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**Research Paper**

# Climate-Responsive Vernacular Architecture: Environmental and Cultural Adaptation Strategies in the Historic City of Lar

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***Abstract***
*This study examines climate-responsive form in the historic fabric of Lar (Fars, Iran) and clarifies how its vernacular differs from canonical hot-arid cases such as Yazd/Kashan. We adopt a mixed-methods, mechanism-centred approach: plans and field documentation were compiled for 30 dwellings (19 with an iwan, 11 without), iwan and courtyard attributes were coded, and findings were benchmarked against the Mahoney tables. An expert elicitation (n = 218, Cronbach's α = 0.91) provided ranked environmental and cultural priorities to contextualize the spatial evidence. Across the sample, Lar's dwellings consistently express façade buffering, solar control, and ventilation staging. Iwans are typically summer-oriented, often aligned with prevailing winds, span about half the façade, and have depth equal to or greater than the principal room, with one-way side access used more often than two-way. Openings on exposed fronts are small and recessed. At the urban-fabric scale, narrow lanes and covered passages (sabat) sustain shaded, ventilated continuity. Courtyards are predominantly central or three-sided, with intermediate plot shares (~20–40%) and elongated proportions (~1/2–1/3) that deepen self-shade and channel breezes; walls and roofs are heavy earthen assemblies, sometimes complemented by basements for thermal damping. Expert rankings place temperature/sunlight as the leading environmental concern and historical/place-based practices as the leading cultural theme, aligning with the observed configurations. Distinctive features of Lar include its dense sabat network, short-wide wind-catchers, and water-organized urban grain. The paper translates these convergences into practice-ready rules for hot-arid design: compact courtyard planning with elongated courts; deep transitional iwans serving principal rooms; protected, recessed openings; shaded, narrow pedestrian ways; and heavy, time-lagging envelopes with adequate drainage. These lessons demonstrate how Lar's vernacular can inform contemporary, culturally resonant low-energy architecture.*

***Keywords:*** *Vernacular architecture, Climate-responsive design, Hot–arid climate, Passive cooling, Lar.*

## INTRODUCTION

Vernacular architecture is widely described as the co-evolution of culture, climate, and form. Foundational work shows how social practices and environmental constraints organise plan, section, and construction (Rapoport, 1969; Oliver, 1997), while studies of climatic responsiveness demonstrate the performance of traditional configurations under heat and aridity (Coch, 1998; Dayaratne, 2010, 2018; Foruzanmehr, 2015). Yet two issues remain under-specified for Iran's hot-arid settlements. First, key transitional elements—most notably the iwan—are rarely treated as explicit climate devices with observable geometry and adjacency that can be linked to mechanisms such as short-wave control, mean radiant temperature (MRT) reduction, and staged ventilation. Second, Lar (Fars, Iran) is often folded into canonical Yazd/Kashan narratives, despite its dense network of covered alleys (sabat), prevalence of short-wide wind-catchers, and a water-organized urban grain.

This study examines climate-responsive form in Lar's historic fabric using a mixed-methods, mechanism-centred approach. We document plans/sections and field photographs for 30 dwellings

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(19 with an iwan, 11 without), code courtyard share and aspect, iwan depth and coupling to rooms, street canyon proportions and covered continuity, opening configuration, wind-catcher morphology, and envelope mass; and benchmark observations against the Mahoney tables. To contextualize these readings, we elicit expert priorities (n = 218; validated instrument) on environmental and cultural drivers. Rather than testing numerical thresholds, the analysis triangulates spatial evidence, expert judgement, and bioclimatic guidance to clarify what is distinctive about Lar and to derive practice-ready rules for façade design, street shading, and device selection in comparable hot-arid settings.

The contribution is threefold: (i) Lar documented mechanisms (façade buffering by iwan, shaded/ventilated pedestrian continuity, and thermal damping by heavy assemblies); (ii) it articulates measurable, reproducible indicators that make these mechanisms auditable in historic fabric without resorting to simulation; and (iii) it translates the evidence into design principles that retain cultural fit while reducing reliance on mechanical cooling.

## LITERATURE REVIEW

Research on vernacular architecture consistently connects climatic adaptation with culturally embedded spatial practice. Foundational accounts explain how everyday use, privacy, and ritual organize plan and section (Oliver, 1997; Rapoport, 1969), while climatic studies show how orientation, transitional spaces, shading, ventilation paths, and thermal mass improve comfort in hot-arid conditions (Coch, 1998; Dayaratne, 2010; Foruzanmehr, 2015). International bioclimatic frameworks—Olgyay and Givoni's charts and the Mahoney tables (Szokolay & Koenigsberger, 1973) together with urban microclimate theory after Oke, provide a mechanism-based language (solar control/MRT, ventilation potential, time-lag) that complements typological readings and supports indicator-based analysis. Recent work sharpens this mechanism-based lens by quantifying how specific devices and geometries—hybrid windcatcher–solar-chimney systems, courtyard aspect ratios/orientations, and perforated screens—modulate ventilation, cooling loads, and mean radiant temperature in hot–arid settings (Khakzand et al., 2024; Taki & Kumari, 2023) Complementary simulation and field studies now show that radiative-cooling strategies and courtyard energy tuning can be operationalized as reproducible design rules, strengthening the bridge from typology to performance (Diz-Mellado et al., 2023; Domínguez-Torres & Domínguez-Delgado, 2024). To avoid a narrow regional lens, the review also draws on African and South Asian scholarship. Fathy's work on Egyptian courtyards and malqaf wind-catchers (Fathy, 1986, 2010), and studies of verandas and jaali screens in South Asia (Lavanya & Vignesh, 2022; Rajapaksha et al., 2003), document how geometry and materiality reduce solar gains, lower MRT, and modulate airflow—mechanisms comparable to those observed in Middle Eastern cases. These strands suggest families of climate devices—deep transitional spaces, recessed/protected openings, narrow shaded canyons and covered passages, wind-induction elements, and heavy envelopes—whose effects can be examined with simple, reproducible measures in built fabric.

Within this literature, several gaps persist. First, the iwan is often discussed as a cultural form but seldom operationalized as a climate device with explicit depth, façade coverage, and coupling to principal rooms that would evidence buffering and pre-ventilation. Second, Iranian hot-arid settlements are frequently treated as interchangeable exemplars; differentiation among Lar, Yazd, and Kashan is limited, despite distinct street canyons, covered-passage networks, and wind-catcher geometries. Third, many studies privilege typological description or comfort perception without triangulating measured morphology, expert judgement, and bioclimatic guidance. Addressing these gaps, this study organizes the evidence by mechanism (solar control/MRT, ventilation, thermal mass) and employs observable indicators at dwelling and street scales. Table 1 summarizes the environmental and cultural domains used to structure both the expert elicitation and the coding of spatial proxies (e.g., filtered thresholds, recessed openings, and sabat adjacency), allowing cultural themes to be acknowledged without reductionism while making their spatial manifestations empirically auditable.

## METHODOLOGY

This study employs an integrated, mixed-methods design to document and interpret climate-responsive form in the historic fabric of Lar. The unit of analysis is the dwelling and its immediate street/courtyard context. Three evidence streams are combined: (i) systematic field documentation of plans, sections, and photographs; (ii) structured coding of dwelling, iwan, and courtyard attributes summarized in Tables 3–5; and (iii) expert elicitation on environmental and cultural priorities, used to contextualize the spatial evidence and to benchmark it against bioclimatic guidance from the Mahoney tables(Sealey, 1979).

The study area is Lar (Fars, Iran), with the municipal setting and historic core shown in Figures 1 and 2.

**Table 1.** Components and Indicators Affecting the Formation of Vernacular Architecture (Source: Authors)

| Factors | Components | Indicators |
|---|---|---|
| Environmental factors | Physical conditions of the area (Algburi & Beyhan, 2019; Alkhalidi, 2013; Alp, 1991; Altan et al., 2016; Amiri Mohammadabadi & Ghoreshi, 2011; Ardeshiry et al., 2015) | Topography and its directions |
| | | vegetation |
| | | Soil type |
| | | The presence of some natural elements, such as rivers, mountains, etc. |
| | Atmospheric-climatic conditions (Arghavan, 2020; Bahramifar et al., 2021; Barbero-Barrera et al., 2014; Batty et al., 1991; Chang et al., 2021) | Temperature and sunlight |
| | | Rainfall |
| | | Humidity |
| | | wind |
| Cultural factors | Time (Nour Mohammadi, 2009; Rokneddin Eftekhari et al., 2012; Sadeghipey, 2012) | Historical and architectural background of the region |
| | Place (Mohahammadzadeh & Javanroodi, 2012; Najimi, 2016; Setayesh & Mehdizade, 2013; Soltanzadeh, 2014; Yekkeh, 2018) | Gender of spatial identity and behavioral patterns influenced by place |
| | Beliefs (human spirit and thoughts) (Forsat, 2015; Fotovvat, 2010; Shirzad, 1993; Zare et al., 2013) | Social groups with a common language |
| | | Social groups with a common religion and religious beliefs |
| | | Social groups with similar livelihoods or a homogeneous economic level |
| | | Local customs |
| | | Local arts |
| | | Social groups with the same gender |
| | | Social groups with similar age ranges |
| | | Tribal structures |

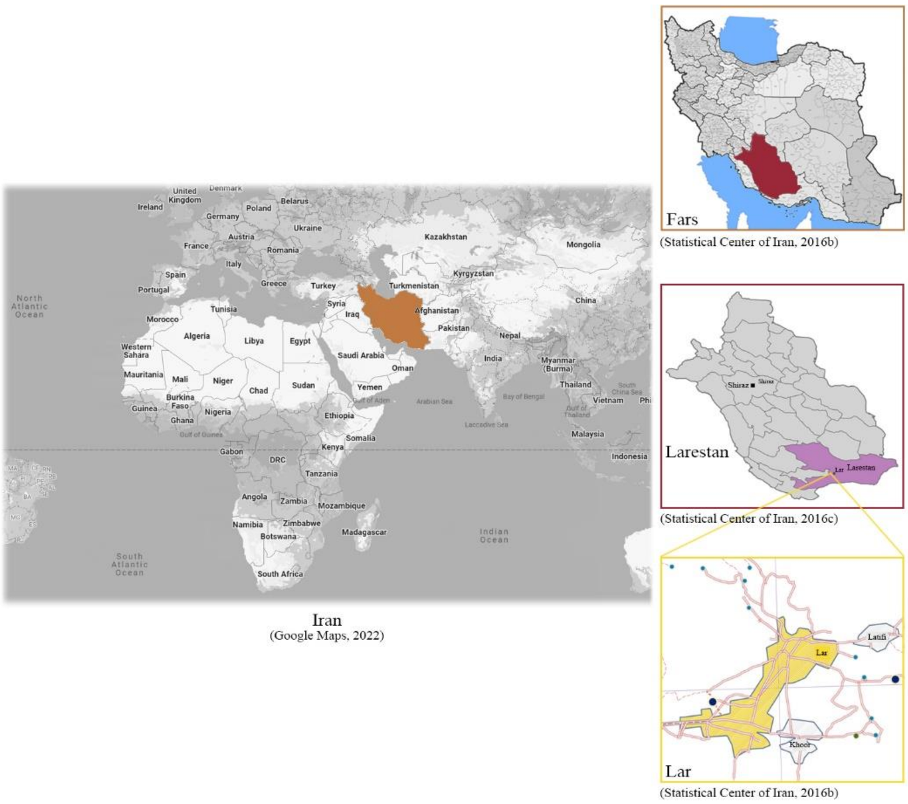


**Fig 1.** Location of Lar City (Statistical Center of Iran, 2016a)

Climatic inputs (temperature, humidity, rainfall, sunshine) were compiled for the period 1990–2021 (Table 2) and used later for Mahoney diagnostics and design indications. Prevailing winds in Larestan are predominantly northwest–southeast and west–east with typical speeds around 12 m/s; these data informed orientation notes during field recording.

