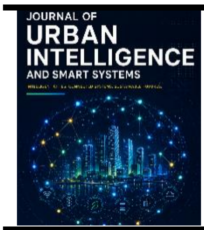

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A Geospatial Framework for Heritage-Led Smart Governance: Space Syntax, Adaptive Reuse, and a Distributed Heritage-Anchor Corridor

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ABSTRACT

This study examines heritage-led regeneration in the historic fabric of Kermanshah, western Iran, where the conservation of Qajar-era residential heritage must be balanced with new contemporary uses that support everyday urban life. It proposes a spatial decision-support framework combining space syntax analysis, field-verified heritage data, and adaptive reuse evaluation. Six nationally listed Qajar houses in the historical area (Javanshir and Feyzabad quarters), along with a proposed commercial-cultural infill site, were analysed. The findings show that these houses form a north-south Distributed Heritage-Anchor Corridor of about 1,128 metres. The proposed infill site has a higher spatial integration value than all six houses, making it a strategic location for future intervention. The study also shows that restoration has depended on a recurring partnership between heritage authorities, government loans, and private investment, while local residents remain largely excluded. Overall, the research offers a transferable model for heritage-led regeneration in Iranian and Middle Eastern historic cores.

1. Introduction

Historic urban cores across Iran and the wider Middle East face a recurring dilemma: preserving inherited residential typologies while accommodating the functional and economic demands of contemporary urban life. Kermanshah, a historic city in western Iran, retains a historic fabric of approximately 342 hectares that took shape around the bazaar nucleus by the late Qajar period (Kermanshah Provincial Cultural Heritage, Handicrafts and Tourism Organization [CHHTO] and Kermanshah Municipality, deteriorated-fabric renewal report, 2023, unpublished). Within this fabric, the adjoining Javanshir and Feyzabad quarters contain a concentration of Qajar-period courtyard houses documented in the regional architectural historiography by Bani Masoud [1] and Memarian [2]. Beyond their residential stock, the quarters also contain landmark religious and civic buildings, including the Emad al-Dowleh Mosque and the Biglarbeigi *tekyeh*, a hall for religious gatherings and Muharram commemorations, described in internal heritage documentation as central to the historic identity of the area (Qadiri, 2018, unpublished internal report, Kermanshah CHHTO).

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The Qajar house type at the centre of this study is organised introspectively around a central courtyard (*hayat*), with the *biruni/andaruni* division separating a semi-public reception domain from the private family domain, a columned reception hall (*talar*) facing the courtyard, and an entrance sequence of vestibule (*hashti*) and corridor (*dalan*) that grades privacy from the public alley to the domestic interior [1,2]. Configurational research has shown that such courtyard arrangements constitute measurable topological structures rather than purely stylistic conventions: Zolfagharkhani and Ostwald [3], analysing thirty-seven courtyard houses in Yazd, demonstrated that the courtyard occupies a mathematically distinctive position within the spatial network of the plan. Because the type presupposes the fine-grained organic fabric of alleys and culs-de-sac that surrounds it, the position of each house within the street network is integral both to its heritage character and to its adaptive-reuse potential; this premise underlies the analysis developed below.

The condition of the surrounding fabric, however, is fragile. Habibi and Maghsoudi [4] characterise the morphological deterioration typical of Iranian historic quarters, and field assessment specific to Javanshir has reported a physical deterioration rate of approximately 92 per cent alongside a building-renewal rate below two per cent per annum (unpublished internal report, Kermanshah CHHTO and Kermanshah Municipality,2020). These figures indicate that, notwithstanding the presence of well-documented heritage assets, the surrounding urban fabric remains structurally and economically vulnerable.

Spatial configuration theory offers a quantitative lens through which the accessibility and integration of historic street networks can be assessed independently of subjective description. Hillier and Hanson [5] established the foundational premise that the configuration of a street network, rather than its individual buildings, determines patterns of movement and social encounter, and Hillier et al. [6] extended this logic to natural movement generated by network structure itself. The method has since consolidated into a standard analytical toolkit for urban research [7] and into an operational instrument for regeneration planning in historic cities [8]. In the Iranian context, Askarizad et al. [9] demonstrated that configurational connectivity and integration in organic street networks are strongly shaped by subsidiary alleyways and that high connectivity does not necessarily entail high intelligibility for an unfamiliar visitor; related work has quantified the legibility of historical neighbourhoods [10] and the configurational determinants of walkability in Iranian cultural-heritage sites [11].

A complementary body of work frames heritage as an active resource for urban development rather than a constraint upon it. The Historic Urban Landscape recommendation [12] institutionalised this reframing at the international policy level, while adaptive reuse has matured into a discipline with its own concepts and case repertoire [13] and with structured decision frameworks for selecting new uses for heritage buildings [14]. At the intersection of these agendas, research on cultural heritage in smart-city environments [15] and on the emerging ‘smart heritage’ discourse [16] argues that data-driven evidence layers, including spatial-analytic screening of the kind developed here, are becoming a constitutive component of heritage governance rather than a technical afterthought.

The institutional literature on heritage-led regeneration provides the third strand of the framework. De Medici et al. [17], analysing the Ortigia district of Syracuse, adapted the Triple Helix model of Etzkowitz and Leydesdorff [18,19] to interpret how a knowledge-provision institution, a cultural-heritage entrepreneurship sector, and a local authority can jointly generate a self-reinforcing cycle of skills specialisation, funding attraction, and site attractiveness. The concept of the anchor institution, developed by Birch et al. [20] and Taylor and Luter [21] and more recently reframed by Corazza et al. [22], Jeffrey [23], and Toulmin et al. [24], describes organisations whose scale, permanence, and local embeddedness generate measurable regenerative effects on the surrounding fabric. Work on innovation districts further shows that such configurations can be evaluated through measurable indicators of skills, funding, and site attractiveness rather than qualitative description alone [25-27].

