backbone of the fabric, has enhanced the indices of connectivity, integration, and choice at both local and global scales, thereby strengthening the capacity of the fabric to maintain dynamism and sustain urban functions under crisis conditions. On the other hand, although the intelligibility index at the global scale indicates difficulties in understanding the overall system from local connections, at the neighborhood scale the appropriate correlation between connectivity and integration confirms that the historic fabric possesses a relative capacity for legibility and the guidance of movement. Overall, it may be stated that the street network structure of historic Kermanshah, with its balanced combination of primary routes characterized by high connectivity and control, and local passages with internal cohesion, provides an intermediate level of physical resilience. This capacity, however, could be elevated to higher levels through the strengthening of internal linkages and the mitigation of localized discontinuities.

This study set out to examine the relationship between spatial configuration and physical resilience capacity in Kermanshah's historic core, using Space Syntax analysis and a composite Spatial Resilience Index (SRI). The results show three main responses to the research question:

First, the constructed SRI, validated using reliability analysis (Cronbach's $\alpha = 0.729$), indicates that spatial configurational indices including integration, connectivity, choice, and control can be reliably combined into a single quantitative measure of resilience potential. This confirms the utility of Space Syntax as a diagnostic tool in data-scarce historic contexts, and resolves a key methodological gap in the literature.

Second, the spatial distribution of SRI values reveals a statistically significant concentration of resilience potential in the historic core (bazaar and main arteries), while peripheral areas and cul-de-sacs exhibit significantly lower resilience potential (ANOVA: $F = 1713.306$, $p < 0.001$). This uneven distribution indicates that while the core has spatial properties theoretically associated with robustness, redundancy and functional stability, the periphery is still susceptible to isolation during crises.

Third, the results are consistent with the hypothesis that higher configurational values are positively related to higher resilience potential as measured by SRI. It should be noted that the theoretical framework developed in the literature review was validated as areas with high integration, connectivity and choice consistently had higher SRI scores. However, the low global intelligibility ($R^2 = 0.25$) remains a critical vulnerability even in areas with high SRI. This is because unfamiliar users (e.g., emergency responders) may struggle to navigate the fabric efficiently.

Finally, this study redefines the historic core of Kermanshah not as a collection of buildings but as a spatial-functional network, whose resilience is highly dependent on its connective network. Furthermore, the SRI provides a quantitative, replicable method to assess resilience potential in historic contexts where data at the building level is unavailable. Hence, the findings offer practical insights for urban planning: strengthen connectivity in vulnerable peripheral areas, enhance global legibility through wayfinding interventions, and safeguard the high-resilience core routes as critical infrastructure. Future studies should test these deductions using direct measures of resilience (e.g. evacuation simulations, post-disaster assessments). The SRI framework can be applied to other historic cores in Iran to allow comparison.

Recent studies have demonstrated a strong trend toward the multi-scalar application of Space Syntax variables (integration, choice, connectivity, control) within the framework of assessing physical resilience and their alignment with functional indicators such as accessibility, service provision, and vulnerability. In the context of historic fabrics, recent research has particularly emphasized multi-scalar analyses (both local and network scales) to examine how physical interventions—such as restorations, revitalizations, and green infrastructure—affect accessibility, visitor attraction, and functional resilience. The findings are broadly consistent with this trend, while also highlighting that global intelligibility in organic fabrics may be lower than in more regular grids—a nuance that deserves further attention.

It is recommended that future studies focusing on historic fabrics incorporate environmental variables and on-site movement data in their assessments. To move beyond inferential claims, direct validation methods—such as GPS tracking of evacuation drills, agent-based simulations, or post-disaster damage assessments—should be employed alongside Space Syntax analysis. The study is limited to a single historic fabric (Kermanshah); therefore, the findings may not be directly generalizable to other Iranian historic cores without site-specific analysis. Furthermore, to strengthen the theoretical foundation and test causal relationships, statistical models such as multivariate regression and structural equation modeling (SEM) can be employed across multiple case studies (e.g., comparing Kermanshah with Yazd, Shiraz, Isfahan and Tabriz). Finally, future research should include sensitivity analyses to test the robustness of configurational findings against different network representation methods.