Sampling of dwellings was purposive and coverage-oriented: thirty houses were selected from the historic fabric to span the range of preserved vernacular forms, explicitly balancing 19 with an iwan and 11 without to enable within-sample contrasts. Selection criteria prioritized (a) presence/absence of iwan and courtyard; (b) diversity of spatial configuration and orientation; and (c) sufficient preservation to recover reliable geometric relationships. Architectural maps of the case studies are presented in Figure 3 (and continuation). This sample supports analytic generalization (pattern completeness across types) rather than city-wide frequency estimation.

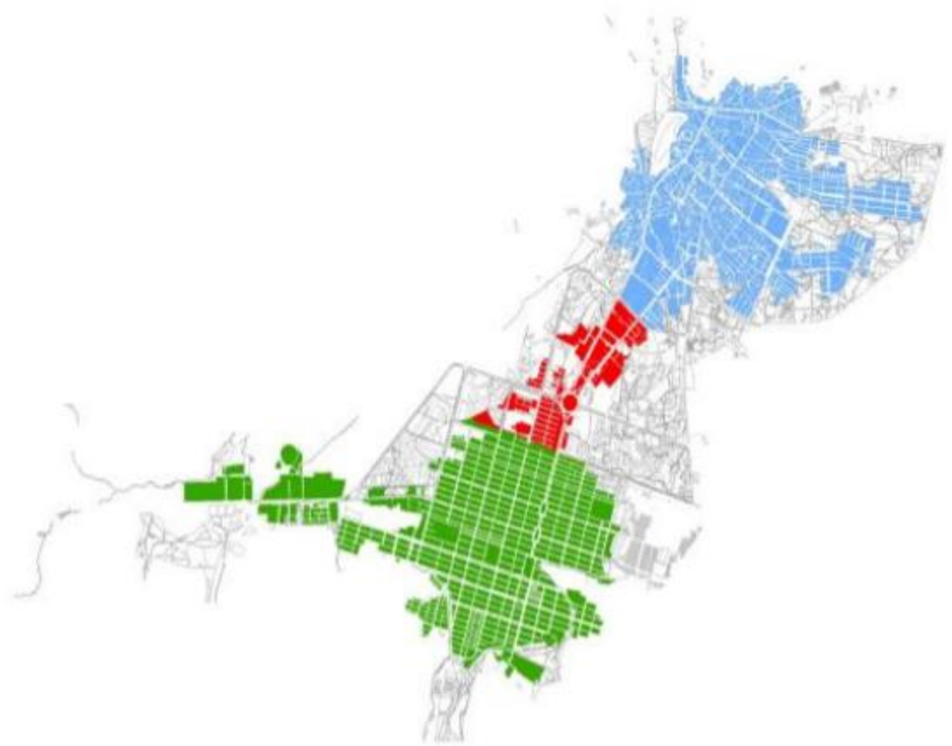

**Fig 2.** Lar City (Blue: Old City, Green: New City, Red: Middle Part) (Statistical Center of Iran, 2016b)

**Table 2.** Climatic Data of Lar City in 1400 AH

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Absolute maximum temp. (°C) | 24.4 | 25.2 | 32.8 | 37.4 | 42.8 | 47.0 | 46.0 | 45.0 | 43.0 | 40.4 | 33.8 | 30.0 |
| Average maximum temp. (°C) | 19.1 | 21.0 | 27.9 | 33.9 | 37.2 | 44.1 | 42.9 | 42.8 | 41.2 | 37.3 | 28.8 | 24.2 |
| Average minimum temp. (°C) | 8.0 | 6.0 | 11.0 | 15.5 | 20.4 | 25.0 | 26.7 | 27.4 | 24.1 | 19.9 | 12.2 | 7.6 |
| Absolute minimum temp. (°C) | 1.6 | 0.2 | 7.2 | 11.2 | 16.6 | 20.8 | 23.6 | 22.2 | 21.4 | 13.4 | 8.4 | 2.6 |
| Rainfall (mm) | 191.3 | 1.5 | 4.4 | 0.0 | 0.5 | 0.0 | 3.9 | 13.1 | 1.4 | 0.0 | 0.0 | 0.0 |
| Sunshine hours (h) | 199.3 | 286.4 | 281.0 | 316.5 | 332.8 | 377.8 | 330.6 | 314.6 | 333.2 | 306.9 | 276.9 | 247.8 |

(Source: Authors, based on (Fars Meteorological Bureau, 2022)


**Fig 3.** Architectural Maps of the Case Studies

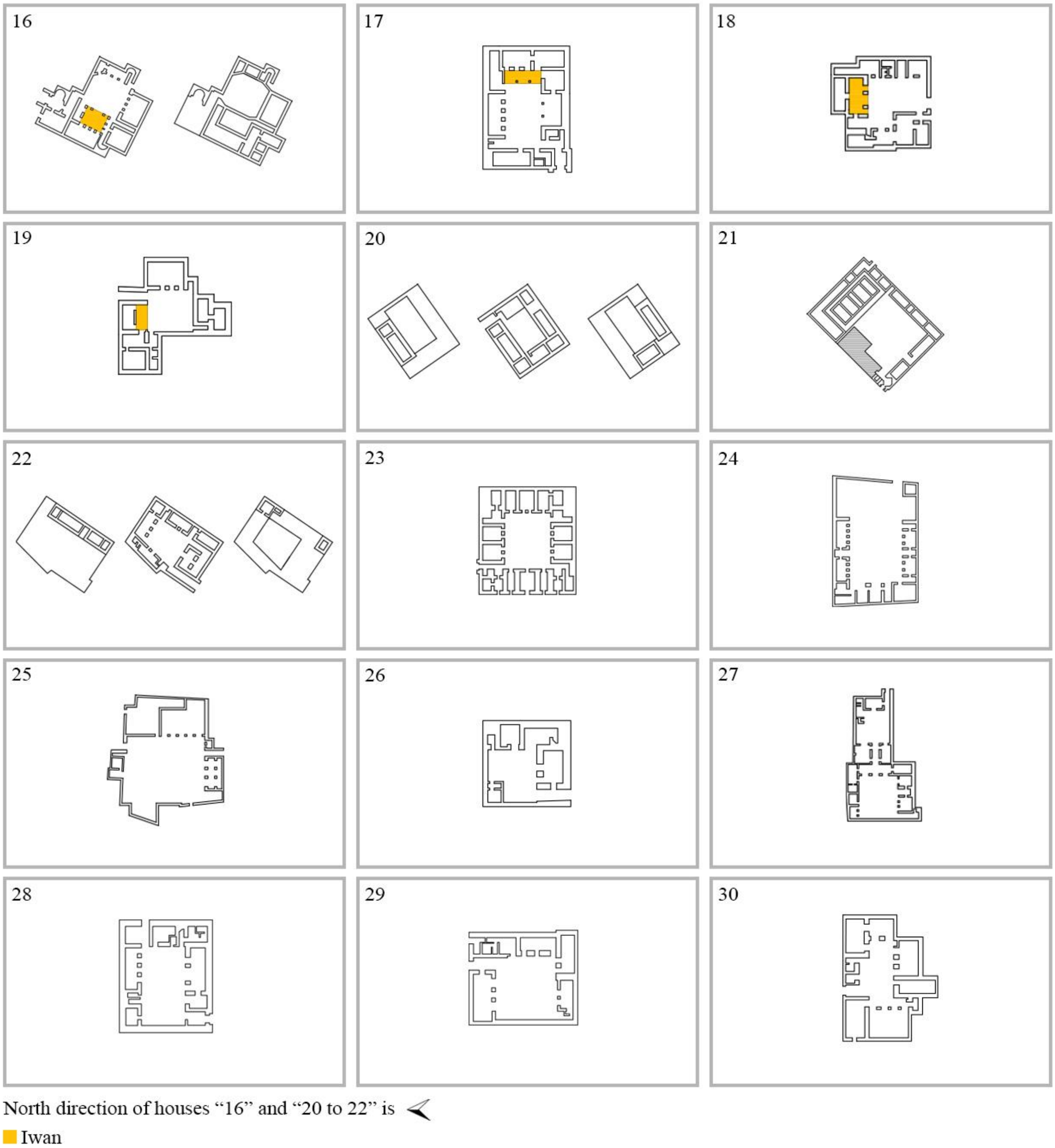


**Fig 3.** (continued)

Field documentation followed a standardized protocol. For each house, plans and sections were traced or verified on site; measurements were taken for key spans and depths; and photographs recorded thresholds, façades, covered passages (sabat), wind-catchers, and roof/wall build-ups. Using these materials, a structured codebook was applied to three morphological tables: Table 3 (Physical characteristics of houses) records storeys (basement/ ground/ first), plan form (near-square/ rectangular/ irregular), presence and number of iwans, rooms directly served by the iwan, and the type of iwan–room coupling (no/ one-way/ two-way) including the relative interface width (narrow/wide).

**Table 3.** Physical Characteristics of Houses

| House's physical characters | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storey | Underground | | | | ■ | | ■ | ■ | ■ | | | | ■ | | ■ | | ■ | | |
| | Ground | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | First | | | | ■ | ■ | ■ | ■ | | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Layout of building | Building form | Near square | | | | | | | | | | | | | | | | | |
| | | Near rectangle | | | | | | | | | ■ | ■ | | | | | | ■ | ■ |
| | | Irregular form | | | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ | ■ | ■ | ■ | | |
| | Room's* shape | Almost the same length of the iwan | One part* | No access* | ■ | | | | | | | ■ | ■ | ■ | ■ | ■ | | | |
| | | | | Access with a wide view | ■ | | ■ | | | | | | | | | | | | |
| | | | Two parts | | | | | | | | | | | ■ | | | | | ■ |
| | | Longer than the iwan | One part | No access | | | | | | ■ | | | | | ■ | | | | |
| | | | | Access with a narrow view | | | | ■ | ■ | | | | | | | | | ■ | |
| | | | | Access with a wide view | | ■ | | | | | | | | | | | | | |
| | | | Two parts | | | | | | | | ■ | | | | | | | | |
| | Room's adjacency* | One-way access | | | ■ | ■ | ■ | ■ | | | | | | ■ | | | | ■ | |
| | | Two-way access | | | | | | | ■ | | | | | | | | | | |
| Iwan | One iwan | | | | | ■ | ■ | | ■ | ■ | ■ | | ■ | | | ■ | ■ | | |
| | Two iwans | | | | ■ | | | ■ | | | | ■ | | ■ | ■ | | | ■ | ■ |

| House's physical characters | | | | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Storey | Underground | | | | | | | | ■ | | ■ | | | | | | | | |
| | Ground | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| | First | | | | ■ | | | | ■ | | ■ | | | | | | | | |
| Layout of building | Building form | Near square | | | | | | | | | | | | | ■ | | | | |
| | | Near rectangle | | | | ■ | | | ■ | ■ | ■ | ■ | ■ | | | | ■ | ■ | |
| | | Irregular form | | | ■ | | ■ | ■ | | | | | | ■ | | ■ | | | ■ |
| | Room's shape | Almost the same length of the iwan | One part | No access | | | ■ | ■ | | | | | | | | | | | |
| | | | | Access with a wide view | | | | | | | | | | | | | | | |
| | | | Two parts | | | | | | | | | | | | | | | | |
| | | Longer than the iwan | One part | No access | ■ | | | | | | | | | | | | | | |
| | | | | Access with a narrow view | | | | | | | | | | | | | | | |
| | | | | Access with a wide view | | | | | | | | | | | | | | | |
| | | | Two parts | | | ■ | | | | | | | | | | | | | |
| | Room's adjacency | One-way access | | | | | | | | | | | | | | | | | |
| | | Two-way access | | | | | | | | | | | | | | | | | |
| Iwan | One iwan | | | | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| | Two iwans | | | | | | | | | | | | | | | | | | |

*In this article, the "room" is the space located behind the iwan.
*In this article, "access" refers to the spaces on both sides of the room, except the side where the iwan is located.
*The "part" refers to the number of rooms behind the iwan.
*Room's "adjacency" refers to the spaces on both sides of the room, except the side where the iwan is located.