Field records maintained by the Kermanshah CHHTO (personal communication, 2024) indicate that six Qajar-period houses in the Javanshir–Feyzabad quarters, namely Haj Kobra, Samadi, Khajeh Baroukh, Sa'advandi, Hakim Nasir, and Faiz Mahdavi, have each been identified and entered in the national heritage register, and have been drawn, sequentially over approximately the past decade, into a single revival pathway combining heritage-authority listing, government-loan financing, and private capital participation. Four of the six houses currently operate as boutique lodging with attached traditional restaurants, retaining original furnishings as decoration rather than museological display, while Hakim Nasir and Haj Kobra remain under restoration. The recurrence of heritage-authority involvement in comparable restoration processes within the wider Kermanshah historic fabric is independently documented (Pournaderi, 2019, unpublished internal report, Kermanshah CHHTO). Despite this repeated revival pattern, no study has examined whether these assets occupy comparable or divergent positions within the underlying street network, nor whether their recurring institutional configuration constitutes a replicable model rather than a set of isolated interventions.

The research gap is therefore twofold. Methodologically, the existing documentation of the heritage assets of Kermanshah's historic core is exclusively typological and institutional; no configurational analysis has established whether the six listed heritage houses, or a prospective infill site, occupy advantageous or peripheral positions within the surrounding pedestrian network, which constrains evidence-based site selection for future adaptive reuse. Theoretically, the recurrence of an identical three-actor revival configuration across six independently documented assets suggests a systematic and potentially transferable local governance model that has not previously been conceptualised through Triple Helix or anchor-institution theory. The significance of closing this gap lies in the condition of most Iranian and Middle Eastern historic cores, where large university, foundation, or corporate anchors are absent and where regeneration must instead be assembled from clusters of modest listed assets. Accordingly, the objective of this study is to develop and test a geospatial decision-support framework for heritage-led smart governance, using the Javanshir–Feyzabad quarters of Kermanshah and a proposed commercial–cultural infill complex as the validation case. Three research questions structure the analysis: (RQ1) what configurational positions do the six listed heritage houses occupy within the city-wide axial network; (RQ2) does the proposed infill site hold a configurational advantage that justifies visitor-facing adaptive reuse at that location; and (RQ3) does the recurring three-actor revival configuration constitute a replicable, heritage-led adaptation of the Triple Helix in which the anchor function is distributed across a cluster of assets? The study pursues these questions through four specific objectives: (i) documenting the shared and divergent spatial-configurational positions of the six houses; (ii) quantifying the position of the proposed infill site within the historic street network using axial-line Integration and Choice measures; (iii) reconstructing the recurring institutional model underlying the revival of the houses; and (iv) interpreting the combined evidence through Triple Helix and anchor-institution theory to inform heritage-led spatial decision support in comparable historic cores.

2. Methodology

2.1 Study Area

The study area lies within the historic fabric of Kermanshah, western Iran, an area of approximately 342 hectares referred to in municipal renewal documentation as Historic Fabric District D and comprising five contiguous neighbourhoods: Feyzabad, Kolahvas, Gomrok, Kouhsari, and Javanshir. The empirical focus is the adjoining Javanshir and Feyzabad quarters. According to their registered addresses in the national heritage register, four of the six listed houses (Haj Kobra, Samadi, Sa'advandi, and Faiz Mahdavi) are located in Javanshir and two (Khajeh Baroukh and Hakim Nasir) in Feyzabad, so that the corridor analysed in Section 3 spans the boundary between the two quarters. Javanshir proper covers approximately 87,777 square metres with a recorded population of 2,842 at the 2011 national census (Kermanshah CHHTO, 2023, unpublished). The proposed infill site, a vacant parcel of approximately 64.1 by 109.3 metres located immediately south of Javanshir Square, completes the empirical sample.

2.2 Data Sources

Seven categories of data were compiled and cross-referenced, as summarised in Table 1. Each morphological indicator is reported together with its geographic scope, distinguishing figures that describe the whole of Historic Fabric District D from figures specific to Javanshir alone, to avoid conflating district-level and neighbourhood-level statistics. The institutional interview was conducted for factual verification of restoration histories; no personal or sensitive data were collected.

Table 1
Data sources used in the geospatial and institutional analysis

Data source	Type	Geographic scope	Use in this study
Deteriorated-fabric renewal report for Historic Fabric District D (Kermanshah CHHTO and Kermanshah Municipality, 2023, unpublished)	Institutional report	District D (5 neighbourhoc incl. Javanshir and Feyzabad)	Land use, building quality, building height, plot granularity, physical and social regeneration priorities
Field interview, Kermanshah CHHTO (personal communication, 2024)	Primary qualitative record	Six houses	Reconstruction of the three-ac institutional revival model; restoration status
National heritage register entries for the six houses	Public registry data	Six houses	Registration numbers, registrat years, and registered addresses (Table 4)
Street-network vector data (OpenStreetN extraction, UTM Zone 38N)	GIS vector data	Kermanshah, city-wide	Preliminary primal-graph accessibility screening (superseded; Section 2.4)
Axial-line map (depthmapX export, 63,25 axial lines)	Space syntax dataset	Kermanshah, city-wide	Axial-line Integration [HH] and Choice computation
Field-verified GPS coordinates of the six houses and the infill site	Coordinate data	Javanshir–Feyzabad	Spatial join between heritage assets and the axial-line network

2.3 Typological and Institutional Documentation

The typological description of the six houses follows the courtyard-based spatial grammar outlined in Section 1, namely the *biruni/andaruni* division, the central courtyard (*hayat*), and the *talar* reception hall [1,2]. The institutional history of each house was reconstructed from the field interview conducted with the heritage authority and cross-checked against the national register entries and against the general pattern of restoration activity recorded for Historic Fabric District D. Because precise project-level financial figures were not disclosed at the level of the individual building, the institutional model reported in Section 3.5 is qualitative and comparative rather than financially quantified, in contrast to comparable Triple Helix case studies that draw on itemised public funding records [17].