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REFERENCES

Alawneh, S.M., & Rashid, M. (2022). Revisiting Urban Resilience: A Review on Resilience of Spatial Structure in Urban Refugee Neighborhoods Facing Demographic Changes. *Front. Sustain. Cities* 4:806531. https://doi.org/10.3389/frsc.2022.806531

Askarizad, R., Lamíquiz Daudén, P. J., & Garau, C. (2024). Exploring the role of configurational accessibility of alleyways on facilitating wayfinding transportation within the organic street network systems. *Transport Policy, 157*, 179–194. https://doi.org/10.1016/j.tranpol.2024.09.001

Barakpour, N., & Asadie, I. (2022). Areas of Transition to Integrated Urban Management in Iran, with Emphasizing the Duties, Functions and Competencies of the City Council and Municipality. *Urban Economics and Planning, 3*(2), 70–81. https://doi.org/10.22034/uep.2022.319517.1151

Cutini, V., & Pezzica, C. (2020). Street Network Resilience Put to the Test: The Dramatic Crash of Genoa and Bologna Bridges. *Sustainability*, *12*(11), 4706. https://doi.org/10.3390/su12114706

depthMapX Space Syntax – *Online Training Platform.* (n.d.). Retrieved September 3, 2025, from https://www.spacesyntax.online/software-and-manuals/depthmap

Ebrahimi,F. and Mohammdzade,R. (2025). Identifying and Prioritizing Compatible Spatial Organization Theories for the Analysis of Tabriz's city Historic Urban Fabric. *Journal of Sustainable Urban & Regional Development Studies (JSURDS), 6*(3), 310-327.

Eldesoky, A. H. (2022). **On urban form and urban resilience: Appendices** [Appendices to thesis, IUAV University]. AIR IUAV. Retrieved from https://air.iuav.it/retrieve/88e8354b-30f4-491e-9493-9186a51d8741/Thesis%2BAppendices_Eldesoky.pdf

Figueiredo, L., & Amorim, L. (2005). *Continuity lines in the axial system. The Fifth Space Syntax International Symposium*. Delft University of Technology, Delft, The Netherlands. https://www.researchgate.net/profile/Luiz-Amorim/publication/228573949_Continuity_lines_in_the_axial_system/links/5d19f86692851cf4405a5408/Continuity-lines-in-the-axial-system.pdf

Fu, J.-M., Tang, Y.-F., Zeng, Y.-K., Feng, L.-Y., & Wu, Z.-G. (2025). Sustainable Historic Districts: Vitality Analysis and Optimization Based on Space Syntax. *Buildings, 15*(5), 657. https://doi.org/10.3390/buildings15050657

Giuliani, F., De Falco, A., & Cutini, V. (2020). The role of urban configuration during disasters. A scenario-based methodology for the post-earthquake emergency management of Italian historic centres. *Safety Science, 127*, 104700. https://doi.org/10.1016/j.ssci.2020.104700