Table 4 (Physical characteristics of iwans) documents seasonal orientation (summer/winter; noting alignment with prevailing winds where applicable), iwan length as façade coverage (less than half/about half/more than half/all of the façade), depth relative to the principal room, and lateral neighbourhood (no/one-way/two-way side access).

Table 5 (Features related to the courtyards) records courtyard structure (central/three-sides/separated), approximate courtyard-to-plot share (banded), and indicative length-to-width ratios (banded, including irregular forms). In the Methodology, we report these variables descriptively and defer all interpretation and comparison to the Results and Discussion.

Bioclimatic benchmarking followed the Mahoney tables (Szokolay & Koenigsberger, 1973). Monthly climate from Table 2 was entered to derive thermal diagnoses (day/night comfort bands) and the associated design indications (e.g., thermal storage, outdoor sleeping, opening size/position, protection, mass/insulation, spacing/compactness). The design cross-walk used in this study appears as Table 14, which maps Mahoney's indications to architectural features observable in Lar (e.g., compact courtyard planning, protected small/medium openings, heavy walls/roofs with time-lag, drainage provision). These guidance items are used in the Results as an external frame of reference; no simulation was undertaken.

An expert-oriented questionnaire was developed to elicit priorities across environmental factors (e.g., temperature/sunlight, wind, rainfall, humidity, topography, vegetation, soil, natural features) and cultural factors (e.g., historical/architectural background, place-mediated practices, religion, livelihoods, customs, arts, language, age/gender groupings, tribal structures). The instrument used a 5-point Likert scale and was refined through pilot feedback. A total of 218 experts in architecture, urban design/planning, building conservation, and related fields were recruited through professional networks, academic departments, and municipal/heritage bodies; inclusion required relevant training and at least three years of practice or research experience in hot-arid contexts. Responses were anonymous and voluntary. Internal consistency was assessed, yielding Cronbach's $\alpha = 0.91$. The analysis plan (reported in the Results) employs descriptive summaries and, for within-respondent prioritization, the Friedman test for related samples with Kendall's W as effect size; where single-item comparisons to a neutral anchor are noted, one-sample t-tests are complemented by non-parametric sensitivity checks. Inferential modelling beyond rankings was not the aim; the survey serves to situate and interpret the spatial evidence rather than to estimate population parameters.

Quality assurance measures included double-entry of a subset of dwelling records, field note reconciliation, and independent cross-checks of coding for a random sample of cases with resolution by consensus. Figure and table captions identify data sources and clarify what each sheet or panel shows to aid reproducibility. The principal limitations are the non-probabilistic sample of dwellings (analytic rather than statistical generalization), the reliance on banded/ordinal coding for certain geometric relations in heritage conditions, and the expert sample's concentration in built-environment professions. These constraints are acknowledged in the Discussion and inform the scope of claims.

**Table 4.** Physical Characteristics of Iwans

| Iwan's physical characters | | House numbers | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | 2 | 3 | 4 | | 5 | 6 | 7 | 8 | | 9 | 10 | | 11 | | 12 | 13 | 14 | | 15 | | 16 | 17 | 18 | 19 |
| | | Summer | Winter | | | Summer | Winter | | | | Summer | Winter | | Summer | Winter | Summer | Winter | | | Summer | Winter | Summer | Winter | | | | |
| Orientation | Summer residence | ■ | | ■ | | ■ | | ■ | ■ | | ■ | | | ■ | | ■ | | ■ | | ■ | | ■ | | | | | |
| | Winter residence | | ■ | | ■ | | ■ | | | ■ | | ■ | ■ | | ■ | | ■ | | ■ | | ■ | | ■ | ■ | | | |
| | Almost in the main direction of the wind | | ■ | | | | ■ | | | | | ■ | | | ■ | | ■ | ■ | | | ■ | ■ | | | | | |
| Length | All facade | ■ | ■ | | ■ | | | | | ■ | | | | | | | | | | | | | | | ■ | | |
| | Almost half the facade | | | | | | | ■ | | | | | | | | | | | | | | | | | | | |
| | More than half the facade | | | ■ | | ■ | ■ | | ■ | | ■ | ■ | | | ■ | ■ | ■ | ■ | | | ■ | ■ | ■ | ■ | | ■ | ■ |
| | Less than half the facade | | | | | | | | | | | | ■ | ■ | | | | | ■ | | | | | | | | |
| Depth | Almost the same size as the room | | | | | | | | | | | | | | | | | | | ■ | | | | | | | ■ |
| | More than the room | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | | ■ | | ■ | ■ | ■ | ■ | | | | | | ■ | | ■ | |
| | Less than the room | | | | | | | | | | | | | ■ | | | | | | ■ | | ■ | ■ | | ■ | | |
| Neighborhood* | No access | ■ | ■ | | | | | | | | | | ■ | | | | | | | | | | | | | | |
| | One-way access | | | | ■ | | | | ■ | ■ | | | | | | | | ■ | | | ■ | | | | ■ | ■ | ■ |
| | Two-way access | | | ■ | | ■ | ■ | ■ | | | ■ | ■ | | ■ | ■ | ■ | ■ | | ■ | ■ | | ■ | ■ | ■ | | | |

*Iwan's "Neighborhood" refers to the spaces on both sides of the iwan, except the sides where the room(s) behind it and the courtyard are located.

■ Summer iwan

■ Winter iwan

**Table 5.** Features Related to the Courtyards

| Features related to the courtyards | | House numbers | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Courtyard structure according to mass pattern | Three sides construction | ■ | ■ | | | | | ■ | | | | | | ■ | | |
| | Central courtyard | | | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ | ■ | | ■ | ■ |
| | Seprated construction | | | | | | | | | | | | | | | |
| The percentage of courtyard area to the total land | 0-20 | | ■ | ■ | ■ | | | | | | | | | | | |
| | 20-30 | ■ | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ |
| | 30-40 | | | | | | | | | | | | | ■ | | |
| | 50-60 | | | | | | | | | | | | | | | |
| The approximate ratio of the length to the width | Irregular | | | | | | | ■ | | | | | ■ | | | |
| | 1 | | | | | | | | | | | | | ■ | | |
| | 1/1 | | | ■ | | | | | ■ | ■ | | | | | | ■ |
| | 1/2 | | | | | ■ | ■ | | | | ■ | ■ | | | ■ | |
| | 1/3 | ■ | | | | | | | | | | | | | | |
| | 1/4 | | | | ■ | | | | | | | | | | | |
| | 1/8 | | ■ | | | | | | | | | | | | | |
| | 1/9 | | | | | | | | | | | | | | | |
| Features related to the courtyards | | House numbers | | | | | | | | | | | | | | |
| | | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Courtyard structure according to mass pattern | Three sides construction | ■ | | ■ | ■ | ■ | | | | | ■ | | ■ | ■ | ■ | |
| | Central courtyard | | ■ | | | | ■ | ■ | ■ | | | | | | | ■ |
| | Seprated construction | | | | | | | | | ■ | | ■ | | | | |
| The percentage of courtyard area to the total land | 0-20 | ■ | | | | | | | | | | | | | | |
| | 20-30 | | ■ | ■ | ■ | | | ■ | ■ | | | ■ | ■ | | | ■ |
| | 30-40 | | | | | ■ | ■ | | | | | | | ■ | ■ | |
| | 50-60 | | | | | | | | | ■ | ■ | | | | | |
| The approximate ratio of the length to the width | Irregular | | | ■ | | | ■ | | | ■ | ■ | ■ | | | | ■ |
| | 1 | | | | | | | | | | | | | | ■ | |
| | 1/1 | ■ | | | ■ | | | | | | | | ■ | | | |
| | 1/2 | | | | | | | ■ | ■ | | | | | | | |
| | 1/3 | | | | | | | | | | | | | | | |
| | 1/4 | | | | | | | | | | | | | | | |
| | 1/8 | | ■ | | | | | | | | | | | ■ | | |
| | 1/9 | | | | | ■ | | | | | | | | | | |

## RESULTS

### *Factors Affecting the Formation of Vernacular Architecture*

The expert questionnaire showed high internal consistency (Cronbach's α = 0.91) and a broad respondent profile (Table 6; Chart 1).

Rankings obtained with Friedman's test indicate that within the environmental domain, "temperature and sunlight" was the highest-priority item among atmospheric–climatic factors, followed by rainfall, wind and humidity, while the leading items among physical conditions were topography/orientation and the presence of natural elements (Table 7; $\chi^2 = 147.326$, df = 7, $p < 0.001$). Within the cultural domain, "historical and architectural background of the region" and "place-mediated behavioral patterns" led the priorities, with local customs and livelihoods also rated highly (Table 8; $\chi^2 = 591.074$, df = 9, $p < 0.001$).

Perceived interrelations between domains were explored using the communication matrix (Table 9). The strongest reported linkage was between physical characteristics of areas and atmospheric–climatic conditions (mean = 4.16, SD = 0.97), with other comparatively strong ties between "time" and "place" (mean = 3.81, SD = 1.06) and between atmospheric–climatic conditions and "place" (mean = 3.56, SD = 1.10). Weaker couplings were noted between physical area and beliefs (mean = 3.27, SD = 1.24). Taken together, Tables 7–9 confirm that experts view climate (especially heat/sun) and place-based practice/heritage as the principal drivers shaping vernacular form.