2.4 Axial-Line Space Syntax Analysis

An initial accessibility screening used a primal-graph approximation in which the OpenStreetMap street network was represented as a planar graph and closeness and betweenness centrality were computed with the NetworkX library. This screening served only as preliminary design intelligence for site evaluation and is not the basis of any configurational result reported in Section 3. All reported configurational values derive from a full axial map of Kermanshah comprising 63,253 axial lines, constructed and analysed in depthmapX following standard axial-analysis procedure [5,7]. For each of the six houses and the infill site, field-verified coordinates were reprojected from WGS84 to UTM Zone 38N (EPSG:32638) and the nearest axial line was identified by minimum perpendicular distance; matching distances are reported in Table 2 to indicate the positional reliability of the spatial join. Global Integration [HH], local Integration (radius 400 m), global Choice, local Choice (radius 400 m), Connectivity, and Control were extracted for each matched line. City-wide percentile ranks for Integration, Choice, and Control were computed against the full distribution of the corresponding measure across all 63,253 lines, using an identical procedure in every case. To test the directionality of the house cluster, principal component analysis was applied to the six coordinate pairs and the share of variance and bearing of the first component were recorded. One property of the dataset requires note: across all 63,253 lines, local Choice (R400) and global Choice are almost perfectly correlated ($r = 0.9997$), and 82.1 per cent of lines differ by less than one per cent between the two measures when the 6.4 per cent of lines with zero Choice, identical in both, are included. The close agreement reported in Table 3 therefore reflects a property of this axial export rather than a data-extraction error; Choice R400 values are reported as supplementary diagnostics rather than independent predictors, and future replication should verify radius-based Choice extraction directly in depthmapX.

2.5 Site Selection and Design Validation

The infill site was first identified through the design-stage accessibility screening described above, as part of an architectural design study for a commercial–cultural complex prepared by the, and was then validated using the axial-line Integration [HH] and Choice values obtained from the depthmapX dataset. The site-selection analysis therefore treats the primal-graph results as preliminary design intelligence only, while the configurational justification reported in Section 3 rests exclusively on the axial-line findings. Section 3.6 evaluates the access structure and massing principles proposed in the design study against this configurational evidence.

3. Results and Discussion

3.1 Urban Morphological Conditions of the Historic Fabric

Institutional renewal records for Historic Fabric District D indicate that 98.15 per cent of parcels carry buildings classified as requiring repair but restorable, 0.98 per cent are vacant plots without buildings, and 0.87 per cent carry newly constructed buildings (Kermanshah CHHTO and Kermanshah Municipality, 2023, unpublished). Building-height data in the same report show that 98.1 per cent of the stock is limited to two storeys, with taller construction (four storeys) confined to 0.9 per cent of buildings, and land ownership within the district is recorded as entirely private. These district-level percentages describe the aggregate condition of all five neighbourhoods and are interpreted here as contextual evidence of the historic core's structural fragility rather than as neighbourhood-specific statistics. For Javanshir itself, the report records a mean residential parcel area of approximately 74 square metres, a building-renewal rate below one per cent per annum in recent years, and roughly 29 per cent of the neighbourhood area occupied by commercial uses and vacant land, a granularity and land-use profile consistent with the deterioration assessment cited in Section 1. The report's physical-intervention prioritisation matrices rank legal and inter-institutional flow-making as the highest-intensity social regeneration action (intensity 5 of 5), followed by place-making through cultural and historical identity (intensity 4), with resident empowerment through financial facilitation ranked lower (intensity 2), reflecting residents' documented shortage of independent renovation capital. This institutional prioritisation pattern is directly consistent with the government-loan component of the revival model described in Section 3.5.

3.2 Location and Configurational Position of the Six Listed Houses

Field-verified coordinates place the six houses within an area of approximately 0.8 by 1.1 kilometres. Principal component analysis of the six coordinate pairs shows that the first component explains approximately 69.8 per cent of the variance in their spatial distribution, aligned along a north–south axis with a bearing of approximately N31°E, against 30.2 per cent for the perpendicular component. The six houses therefore constitute a directional corridor rather than a dispersed cluster. The two extreme points, Haj Kobra to the south and Hakim Nasir to the north, are separated by approximately 1,128 metres. This axis, illustrated in Figure 1, is referred to throughout the paper as the Distributed Heritage-Anchor Corridor. Notably, the corridor crosses the administrative boundary between Javanshir and Feyzabad: the distributed anchor system operates at the scale of the historic fabric rather than within a single neighbourhood frame.