Hashemi, M. (2013). Kermanshah Bazaar: Its History and Patrons. *Soffeh, 23*(4), 99–114.
Hillier, B. (2007). *Space is the machine: A configurational theory of architecture*. Space Syntax.
Hillier, B., & Hanson, J. (1989). *The social logic of space*. Cambridge university press. https://scholar.google.com/scholar?cluster=6099761347693742341&hl=en&oi=scholarr
Hillier, B., & Iida, S. (2005). *Network and Psychological Effects in Urban Movement*. In A. G. Cohn & D. M. Mark (Eds.), Spatial Information Theory (pp. 475–490). Springer. https://doi.org/10.1007/11556114_30
Hillier, B., Penn, A., Hanson, J., Grajewski, T., & Xu, J. (1993). Natural movement: Or, configuration and attraction in urban pedestrian movement. *Environment and Planning B: Planning and Design, 20*(1), 29–66.
Hillier, W. R. G., Yang, T., & Turner, A. (2012). Normalising least angle choice in Depthmap—And how it opens up new perspectives on the global and local analysis of city space. *Journal of Space Syntax, 3*(2), 155–193.
Ibrahim, I., Soussi, I., & Al Qaysi, H. (2025). A space syntax comparative study on sustainable historic districts: Al-Fahidi, UAE and Al-Darb Al-Ahmar, Egypt. *City, Territory and Architecture, 12*(1), 24. https://doi.org/10.1186/s40410-025-00274-8
Jiang, B. (2009). Ranking spaces for predicting human movement in an urban environment. *International Journal of Geographical Information Science, 23*(7), 823–837. https://doi.org/10.1080/13658810802022822
Jiang, B. (2013). Head/Tail Breaks: A New Classification Scheme for Data with a Heavy-Tailed Distribution. *The Professional Geographer, 65*(3), 482–494. https://doi.org/10.1080/00330124.2012.700499
Jiang, J., Xu, H., Ma, R., Chen, S., Wang, H., & Zheng, Z. (2024). What Is the Perceived Environmental Restorative Potential of Informal Green Spaces? An Empirical Study Based on Visitor-Employed Photography. *Land, 13*(11), 1768. https://doi.org/10.3390/land13111768
Karimi, K. (1997). The spatial logic of organic cities in Iran and the United Kingdom. *Proceedings of the 1st International Space Syntax Symposium*, University College London, London, UK.
Karimi, K. (2012). A configurational approach to analytical urban design:'Space syntax'methodology. *Urban Design International, 17*(4), 297–318.
Kassem, A. (2021, February 23). *Efficient land use: Tools and practices. Technical session 5/b. The role of urban governance in shaping the resilience of urban form*. GLTN Arab Land Initiative. Retrieved from https://arablandinitiative.gltn.net/wp-content/uploads/2021/03/TechnicalSession5b_Resilience_Kassem-paper-1.pdf
Law, S., Shen, Y., Penn, A., & Karimi, K. (2019). Identifying street-character-weighted local area using locally weighted community detection methods the case study of London and Amsterdam. *12th International Space Syntax Symposium*, SSS 2019, 12. https://discovery.ucl.ac.uk/id/eprint/10081813/
Li, Y., Wang, M., Wang, B., & Liang, Y. (2025). Bridging Subjective and Objective Dimensions of Resilience: A Space Syntax Approach to Analyzing Urban Public Spaces. *Sustainability, 17*(13), 5937. https://doi.org/10.3390/su17135937
Li, Y., Wang, M., Wang, B., & Liang, Y. (2025). Bridging Subjective and Objective Dimensions of Resilience: A Space Syntax Approach to Analyzing Urban Public Spaces. *Sustainability*, *17*(13), 5937. https://doi.org/10.3390/su17135937
Liao, W., Liu, P., Chen, Z., & Liu, S. (2025). Investigating impacts of renovated exteriors in historic districts on visitor vitality through space syntax reflection. *Npj Heritage Science, 13*(1), 336. https://doi.org/10.1038/s40494-025-01878-6
Lorzangeneh, M., Talebi Varnosfaderani, A., & Shahivandi, A. (2024). The effects of tangible and intangible physical variables on the structure of neighborhoods in historical cores (Case study: Seyed Mahmoud neighborhood on Dezful). *Journal of Conservation and Architecture in Iran, 14*(37), 53–82. https://doi.org/10.52547/mmi.1254.14011224
Marcus, L., & Colding, J. (2023). Placing Urban Renewal in the Context of the Resilience Adaptive Cycle. *Land, 13*(1), 8. https://doi.org/10.3390/land13010008
Marin Maureira, V. P. (2023). The multiscalar structure of urban systems (*Doctoral dissertation*, UCL (University College London).
Meerow, S., & Newell, J. P. (2019). Urban resilience for whom, what, when, where, and why? *Urban Geography, 40*(3), 309–329. https://doi.org/10.1080/02723638.2016.1206395
Meng, D., & Zhang, J. (2025). The evolution of space syntax over the past two decades: Evidence from China. *Journal of Asian Architecture and Building Engineering, 24*(5), 4606–4624. https://doi.org/10.1080/13467581.2024.2399739
Meshkini, A., Bozorgvar, A., & Alipour, S. (2024). Spatial analysis of the physical resilience of old urban neighborhoods against earthquakes: A case study of the old texture of Tehran. GeoJournal, *89(3)*, 118. https://doi.org/10.1007/s10708-024-11101-x
Mirzakhani, A., Behzadfar, M., & Turró, M. (2023). Pedestrian movement patterns in historical urban fabrics. *GeoJournal*, *88(6)*, 6483–6506. https://doi.org/10.1007/s10708-023-10980-w
Nag, D., Sen, J., & Goswami, A. K. (2022). Measuring Connectivity of Pedestrian Street Networks in the Built Environment for Walking: A Space-Syntax Approach. *Transportation in Developing Economies, 8*(2), 34. https://doi.org/10.1007/s40890-022-00170-7
Parizi, S. M., Taleai, M., & Sharifi, A. (2024). A spatial evaluation framework of urban physical resilience considering different phases of disaster risk management. *Natural Hazards, 120*(14), 13041–13076. https://doi.org/10.1007/s11069-024-06703-0
Penn, A., Hillier, B., Banister, D., & Xu, J. (1998). Configurational modelling of urban movement networks. *Environment and Planning B: Planning and Design, 25*(1), 59–84.
Pezzica, C., Valerio, C., & Bleil De Souza, C. (2019). Rapid configurational analysis using OSM data: towards the use of Space Syntax to orient post-disaster decision making. 12th International Space Syntax Symposium (12SSS)., vol.3 Space Syntax Network / Sejong University Press. https://orca.cardiff.ac.uk/id/eprint/120103
Porta, S., Crucitti, P., & Latora, V. (2006). The network analysis of urban streets: A dual approach. *Physica A: Statistical Mechanics and Its Applications, 369*(2), 853–866. https://doi.org/10.1016/j.physa.2005.12.063