**Table 6.** Frequency Distribution of Participants' Responses (from the Left Side), by Gender, Age, and Education

| Gender | Frequency | Percentage | Age | Frequency | Percentage | Education | Frequency | Percentage |
|---|---|---|---|---|---|---|---|---|
| Female | 104 | 47.8 | 20-25 | 51 | 23.4 | Master | 163 | 74.8 |
| Male | 114 | 52.2 | 26-30 | 79 | 36.2 | Ph.D. and above | 55 | 24.8 |
| Total | 218 | 100 | Above 30 | 88 | 40.4 | Total | 218 | 100 |
| | | | Total | 218 | 100 | | | |

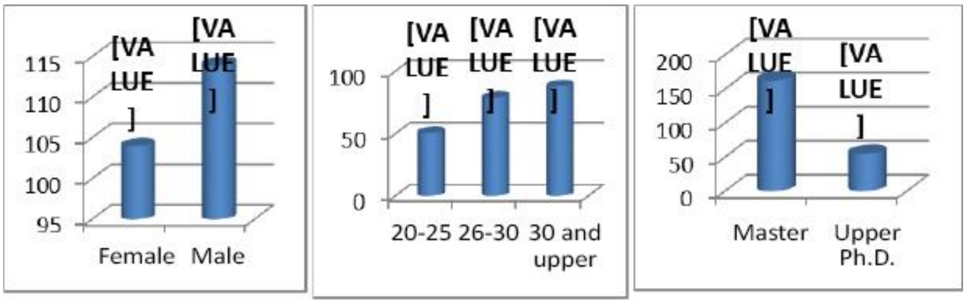


**Chart 1.** Frequency Distribution of Participants' Responses (from Left to Right), by Gender, Age, and Education

**Table 7.** The Results of Friedman's Ranking for Prioritizing the Indicators of Environmental Factors

| Components | Number | Indicators | Average Rank |
|---|---|---|---|
| Physical conditions of the area | 1 | Topography and its directions | 4.92 |
| | 2 | Vegetation | 3.64 |
| | 3 | Soil type | 3.38 |
| | 4 | The presence of some natural elements, such as rivers, mountains, etc. | 4.94 |
| Atmospheric-climatic conditions | 5 | Temperature and sunlight | 5.34 |
| | 6 | Rainfall | 4.79 |
| | 7 | Humidity | 4.30 |
| | 8 | Wind | 4.69 |
| | Chi-Square=147/326 | Df=7 | Sig=0/000 |

**Table 8.** The Results of Friedman's Ranking for Prioritizing the Indicators of Cultural Factors

| Components | Number | Indicators | Average Rank |
|---|---|---|---|
| Time | 1 | Historical and architectural background of the region | 7.62 |
| Place | 2 | Gender of spatial identity and behavioral patterns influenced by place | 7.28 |
| Beliefs | 3 | Social groups with a common language | 3.43 |
| | 4 | Social groups with common religion and religious beliefs | 5.52 |
| | 5 | Social groups with similar livelihoods or homogeneous economic level | 5.66 |
| | 6 | Local customs | 6.60 |
| | 7 | Local arts | 5.41 |
| | 8 | Social groups with the same gender | 3.34 |
| | 9 | Social groups with similar age ranges | 3.53 |
| | 10 | Tribal structures | 6.60 |
| | Chi-Square=591/074 | Df=9 Sig=0/000 | |

**Table 9.** Distribution of Frequency of Communication Between Components

| Components | Standard deviation | Mean | | Communication | | | | | No communication |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Very much | Much | Middle | Low | Very low | |
| 1. Physical characteristics of areas 2. Atmospheric-climatic conditions | 0.97 | 4.16 | Freq. | 96 | 80 | 25 | 9 | 6 | 2 |
| | | | PCT. | 44.0 | 36.7 | 11.5 | ¼ | 2.8 | 0.9 |
| 1. Physical characteristics of areas 2. Time | 1.09 | 3.60 | Freq. | 50 | 60 | 63 | 20 | 9 | 16 |
| | | | PCT. | 22.9 | 27.5 | 28.9 | 9.2 | ¼ | 7.3 |
| 1. Physical characteristics of areas 2. Place | 1.02 | 3.77 | Freq. | 59 | 69 | 58 | 16 | 5 | 11 |
| | | | PCT. | 27.1 | 31.7 | 26.6 | 7.3 | 2.3 | 5.0 |
| 1. Physical characteristics of areas 2. Set of beliefs | 1.24 | 3.27 | Freq. | 40 | 43 | 58 | 32 | 19 | 26 |
| | | | PCT. | 18.3 | 19.7 | 26.6 | 14.7 | 8.7 | 11.9 |
| 1. Atmospheric-climatic conditions 2. Time | 1.17 | 3.55 | Freq. | 45 | 75 | 44 | 23 | 15 | 16 |
| | | | PCT. | 20.6 | 34.4 | 20.2 | 10.6 | 6.9 | 7.3 |
| 1. Atmospheric-climatic conditions 2. Place | 1.10 | 3.56 | Freq. | 47 | 70 | 52 | 32 | 7 | 7 |
| | | | PCT. | 21.6 | 32.1 | 23.9 | 14.7 | 3.2 | 3.2 |
| 1. Atmospheric-climatic conditions 2. Set of beliefs | 1.24 | 3.21 | Freq. | 38 | 41 | 54 | 40 | 18 | 27 |
| | | | PCT. | 17.4 | 18.8 | 24.8 | 18.3 | 8.3 | 12.4 |
| 1. Time 2. Place | 1.06 | 3.81 | Freq. | 63 | 83 | 42 | 20 | 7 | 3 |
| | | | PCT. | 28.9 | 38.1 | 19.3 | 9.2 | 3.2 | 1.4 |
| 1. Time 2. Set of beliefs | 1.04 | 3.62 | Freq. | 48 | 70 | 65 | 20 | 7 | 8 |
| | | | PCT. | 22.0 | 32.1 | 29.8 | 9.2 | 3.2 | 3.7 |
| 1. Place 2. Set of beliefs | 1.13 | 3.63 | Freq. | 60 | 61 | 55 | 31 | 7 | 4 |
| | | | PCT. | 27.5 | 28.0 | 25.2 | 14.2 | 3.2 | 1.8 |

### *Architectural Performance of Vernacular Design in Historical Lar*

Read against these expert priorities, the 30 documented houses (Fig. 3) exhibit a coherent suite of climate-responsive configurations at urban, dwelling, and element scales. Below, we report the salient patterns directly evidenced in the classification tables and figure set.

***Urban Grain, Passages, and Shade–Ventilation Devices***

The historic fabric is compact and water-anchored (Yekkeh, 2018): routes converge radially on the reservoirs (Ab Anbar) and the floodway defines edge conditions (Fig. 4).

Narrow, sinuous alleys and extensive sabats provide continuous shade, microclimatic rest points and wind re-direction (Fig. 5).

The generally uniform skyline and the coupling of cellars with courtyards promote air movement and purge potential (Fig. 6).