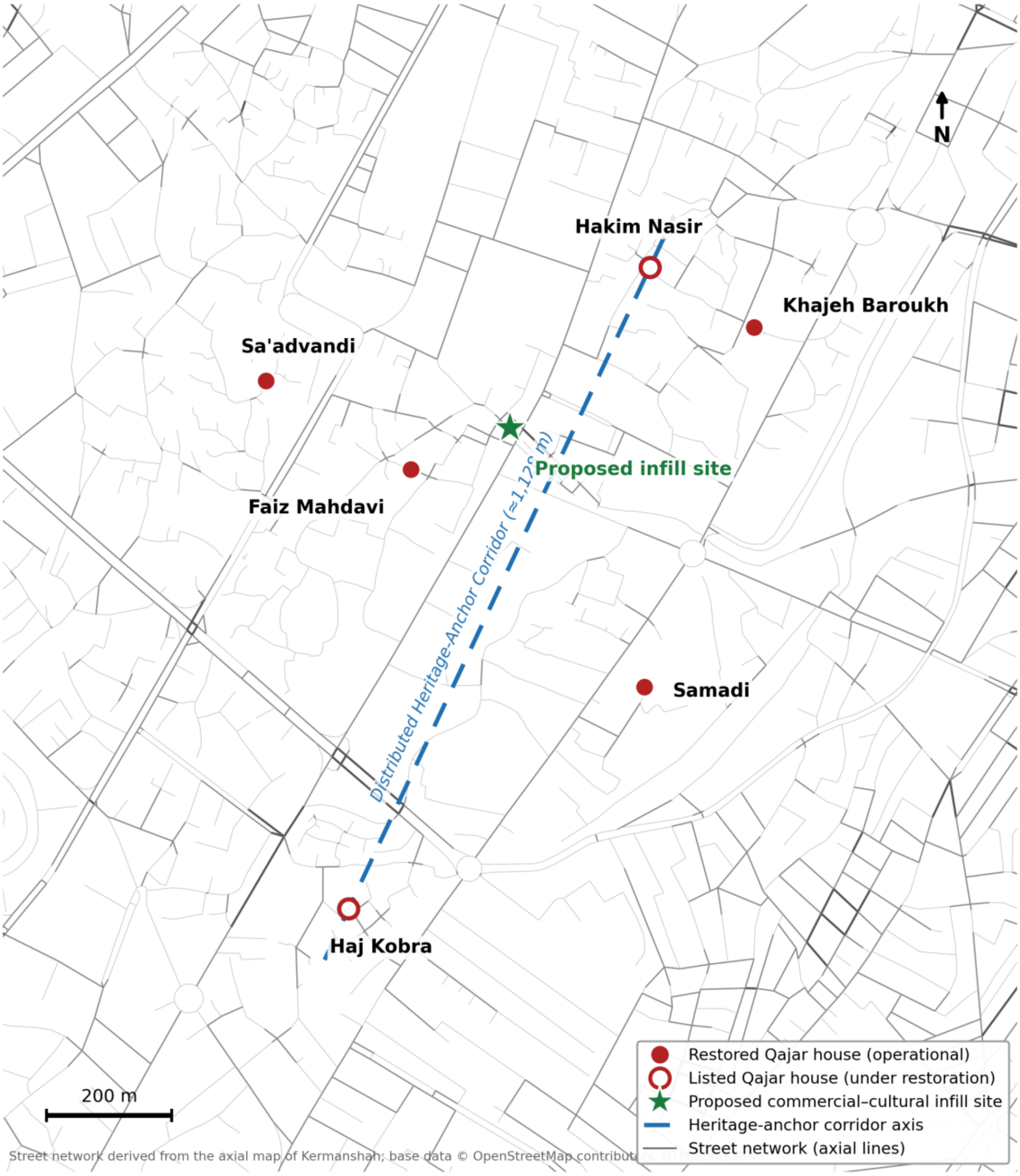

Fig. 1. Location of the six listed Qajar houses and the proposed commercial–cultural infill site along the Distributed Heritage-Anchor Corridor, Javanshir–Feyzabad quarters, Kermanshah
source: by the authors

3.3 Axial-Line Space Syntax Findings

Table 2 reports the configurational values extracted from the 63,253-line axial map for each of the six houses and the infill site, together with each location's percentile rank within the city-wide distribution and the nearest-line matching distance recorded for the spatial join described in Section 2.4. Figure 2 maps the Integration [HH] values of the surrounding network.

Table 2
Axial-line Integration [HH] and Choice values for the six listed houses and the proposed infill site

Location	Integration [HH]	City percentil	Integration R	Choice	Choice percentile	Connectivity	Nearest line (m)
Proposed infill site	0.1116	76.9%	0.1118	907,464	57.8%	5	0.0
Khajeh Baroukh	0.1089	71.7%	0.1090	2,011,709	70.4%	4	17.0
Hakim Nasir	0.1067	67.0%	0.1069	804,346	55.6%	3	8.0
Faiz Mahdavi	0.1044	60.9%	0.1046	220,029	30.4%	2	10.2
Samadi	0.1024	56.2%	0.1026	0	0.0%	1	35.9
Haj Kobra	0.1021	55.3%	0.1022	0	0.0%	2	11.9
Sa'advandi	0.0969	44.1%	0.0971	3,374,892	76.9%	2	1.7

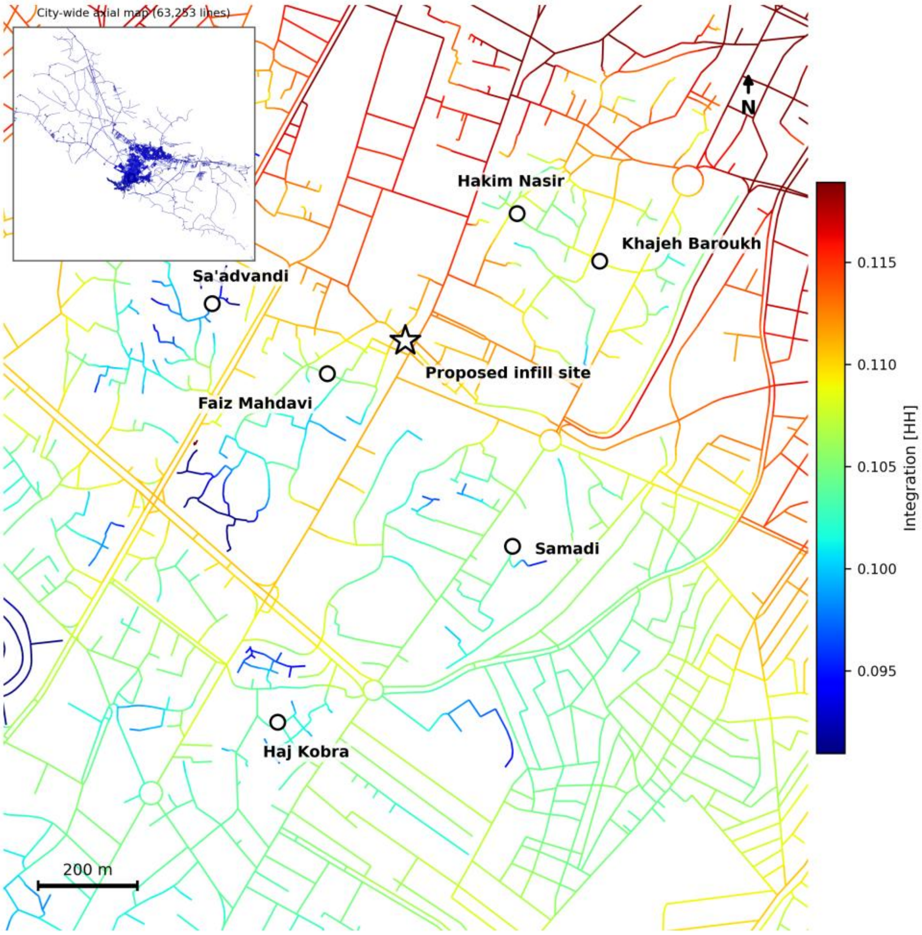

Fig. 2. Axial-line Integration [HH] map of the study area extracted from the 63,253-line axial map of Kermanshah; the colour scale is stretched to the 2nd–98th percentile of values within the view extent, and the inset shows the city-wide axial map with the view extent outlined