Psarra, S. (2009). *Architecture and narrative: The formation of space and cultural meaning*. Routledge.

Refaat, A. M. (2025). The role of spatial structure resilience in the demolition decisions of Jeddah districts. *Journal of Umm Al-Qura University for Engineering and Architecture, 16*(3), 531–545. https://doi.org/10.1007/s43995-025-00125-0

Shamaei, A., Sasanpour, F., & Ali Hosseini, R. (2019). The Spatial Analysis of Resilience of Old Neighborhoods in Central Areas of Tabriz City. *Geographical Urban Planning Research (GUPR), 7*(2), 349–374. https://doi.org/10.22059/jurbangeo.2019.271048.1018

Sharifi, A. (2020). Urban Resilience Assessment: Mapping Knowledge Structure and Trends. *Sustainability, 12*(15), 5918. https://doi.org/10.3390/su12155918

Sharifi, A., & Yamagata, Y. (2016). *Urban Resilience Assessment: Multiple Dimensions, Criteria, and Indicators* (pp. 259–276). https://doi.org/10.1007/978-3-319-39812-9_13

Soltani, A., Javadpoor, M., Shams, F., & Mehdizadeh, M. (2022). Street network morphology and active mobility to school: Applying space syntax methodology in Shiraz, Iran. *Journal of Transport & Health, 27*, 101493. https://doi.org/10.1016/j.jth.2022.101493

Turner, A. (2007). From Axial to Road-Centre Lines: A New Representation for Space Syntax and a New Model of Route Choice for Transport Network Analysis. *Environment and Planning B: Planning and Design, 34*(3), 539–555. https://doi.org/10.1068/b32067

Veddeler, C., Kuijper, J., Gath-Morad, M., & Wal, I. van der. (2023). *Future Cities—City Futures: Emerging Urban Perspectives*. In TU Delft OPEN Books. TU Delft OPEN Books. https://doi.org/10.34641/mg.55

Yang, Y., Lin, X., & Lu, J. (2025). Space syntax analysis of spatial cultural relationships in traditional Xiangxi academies. *Journal of Asian Architecture and Building Engineering*, 1–14. https://doi.org/10.1080/13467581.2025.2536777

Zamani, B., & Arefi, M. (2013). Iranian New Towns and their Urban Management Issues: A critical review of influential actors and factors. *Cities, 30*, 105–112. https://doi.org/10.1016/j.cities.2012.01.003