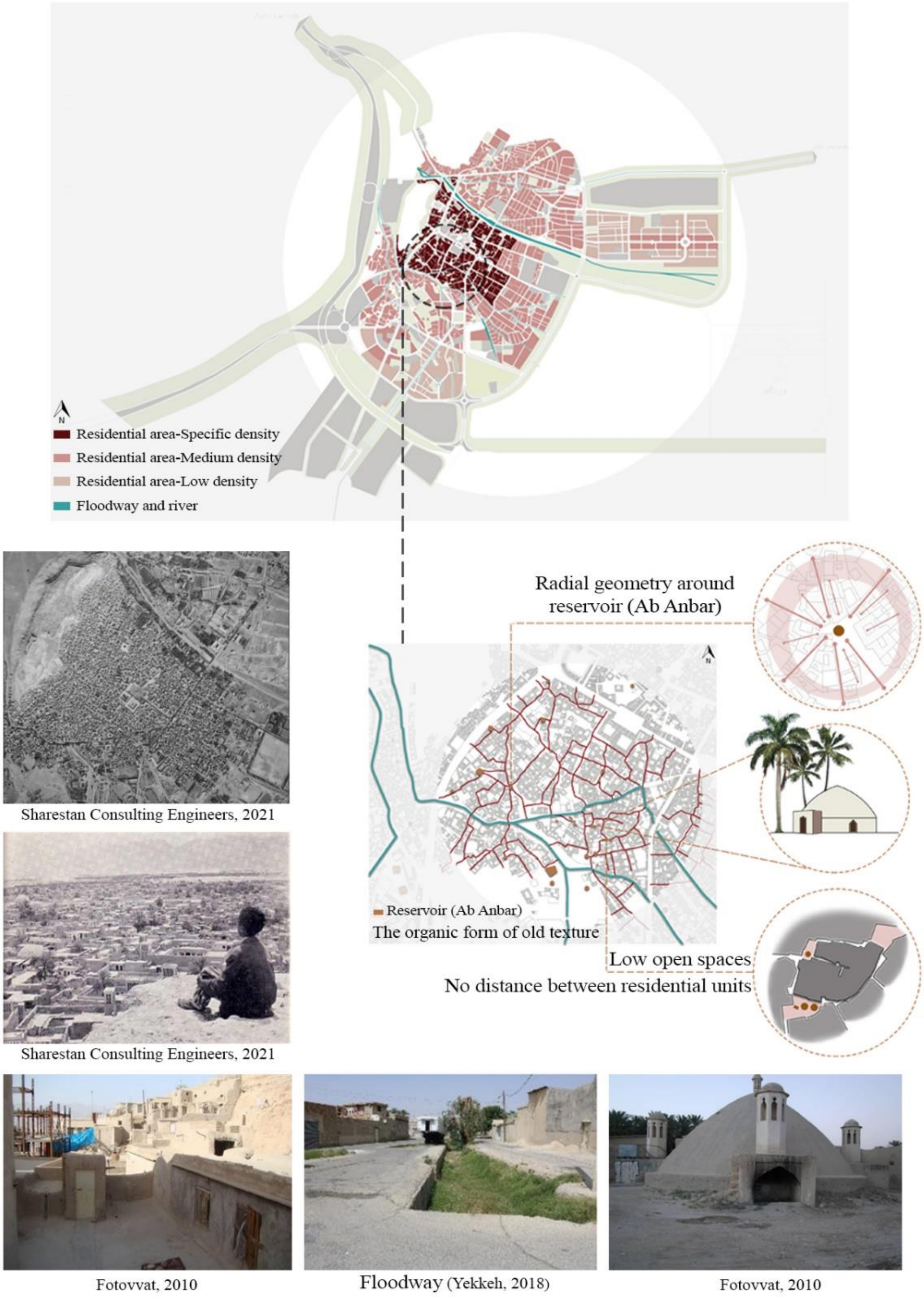


**Fig 4.** Data Sheet of Texture and Settlement Pattern

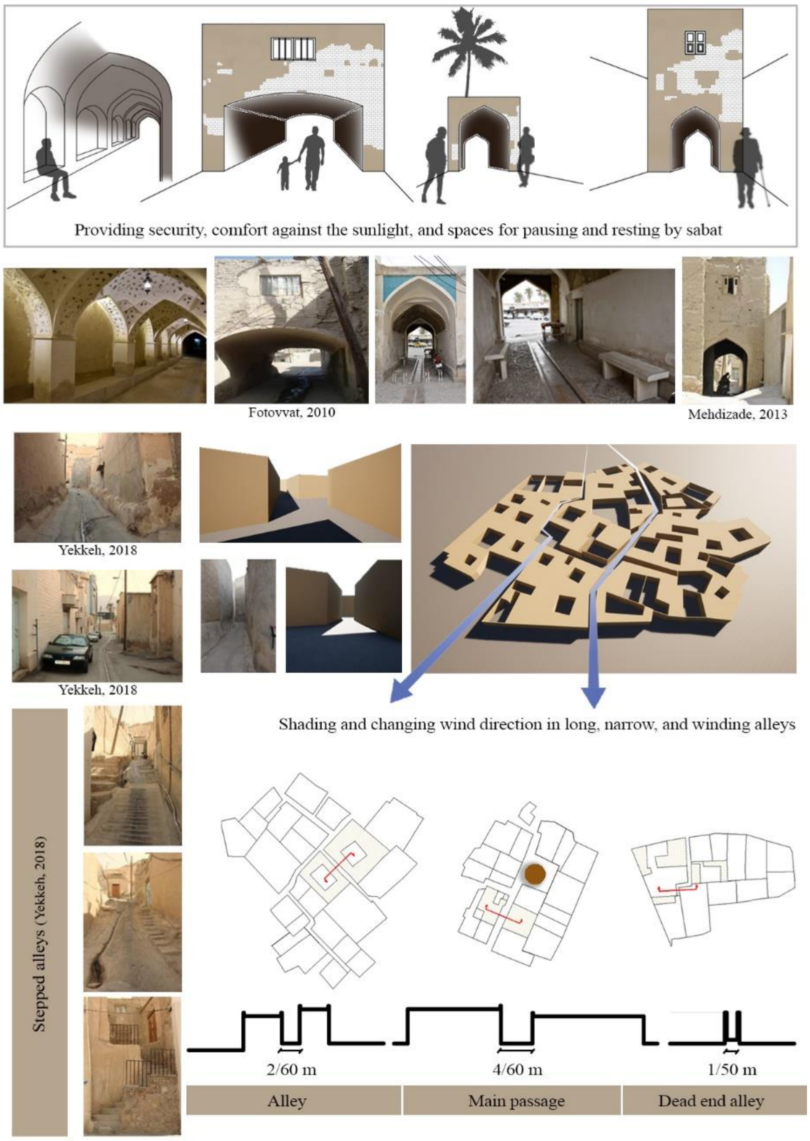


**Fig 5.** Data Sheet of the Passages and Function of Sabat

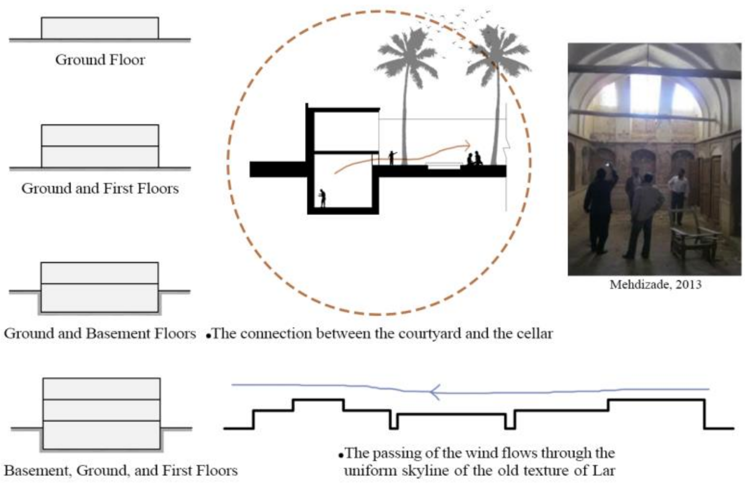


**Fig 6.** Data Sheet Related to the Exterior View and Floors

### *Thresholds and Privacy Filters*

Entrances combine deep reveals, vestibules and small seating platforms, producing shaded thresholds and layered access (Fig. 7).

These arrangements foreshadow recessed façade openings and internal privacy loops that reappear at the dwelling scale (Figs. 10–11).

### *Dwelling Mor0phology*

Across the sample, ground floors are ubiquitous, with first floors frequently present and basements occurring intermittently (Table 3); the sectional variations shown in Fig. 6 (ground–first; ground–basement; three levels) match the entries recorded in Table 3. Near-rectangular plans dominate, with a smaller share of near-square and irregular plots (Table 3), aligning with the compact grain mapped in Fig. 3. Of the 30 houses, 19 include an iwan (as noted in Methods and highlighted in Fig. 3) and the remainder are without; where present, the rooms behind the iwan are configured either as a single part or two parts, and their length is commonly equal to or longer than the iwan frontage (Table 3; Fig. 8). Adjacency to flanking spaces is most often provided from the iwan—one-way or two-way—while "no access" cases are less common (Table 3; Fig. 8), an arrangement that supports cross-ventilation through the semi-open space while preserving privacy.