As shown in Table 2 and Figure 2, the six houses occupy markedly different positions within the local street network despite sharing an identical institutional revival profile. Khajeh Baroukh registers the highest Integration [HH] among the six houses (71.7 percentile), followed by Hakim Nasir (67.0) and Faiz Mahdavi (60.9); Samadi and Haj Kobra occupy intermediate positions (56.2 and 55.3), and Sa'advandi records the lowest Integration in the sample (44.1). Nearest-line matching distances range from 0.0 to 35.9 metres. Most locations were matched within a short distance; the Samadi case shows the largest offset and was checked visually against the street-network map to confirm that the assigned axial line corresponds to the nearest accessible street alignment, and no closer alternative was identified.

A pronounced divergence between Integration and Choice emerges for Sa'advandi, which combines the lowest Integration value in the sample with the highest Choice value (76.9 percentile). The registered address of the house places it in a cul-de-sac branching from the alley network south-west of Javanshir Square, and the matched axial line, at 1.7 metres, corresponds to the through-alley from which the cul-de-sac branches. The house therefore adjoins a heavily used through-route without being well integrated into the broader network, a configuration consistent with the distinction drawn by Askarizad et al. [9] between movement potential and intelligibility in organic alleyway systems. Samadi and Haj Kobra, by contrast, both register a Choice value of zero, occupying terminal positions that are locally accessible but structurally disconnected from city-wide movement; such positions can constrain wayfinding for visitors unfamiliar with the quarter, consistent with evidence on the legibility of historical neighbourhoods [10]. Table 3 extends the analysis with local Choice (R400) and Control values, together with a design-oriented configurational interpretation for each location.

Table 3
Extended configurational profile and design interpretation

Location	Choice R400	Control	Control percentile	Configurational interpretation
Proposed infill site	907,184	1.150	77.0%	High-integration infill node; suitable for visitor-faci adaptive reuse
Khajeh Baroukh	2,011,709	1.200	86.4%	Strongest integrated anchor among the existing houses
Hakim Nasir	804,250	1.083	66.5%	Secondary integrated anchor
Faiz Mahdavi	219,500	0.750	9.1%	Moderate integration, weak through-movement
Samadi	0	0.333	0.2%	Locally accessible but structurally terminal
Haj Kobra	0	0.583	4.3%	Peripheral, terminal anchor requiring wayfinding support
Sa'advandi	3,371,162	0.833	12.6%	High through-movement but low integration; requ frontage and orientation intervention

3.4 Site Selection Validation

The proposed infill site records the highest Integration [HH] value in the entire sample, at the 76.9 city-wide percentile, exceeding every one of the six listed houses, including Khajeh Baroukh. The site's local Integration value (R400 = 0.1118, 77.0 percentile) closely tracks its global value, indicating that its advantageous configurational position holds at both the pedestrian and the city scale. Located approximately 262 metres south of Javanshir Square and 170 metres from Faiz Mahdavi, the nearest listed house, the site inherits rather than fragments the accessibility advantages of the existing heritage cluster. This provides a configurational, rather than purely qualitative, justification for the infill location proposed in the design study, answering RQ2 in the affirmative.

3.5 The Distributed Heritage-Anchor Revival Model

Field interview records obtained from the Kermanshah CHHTO (personal communication, 2024), cross-checked against the national heritage register, indicate that all six houses entered the register between 1998 and 2008 and were subsequently drawn into an identical, recurring three-actor revival configuration, summarised in Table 4. Restoration proceeded incrementally and sequentially over approximately the past decade; four houses are now operational as boutique lodging with attached traditional restaurants, retaining original furnishings as decoration rather than pursuing museumification, while Hakim Nasir and Haj Kobra remain under restoration along the same pathway.

Table 4
Institutional profile of the six listed Qajar houses

House	National registry no. (year)	Quarter (registered addre	Three-actor configuration (listing / loan / private capital)	Current status and use
Haj Kobra	Listed; number not disclosed	Javanshir	Yes / Yes / Yes	Under restoration
Samadi	2908 (2000)	Javanshir (Modarres crossroads)	Yes / Yes / Yes	Operational: boutique lodg with traditional restaurant
Khajeh Baroukh	1990 (1998)	Feyzabad	Yes / Yes / Yes	Operational: boutique lodg with traditional restaurant
Sa'advandi	23898 (2008)	Javanshir (cul-de-sac soutl west of Javanshir Square)	Yes / Yes / Yes	Operational: boutique lodg with traditional restaurant
Hakim Nasir	23901 (2008)	Feyzabad	Yes / Yes / Yes	Under restoration
Faiz Mahdavi	17560 (2007)	Javanshir (Modarres Stree Allaf-khaneh alley)	Yes / Yes / Yes	Operational: boutique lodg with traditional restaurant

Two features of this record carry analytical weight. First, the chronology is two-staged: every house was registered between 1998 and 2008, yet restoration began roughly a decade later. Listing alone did not trigger revival; revival followed only once the two remaining actors, public loan financing and private operating capital, became active. The three-actor configuration is therefore not incidental but constitutive: each strand supplies a condition the others cannot. Second, in none of the six recorded cases do residents or neighbourhood organisations appear as an actor in the revival configuration. The model as it currently operates is a three-strand arrangement of heritage authority, public finance, and private capital, with the resident population positioned as context rather than participant; the governance implications of this absence are taken up in Sections 3.8 and 3.10. The convergence of an identical configuration and a uniform functional outcome across the four completed cases, with the two remaining houses following the same pathway, indicates a systematic and replicable local governance model rather than a series of isolated interventions.

This recurring configuration is best conceptualised as a distributed heritage-anchor revival model, summarised in Figure 3. Its anchor function is distributed across multiple restored houses rather than concentrated in a single large institution. Each house is individually modest in scale, but collectively the six houses generate a repeated pattern of conservation legitimacy, public financial facilitation, private operational investment, and daily visitor-oriented activity. This distributed configuration is particularly relevant to Iranian historic cores, where large university, foundation, or corporate anchors are typically absent from deteriorated heritage neighbourhoods, but where clusters of listed residential assets can still produce cumulative regenerative effects. Table 5 maps the empirical actors identified in Kermanshah onto their corresponding theoretical roles.

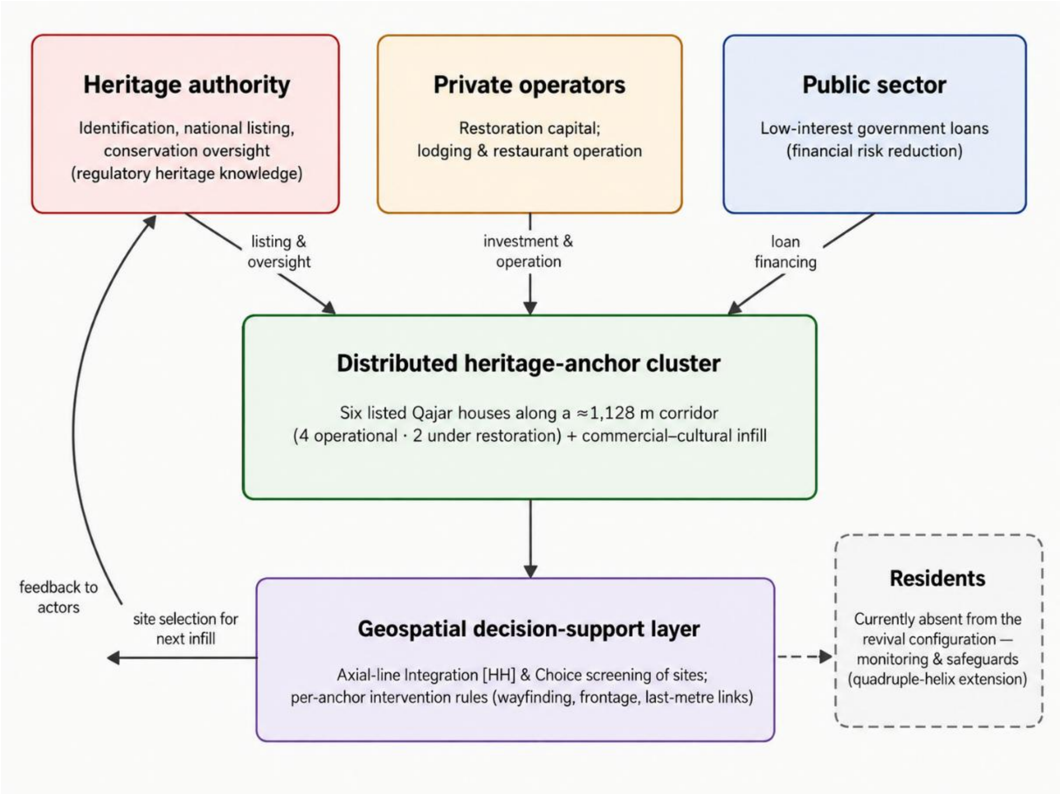

Fig. 3. The distributed heritage-anchor revival model: three-actor configuration, geospatial decision-support layer, and the currently absent resident strand

Table 5
Heritage-led adaptation of Triple Helix and anchor-institution functions in the Kermanshah historic fabric

Empirical actor/component	Function in the case study	Theoretical role	Evidence in this study
Heritage authority	Identification, national listing, conservation oversight	Regulatory and heritage-knowledge actor	All six houses identified and listed through heritage-authority involvement (Table 4)
Government loan mechanism	Financial risk reduction	Public-sector enabling mechanism	All six cases involved government-lo financing
Private capital and operators	Restoration investment and daily operation	Cultural-entrepreneurial actor	Boutique lodging and traditional restaurant use across the four completed houses
Six listed houses as a cluster	Repeated spatial activation	Distributed anchor syste	Six nodes along a 1,128 m corridor spanning two quarters
Proposed commercial–cultural infill	Future infill and network reinforcement	Strategic adaptive-reuse node	Highest Integration [HH] value in th sample
Residents and neighbourhood organisations	Not recorded in any revival case	Prospective fourth (quadruple-helix) strand	Absent from all six documented configurations

3.6 Design Implications for the Commercial–Cultural Infill Complex

Read together, the configurational and institutional findings carry direct implications for the proposed intervention, an infill (Pers. *miyan-afza*) commercial–cultural complex on the vacant parcel south of Javanshir Square. Because the site occupies the highest-integration position identified in the entire sample, its massing and access points should reinforce, rather than obstruct, the pedestrian flows that generate this advantage, particularly along the axis connecting the site to Khajeh Baroukh and Hakim Nasir. The design study organises access accordingly: the principal vehicular approach addresses the Javanshir Square frontage, while a secondary pedestrian edge runs along the eastern boundary towards the bazaar and the Jame' Mosque, aligning the building's permeable side with the directions of established visitor movement. The massing principles, redrawn in Figure 4, follow a six-step derivation: extrusion of the commercial–cultural volume within plot limits; a first-floor setback deflecting the unfavourable westerly wind while opening the massing to the favourable north-easterly breeze; an entrance void inserted as a third volume to draw visitors into the depth of the site; and the adoption of the Persian three-centred arch as the entrance motif and facade module, deriving rhythm from the arcaded grammar of the surrounding historic context. Figure 5 presents the ground-level site plan, in which a sequence of planted courtyards with central water features reinterprets the courtyard grammar of the surrounding Qajar houses at the scale of a public building.