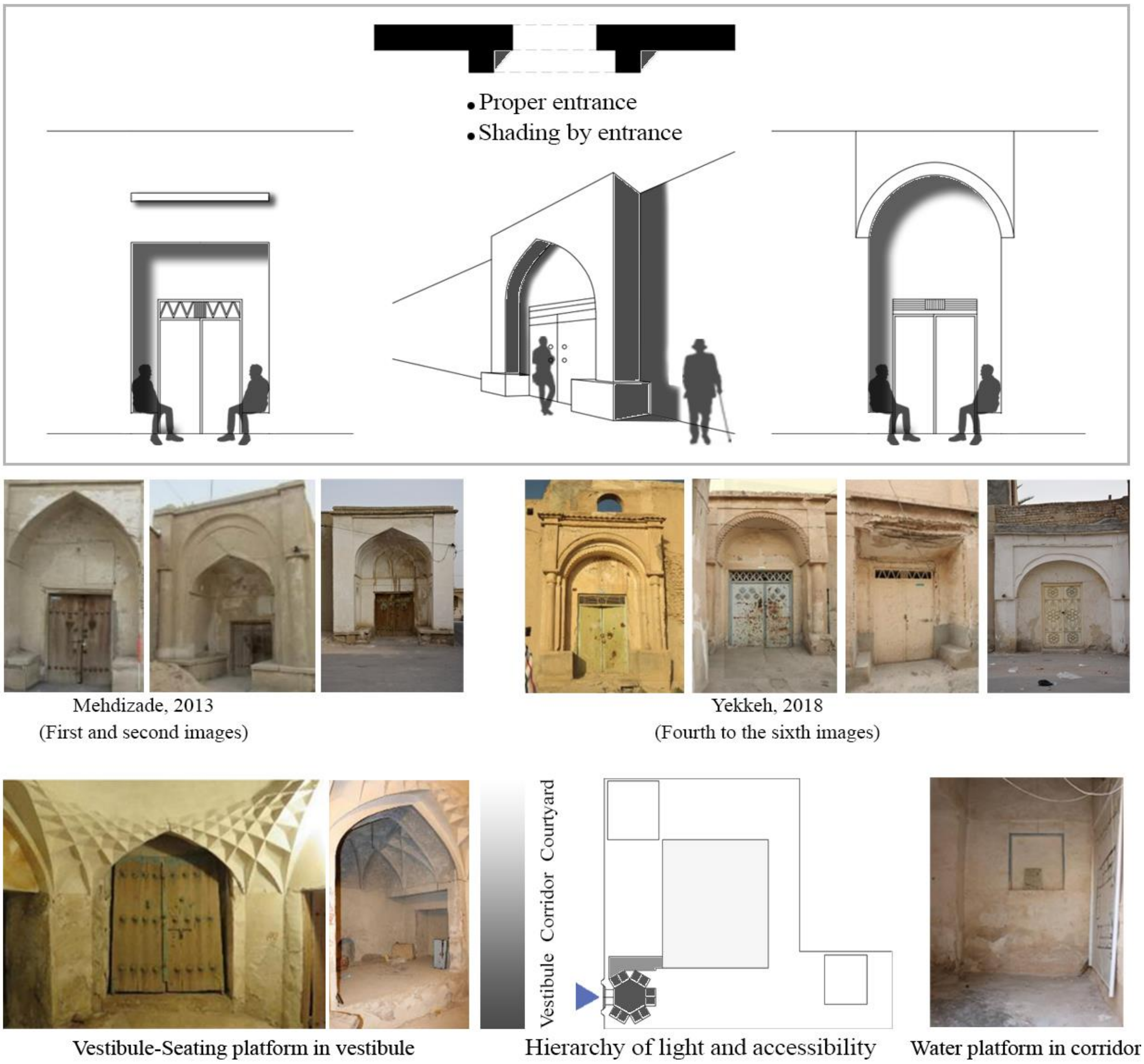


**Fig 7.** Data Sheet of the Entrance

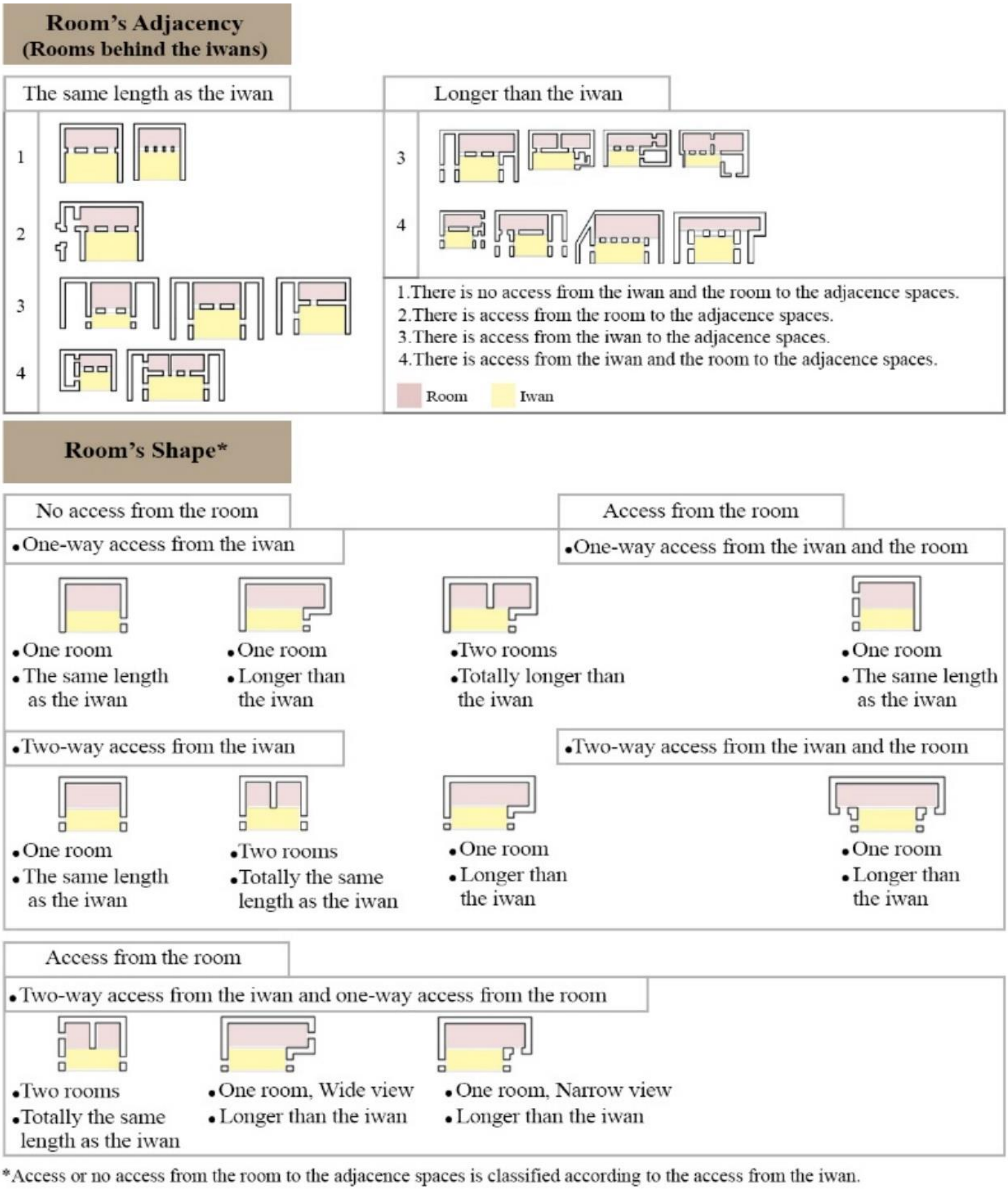


**Fig 8.** Data Sheet of the Configuration of Rooms

***Iwan Characteristics***

Most iwans are identified as summer-oriented, with a smaller group winter-oriented; several are aligned close to the prevailing wind direction noted for Lar (Table 4; Fig. 15). Regarding length along the façade, the modal classes are "almost half of the façade" and "less than half of the façade," while "all-façade" iwans are rare (Table 4; Fig. 15). In depth relative to the served room, the most frequent condition is an iwan depth approximately equal to the depth of the principal room; deeper iwans occur, and shallower ones are least common (Table 4; Fig. 15). For neighborhood (access), two-way and one-way access from the iwan to adjacent spaces are both well represented, with "no access" the minority pattern (Table 4; Fig. 15). These attributes explain the seasonal use illustrated in Fig. 9: deep, summer-facing iwans buffer solar load and mean radiant temperature in hot months, while winter-facing iwans allow controlled solar penetration during cooler periods.

***Openings, Mashrabiyas, and Windows***

Openings are recessed within thick walls, reducing direct solar gains (Fig. 10). Windows and door-windows are concentrated on ground and first floors, frequently above entrances or iwans, and mashrabiyas are placed above doors/entrances to induce the extraction of warm air and permit filtered light (Fig. 11). The photographic set in Fig. 11 corroborates these placements across multiple houses.