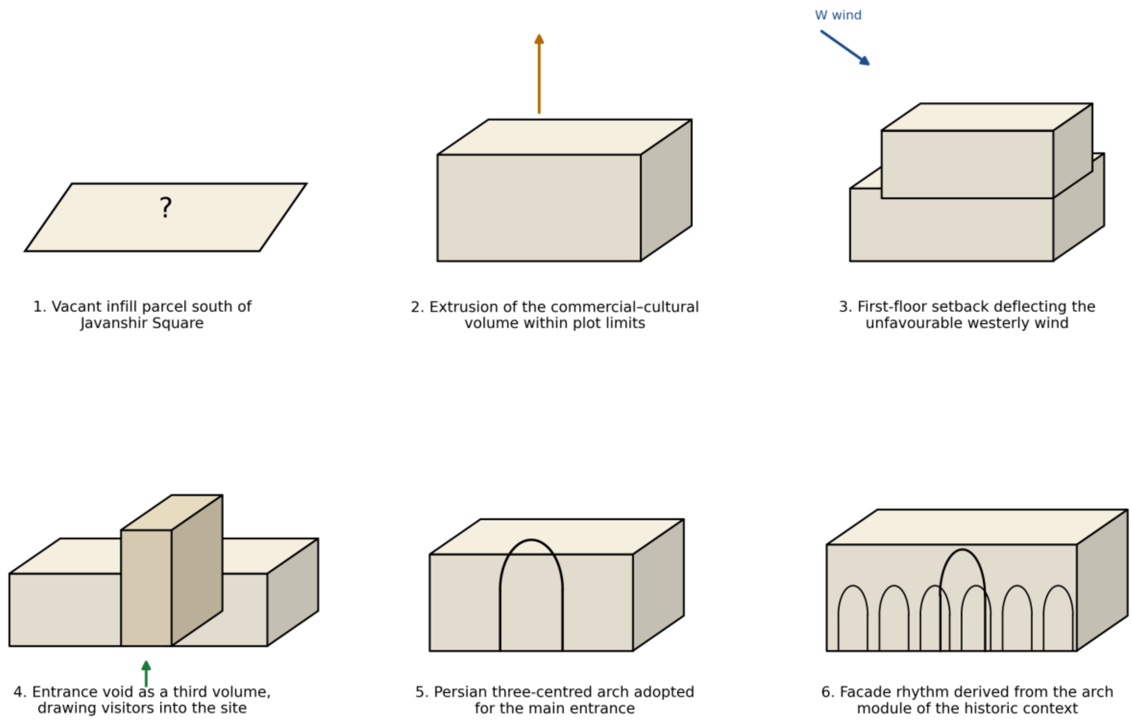

Fig. 4. Massing and design principles of the proposed commercial–cultural infill complex, source: architectural design study by the authors

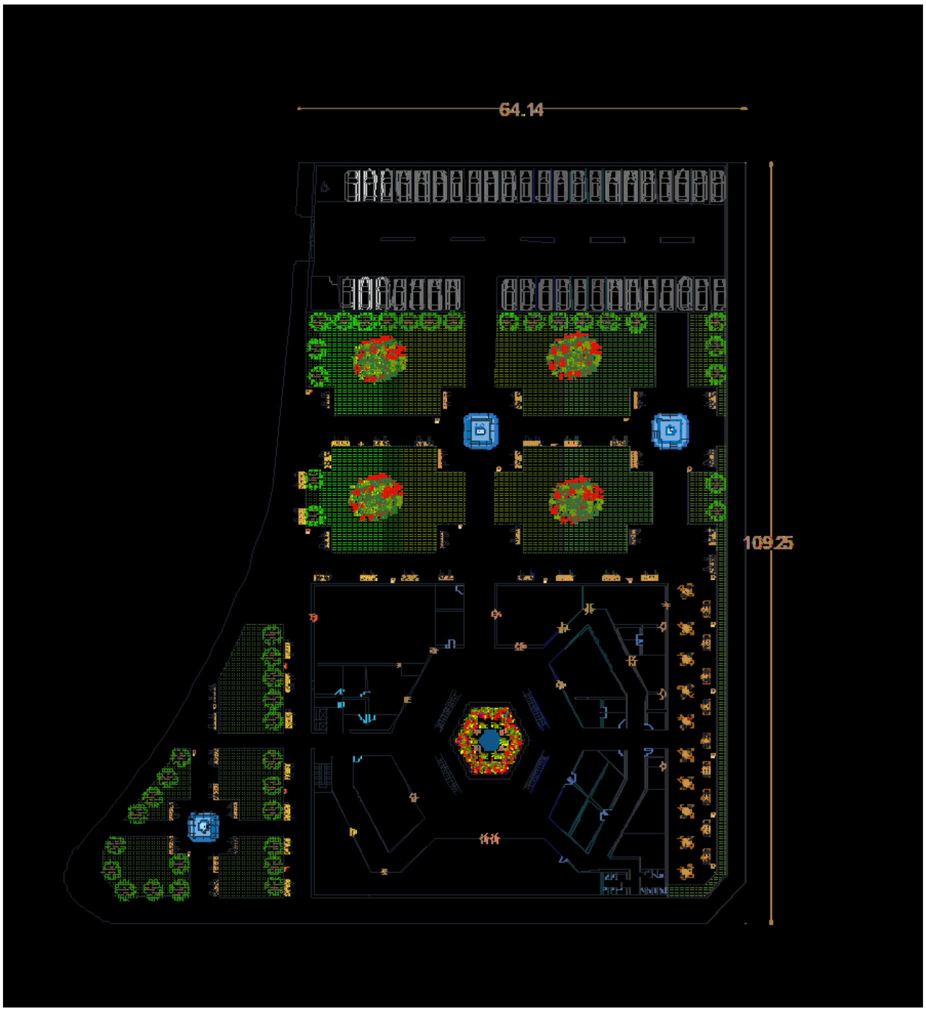

Fig. 5. Ground-level site plan of the proposed commercial–cultural infill complex on the vacant parcel south of Javanshir Square (approximately 64.1 by 109.3 m); source: architectural design study by the authors

Because the distributed heritage-anchor model has already proven replicable across six independent cases, the infill complex is best understood as continuing an established local revival pathway rather than introducing an untested funding or management arrangement. Its visitor-facing programme is consistent with the decision rules derived in Section 3.9 for high-integration locations.

3.7 From Isolated Restoration to a Distributed Anchor System

The findings indicate that the six houses should not be read as isolated conservation successes. Although each was restored or is being restored independently, their cumulative spatial distribution forms a north–south corridor that crosses the Javanshir–Feyzabad boundary, and this corridor is supported by measurable configurational differences in Integration and Choice rather than by cartographic alignment alone: each house occupies a distinct, complementary role within the pedestrian network, from the strongly integrated anchors (Khajeh Baroukh, Hakim Nasir) to the through-movement node (Sa'advandi) and the terminal destinations (Samadi, Haj Kobra). The houses therefore operate as a distributed anchor system in the sense of the anchor-institution literature [20-24]: individually modest, but collectively capable of generating a recognisable spatial and functional structure within a deteriorated historic fabric. What the framework adds to that literature is the demonstration that the anchor function can be assembled from listed residential assets in the absence of any single large institution, and that the assembly is legible, and steerable, through configurational measurement.

3.8 A Heritage-Led Adaptation of the Triple Helix

The Kermanshah case also suggests that Triple Helix theory can be adapted to heritage-led regeneration contexts in which a university or formal knowledge-economy institution is absent. Here, heritage expertise and regulatory authority substitute for the conventional knowledge-provision role, while government-loan financing and private cultural entrepreneurship complete the three-actor configuration. One caveat attends the substitution: regulatory heritage knowledge is not equivalent to research-based knowledge production, and the Kermanshah configuration lacks the endogenous skills-training loop that characterised the university-anchored Ortigia case [17]. The model is therefore a heritage-led adaptation rather than a direct application of the university–industry–government helix, and its knowledge strand remains its thinnest. The absence of residents from all six documented revival configurations points in the same direction: within a quadruple-helix perspective, in which civil society constitutes a fourth strand of innovation systems [28], the incorporation of residents and neighbourhood organisations would convert the safeguards discussed in Section 3.10 from external constraints into internal components of the governance model.

3.9 Spatial Decision Rules for Future Adaptive Reuse

The configurational results support practical decision rules for future adaptive reuse in the Kermanshah historic fabric. High-integration sites, such as the proposed infill location, are appropriate for visitor-facing and publicly accessible functions because they reinforce existing pedestrian accessibility. Sites with high Choice but low Integration, such as Sa'advandi, require careful frontage activation, signage, and wayfinding support, because they experience through-movement without broader spatial intelligibility. Sites with zero or very low Choice, such as Samadi and Haj Kobra, require last-metre connectivity measures, lighting, visual cues, and small-scale public-realm improvements to prevent restored buildings from remaining isolated destination points. Applied prospectively, these rules constitute the operational content of the smart-governance claim in this paper: a geospatial evidence layer [15,16] through which the heritage authority and municipality can screen candidate reuse sites and assign per-anchor supporting measures before capital is committed.

3.10 Regeneration Risks and Governance Safeguards

The same conditions that make the model attractive for heritage-led regeneration also create governance risks. Boutique lodging, restaurants, and commercial–cultural programmes can activate restored buildings, but they may also intensify visitor-oriented commercialisation and increase land-value pressure in a fragile residential fabric whose parcels average only 74 square metres. The model therefore requires safeguards: monitoring of property-value changes, protection of residential functions, design controls on new infill, and continued coordination between the heritage authority, public finance mechanisms, private operators, and, critically, the resident population whose absence from the current configuration Section 3.5 documented.

3.11 Limitations

The study is limited by the absence of itemised restoration budgets, project-level loan amounts, and longitudinal visitor or pedestrian-count data; the institutional model reported in Section 3.5 is therefore interpreted as a recurring governance configuration rather than a financially quantified impact model. The institutional evidence rests principally on a single authority interview, cross-checked against the national register and the district renewal report but not against operator or resident accounts. Positional accuracy is bounded by nearest-line matching distances of up to 35.9 metres; the largest offset was checked visually, but survey-grade coordinates would strengthen replication. The claim of a uniform functional outcome applies to the four completed houses, since Hakim Nasir and Haj Kobra remain under restoration. Finally, the near-identity of global and radius-400 Choice in this axial export (Section 2.4) means that the local-Choice values are diagnostic rather than independent evidence. Future work should integrate archival financing records, operator and resident interviews, longitudinal movement data, and property-value monitoring to test the economic and social effects of the distributed heritage-anchor system.

4. Conclusions

This study developed a geospatial decision-support framework for heritage-led smart governance in the historic fabric of Kermanshah by combining axial-line space syntax analysis, field-verified heritage records, and adaptive-reuse site evaluation. In answer to RQ1, the six nationally listed Qajar houses occupy measurably divergent configurational positions, from a 71.7 to a 44.1 city-wide Integration percentile, yet together form a north–south Distributed Heritage-Anchor Corridor of approximately 1,128 metres that spans the Javanshir and Feyzabad quarters. In answer to RQ2, the proposed commercial–cultural infill site occupies the strongest configurational position in the sample, at the 76.9 percentile of the city-wide integration distribution, exceeding all six houses and providing an evidence-based justification for visitor-facing adaptive reuse at that location. In answer to RQ3, the repeated combination of heritage-authority listing, government-loan financing, and private capital, with registration (1998–2008) preceding revival by roughly a decade and with residents absent from every recorded configuration, constitutes a locally replicable, heritage-led adaptation of the Triple Helix in which the anchor function is distributed across a cluster of listed and reused heritage assets.

The paper contributes to heritage-led regeneration research by showing how spatial configuration analysis can be combined with institutional field evidence to guide adaptive-reuse decisions in deteriorated historic cores, and it extends Triple Helix and anchor-institution debates by specifying both what the heritage-led adaptation supplies, regulatory knowledge, financial facilitation, and cultural entrepreneurship, and what it currently lacks, a research-based knowledge strand and a resident strand. Future research should add itemised financial records, longitudinal pedestrian counts, resident and operator interviews, and property-value monitoring to test the long-term social and economic consequences of the model, and should replicate the configurational screening in other Iranian and Middle Eastern historic cores where regeneration must likewise be assembled from distributed clusters of listed assets. Moreover, recent artificial intelligence tools can be used [29, 30] the results can be compared.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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