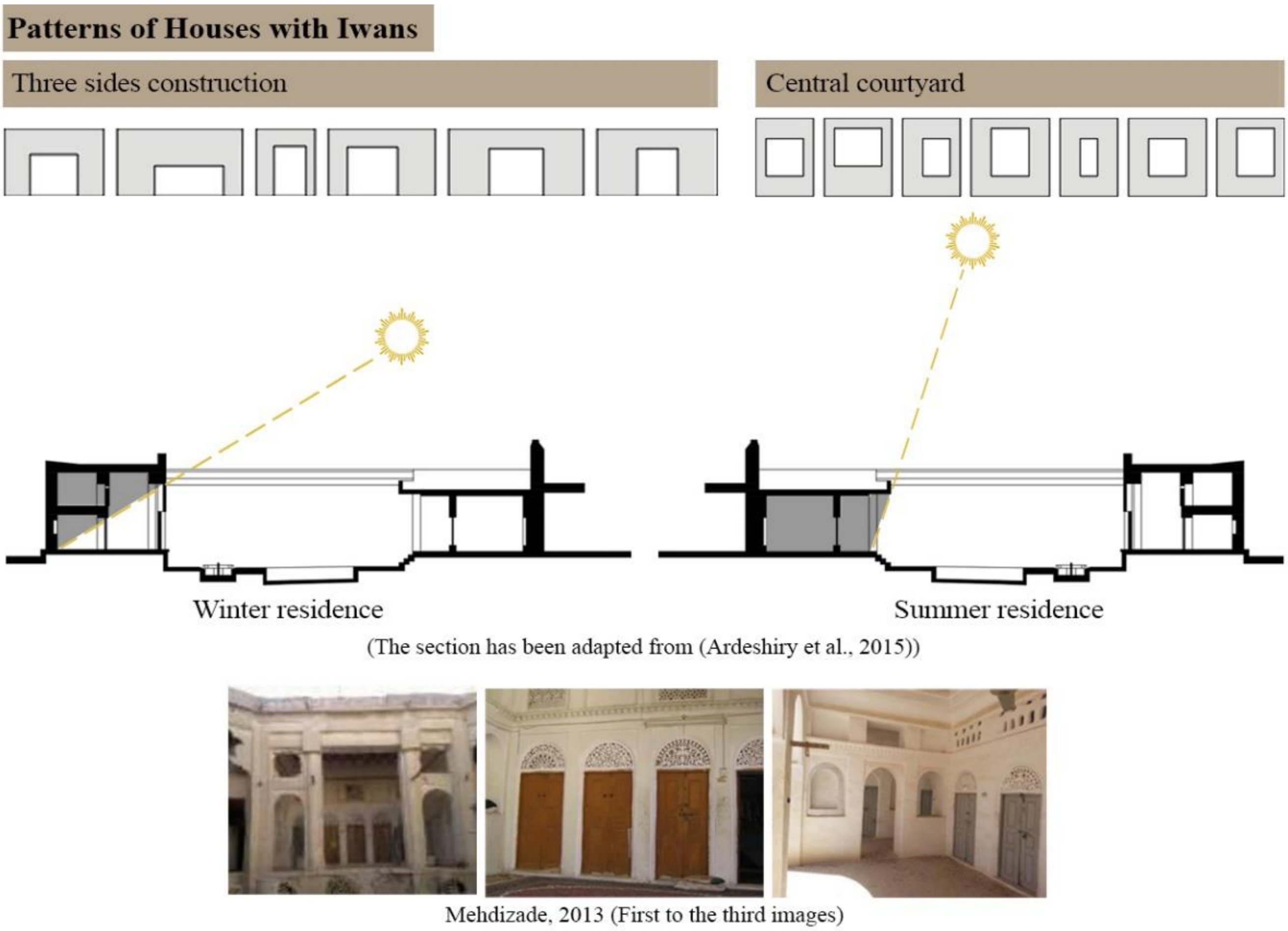


**Fig 9.** Data Sheet of the Patterns of Houses with Iwans and Winter-summer Residence

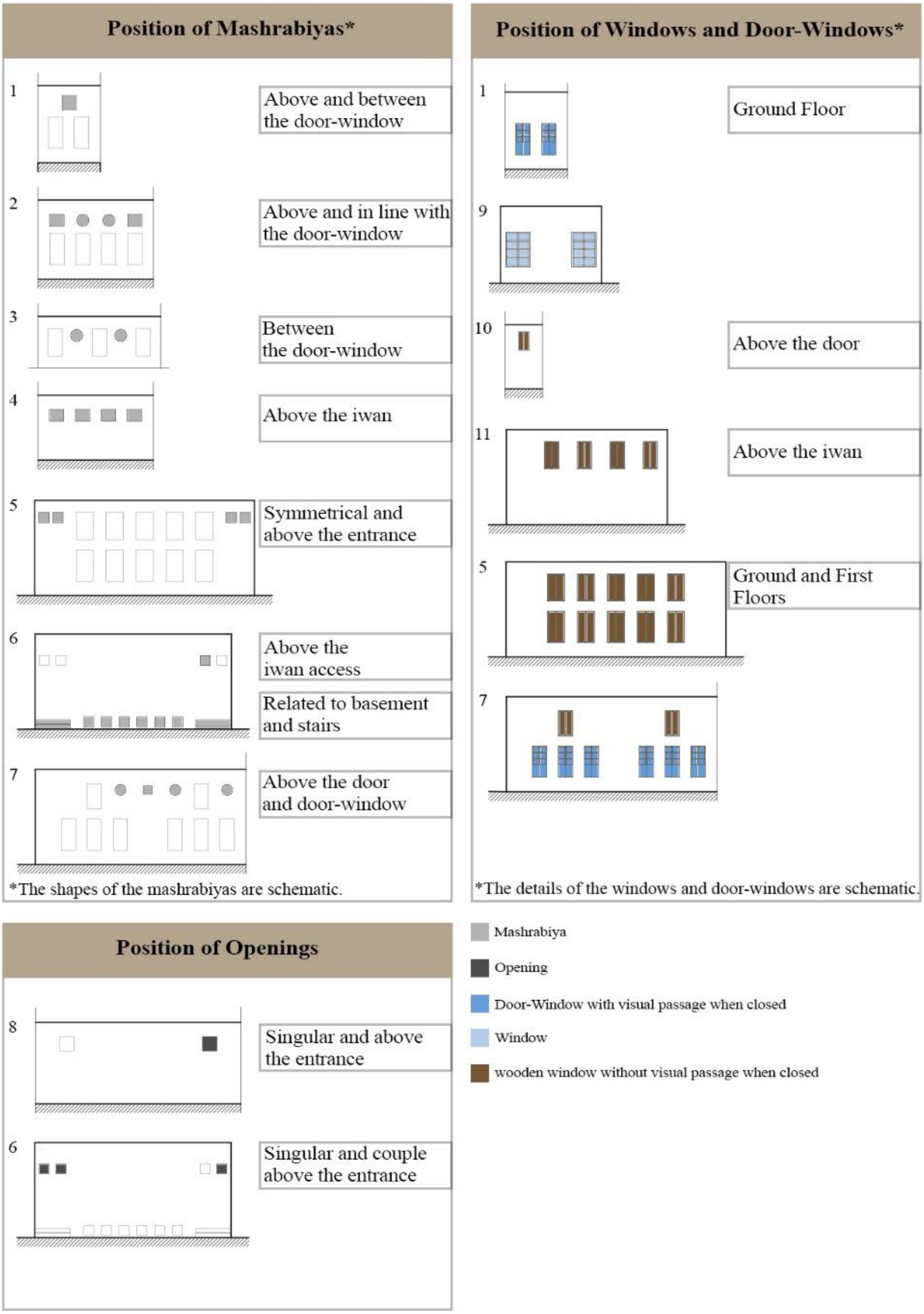


**Fig 10.** Data Sheet of the Position of Mashrabiyas, Openings, Windows, and Door-windows

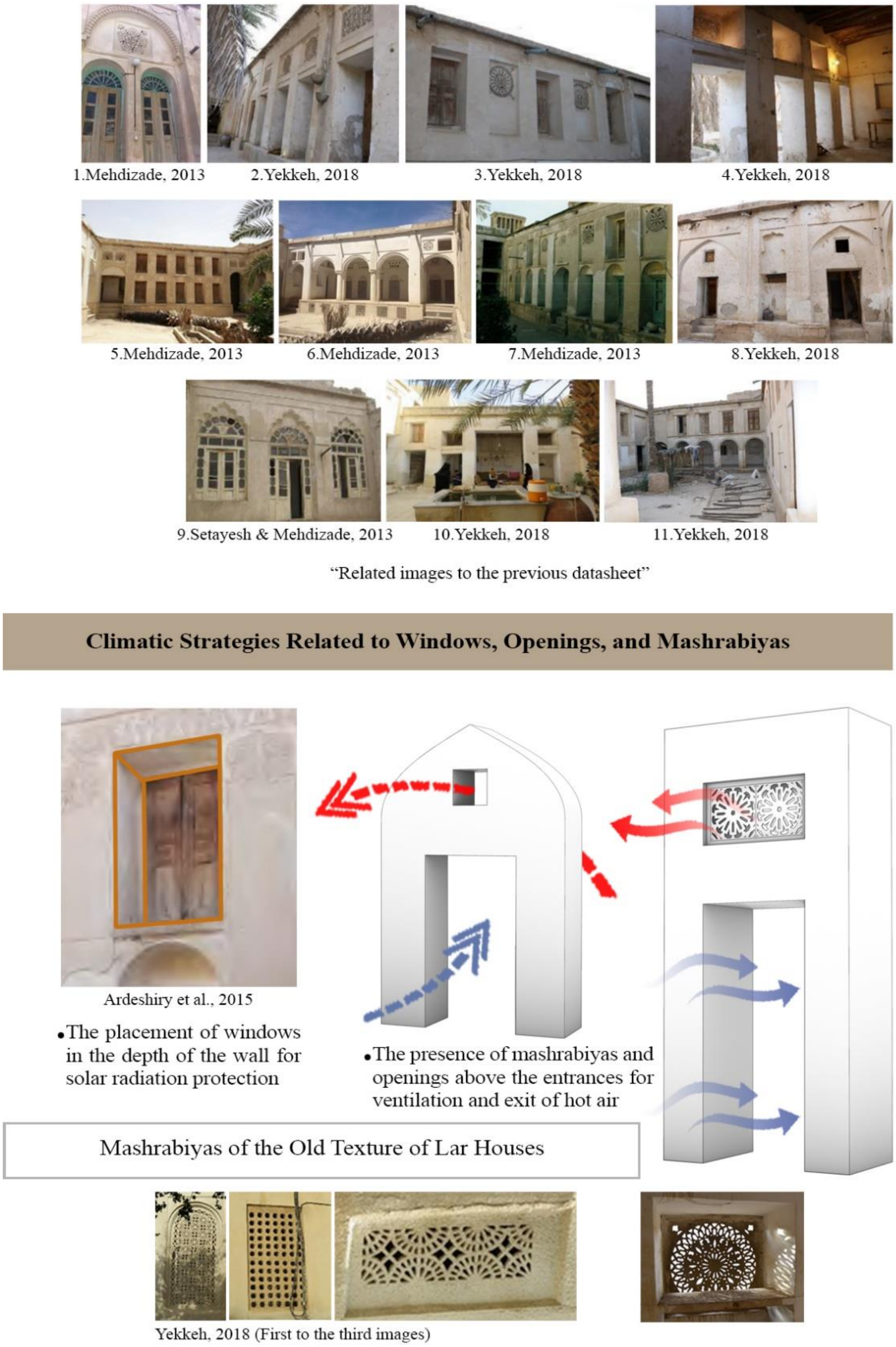


**Fig 11.** Data Sheet of the Mashrabiyas, Openings, and Windows

***Wind Catchers and Ventilation Rooms***

Short, wide badgirs (wind catchers) deliver air to interior spaces and support purge ventilation through connected volumes (Fig. 12). The section diagram and the dedicated wind-tower room photographs (Fig. 12) display the intended flow paths consistent with the prevailing winds reported for Lar.

***Envelope and Materials***

Roofs and walls employ indigenous systems—timber elements (Tir–Mahr), straw/plaster, and earthen construction—providing thermal mass and time-lag benefits; parapets supply shading and privacy (Fig. 13). Projected–recessed wall profiles cast self-shade (Fig. 13).

***Courtyard structure and proportion***

Courtyards occur predominantly in three-sided and central-court compositions, with separated courts present but less frequent (Table 5; upper panels of Fig. 14). Most inner yards fall in the 20–40% range of plot area, while very small (0–20%) or very large (50–60%) shares are uncommon (Table 5). Length-to-width ratios cluster around 1:2 and 1:3, with occasional 1:1, 1:4, and irregular forms (Table 5). Taken together, these proportions match the courtyard's role as the house's climatic "turning point," reinforced by trees and water, which moderate microclimate and steer breezes (Fig. 14).

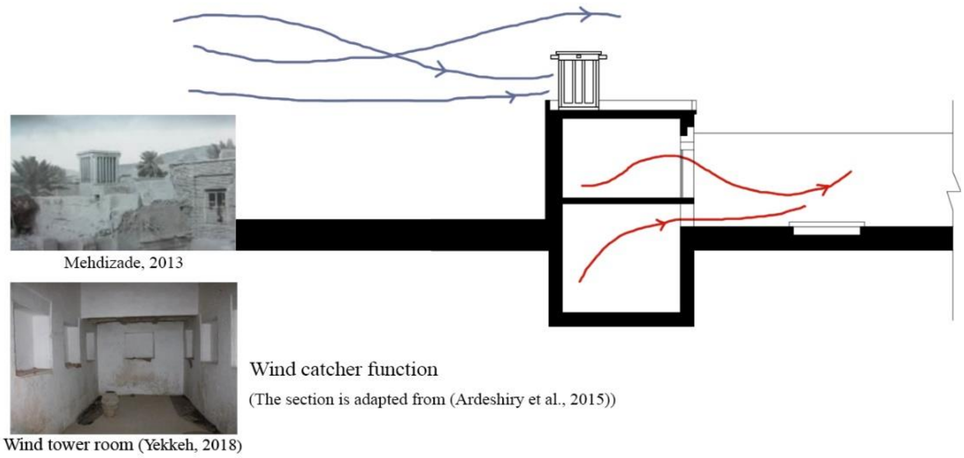


**Fig 12.** Data Sheet of the Wind Catcher Function

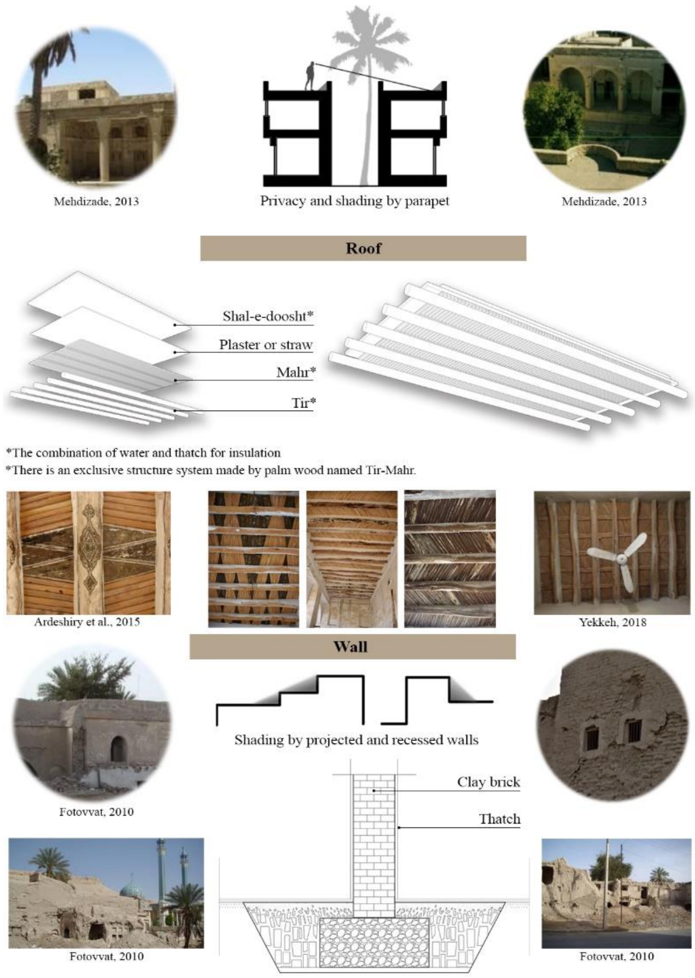


**Fig 13.** Data Sheet of the Construction Techniques and Materials of the Roof and Wall

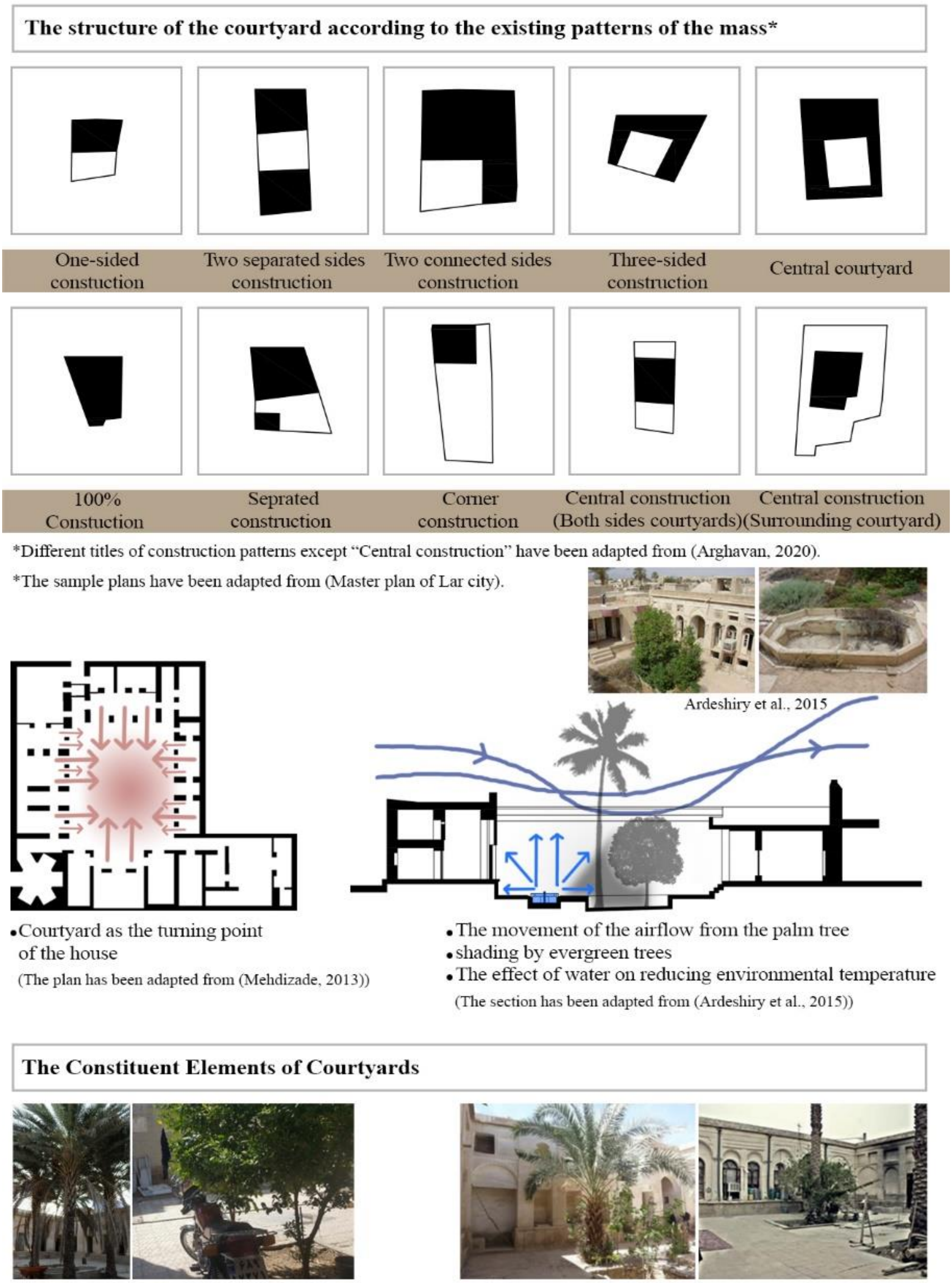


**Fig 14.** Data Sheet of the Courtyard Structure

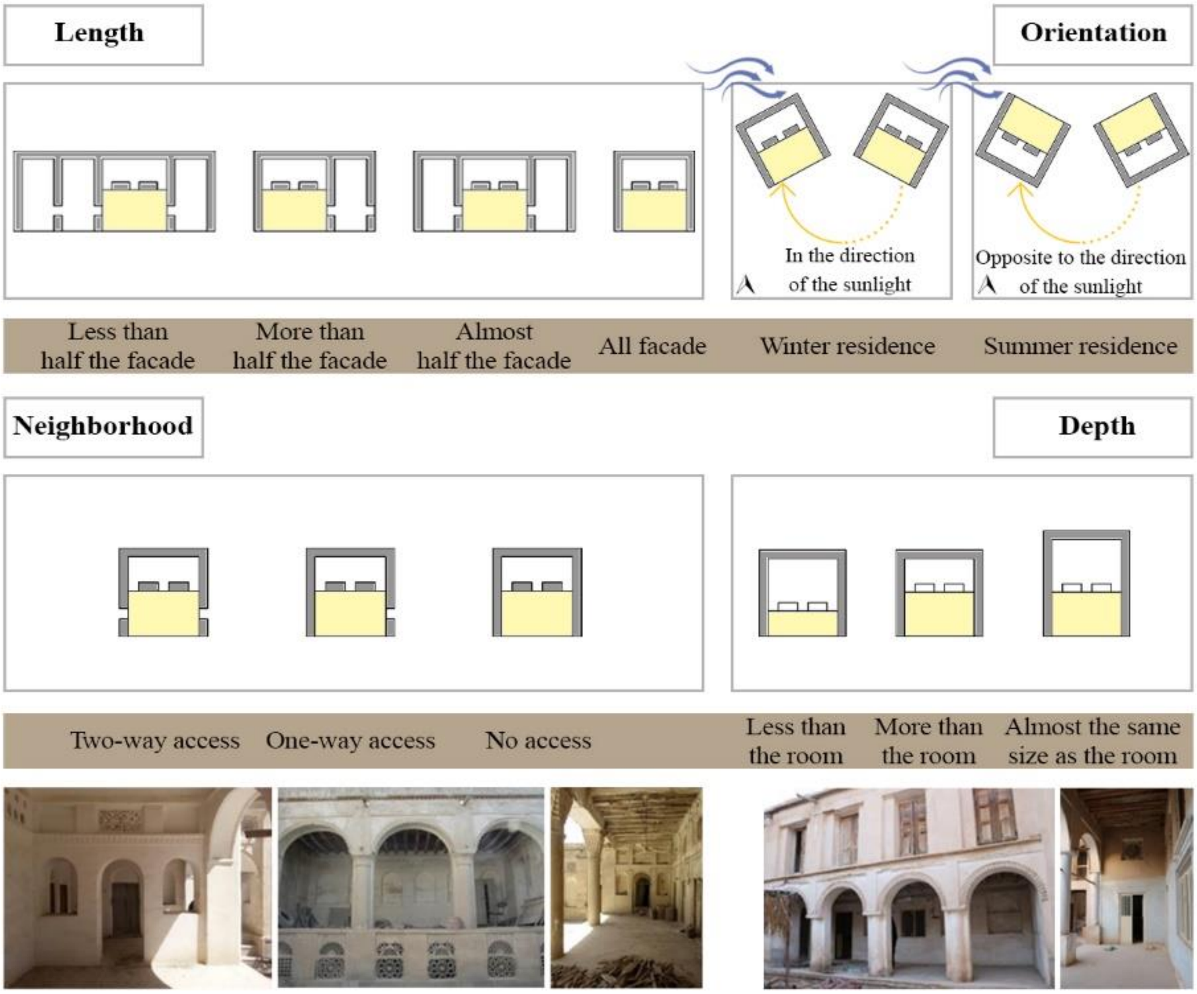


**Fig 15.** Data Sheet of the Orientation, Length, Depth, and Neighborhood of the Iwan

## DISCUSSION

Expert rankings confirm that "temperature and sunlight" dominate environmental priorities and that "historical/architectural background" and place-mediated practices lead cultural priorities (Tables 7–8). The communication matrix (Table 9) indicates strong perceived coupling between physical setting and climate, and between time and place. These priorities are legible in the fabric itself: compact blocks anchored by water infrastructure (Fig. 4), shaded pedestrian continuity via sabats (Fig. 5), layered thresholds (Fig. 7), and the systematic use of iwans and courtyards (Figs. 9, 14–15). In short, the culture–climate–form triad emphasized by experts is borne out by the measured morphology of Lar's historic dwellings. Across the 30 cases, three mechanism families recur:

(i) Solar control and mean radiant temperature (MRT) reduction. Deep transitional spaces and recessed apertures do the primary work. Iwans occur in 19 houses and are most often summer-oriented, with depths commonly comparable to the rooms they serve and lengths typically below "full façade" (Table 4; Fig. 15). Entrances and openings are set back within thick walls and paired with mashrabiyas positioned above doors or iwans to filter light and vent warm air (Figs. 10–11). Courtyard proportions—predominantly three-sided or central arrangements with area shares in the mid ranges and length–width ratios clustered around 1:2–1:3—maintain shaded exposure while permitting controlled solar access (Table 5; Fig. 14).

(ii) Ventilation potential. At street scale, narrow canyons and frequent sabats guide breezes and maintain shaded continuity (Figs. 4–5). At building scale, adjacency patterns give one- or two-way access from the iwan to flanking spaces (Table 3; Fig. 8), supporting cross-flow without sacrificing privacy. Short, wide wind-catchers supplement this system and discharge into dedicated rooms or upper volumes (Fig. 12), consistent with Lar's prevailing winds.

(iii) Thermal mass and time-lag. Roofs and walls employ indigenous assemblies (Tir–Mahr timber elements, straw/plaster, clay, and thatch) and projected–recessed profiles that both damp diurnal swings and cast self-shade (Fig. 13). These envelope choices align with Mahoney's strong indication for heavy construction for Lar's climate (Table 13).

The Mahoney diagnosis (Tables 12–14) calls for compact planning, verandas/iwans, protected openings, breeze corridors, and heavy envelopes. Each prescription is directly observable in the dataset: compact, water-organized urban grain (Fig. 4); extensive sabat coverage (Fig. 5); deep iwans with room-behind coupling (Table 4; Fig. 9); recessed and elevated openings/mashrabiyas (Figs. 10–11); and heavy roof–wall constructions (Fig. 13). This convergence strengthens confidence that the Lar patterns are not idiosyncratic but mechanism-consistent responses to the local climate. It also explains the alignment between expert priorities (Tables 7–9) and measured form (Tables 3–5; Figures 3–15).

Relative to canonical hot-arid cases in Iran, Lar exhibits three emphases that merit attention. First, sabats are unusually continuous along primary pedestrian loops, combining shading with ventilation continuity (Fig. 5). Second, wind-catchers are short and wide rather than tall and slender, suited to the town's street scales and to roof–parapet geometries (Fig. 12). Third, the urban grain is explicitly water-anchored: radial alignments toward Ab Anbar sites and floodway edges structure circulation and neighbourhood clustering (Fig. 4). These features complement, rather than replace, the familiar courtyard–iwan ensemble.

While the study does not report fine-grain metrics such as window-to-wall ratio, it yields practice-ready rules supported by both expert judgement and observed morphology:

• Use deep semi-open buffers coupled to principal rooms. Iwans whose depth is at least comparable to the served room, oriented seasonally and connected to flanking spaces, reliably reduce solar load and stage ventilation (Table 4; Figs. 8–9, 15).

• Deliver shaded, ventilated continuity in the public realm. Narrow canyons complemented by covered segments (sabat) lower sky view and maintain air movement along walking routes (Figs. 4–5).

• Combine recessed apertures with high-level vents or mashrabiyas, particularly above entrances and iwans, to evacuate warm air while preserving privacy (Figs. 10–11).

• Prefer heavy roof–wall build-ups and articulated façades to secure time-lag and self-shading; integrate parapets for privacy and additional shade (Fig. 13).

• Keep courtyards within the mid share of plot area and moderate aspect ratios (as in Table 5) to balance shade, ventilation paths, and social use (Fig. 14).

The house sample is purposive and limited to 30 cases; results characterize patterns rather than city-wide frequencies. Expert statistics (Tables 6–9) capture perceptions, not measured geometry. Microclimatic variables (air temperature, MRT, air speed) were not instrumented, and airflow was inferred from configuration and devices. Future research should instrument representative houses and streets for summer and shoulder seasons, pair courtyard/iwani geometry with thermal logging and CFD/daylighting analysis, and extend the comparative sample across the region to test transferability.

## CONCLUSION

This study integrates expert priorities with a coded survey of 30 historic houses in Lar to explain how climate and culture co-produce form. Across scales, the same mechanisms recur: (1) solar-control and MRT reduction via deep transitional spaces, recessed openings, and appropriately proportioned courtyards; (2) ventilation continuity achieved by narrow canyons, sabats, iwan-to-room coupling, and short-wide wind-catchers; and (3) thermal damping through heavy, articulated envelopes. These patterns are fully consistent with Mahoney's guidance for Lar's climate and with expert rankings that place heat/sun and place-based practice at the top of design concerns.

The distinctive contribution of Lar lies in its water-anchored urban grain, the continuity of sabats, and the prevalent geometry of wind-catchers, all working in concert with the courtyard–iwan ensemble. Without relying on unmeasured quantities, the evidence supports transferable rules of thumb for façade buffering, street shading, opening design, and envelope massing that contemporary practitioners can adapt in comparable hot-arid settings.

Given the study's scope and data types, we refrain from city-wide generalizations and call for instrumented follow-ups. Even so, the convergence between expert judgement, bioclimatic prescriptions and observed form strengthens the case for re-mobilizing Lar's vernacular strategies—in conservation, in adaptive reuse of historic fabric, and in new work seeking low-energy comfort compatible with local culture.

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## DISCLOSURE STATEMENT

*The authors report there are no competing interests to declare.*

## AUTHOR CONTRIBUTIONS

(CRediT taxonomy): A.H.: Conceptualization (lead); Methodology (lead); Writing – original draft (lead); Writing – review & editing (lead); Supervision (lead); Project administration (lead).

H.SH.: Visualization (lead—figures, graphics, and data sheets); Writing – original draft (supporting); Writing – review & editing (supporting).

M.N.: Methodology (supporting); supporting—consultation and feedback.

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