Journal of Civil and Construction Engineering Research (JCCER)
Volume 3, Issue 2, Date: 31- December - 2026
ISSN: 2978-4476, DOI: 10.64820/AEPJCCER.32.9.22.122026

Extracting a Sustainable Paradigm from Passive Design Strategies in Iraqi Traditional Architecture for Hot-Arid Climates

Susan Abed Hassan [1, *]
[1] Department of Architectural Engineering, Al-Nahrain University, Baghdad, Iraq
Email: [1] dr.susan.a.hassan@nahrianuniv.edu.iq
*Corresponding Author

Abstract—**Traditional Iraqi passive design strategies are well documented, but the evidence on how they perform when adapted to contemporary buildings is scattered across separate publications and has rarely been compared across building scales. This paper addresses that gap through a qualitative, documentary multiple-case study of three Iraqi projects designed by the same research group: the Al-Jawadi House in Baghdad (Case A), an experimental wind-catcher house on the Karbala–Najaf road (Case B), and the Sunni Endowment Department Headquarters (SEDH) in Baghdad (Case C). The study did not generate new field measurements or simulations. Instead, it extracts, tabulates and compares the design data and performance values already reported in the published and archival sources for each case, and grades each value by its level of evidence. The reported results indicate that the residential model (Case A) was monitored for about twenty years, with indoor temperatures of 24–28 °C and an annual electricity use of about 14,000 kWh for all domestic purposes. The moisturised wind catcher (Case B) lowered the indoor peak to 31.4 °C against an outdoor peak of 43 °C (a difference of about 12 °C) over a 10-day September 2013 monitoring period, with relative humidity of 29–35%. The institutional building (Case C) is documented only at design stage, and no measured performance is reported. The comparison suggests that the effectiveness of courtyards, wind catchers and thermal mass depends on their combined use and on the match between the technical solution and the scale of the project. The paper proposes a design framework of five principles, each with the parameters reported in the cases, the scale at which it was applied and its level of evidence, and it identifies the measurements still needed to verify them.**

Keywords—passive design; wind catcher (badgir); courtyard (hosh); traditional Iraqi architecture; hot-arid climate; comparative case study

I. INTRODUCTION

Summer air temperatures in Iraq frequently exceed 45 °C and can approach 50 °C, which makes cooling a critical challenge for contemporary architecture. Passive design strategies developed over centuries in traditional Baghdad houses act as a "dynamic filter" that can sustain balanced indoor microclimates with little or no electrical input. Existing research, however, seldom compares how these strategies behave when they are adapted at different scales and in different organisational settings, from private houses to large institutional buildings.

The recent literature supports the value of traditional strategies but approaches them from separate angles. Al-Mashhadani and Eryildiz [1] examined the impact of eco-vernacular elements on contemporary residential areas of Baghdad and compared the eco-levels of traditional and contemporary housing. They concluded that traditional architecture uses local materials and eco-vernacular elements to moderate temperature and humidity, and they recommended integrating such elements into new housing. Yahya [2] studied the reuse of heritage features, originally developed for single-family dwellings, in apartment buildings, and proposed a conceptual framework that helps architects avoid superficial or mistaken reinterpretation; the study singles out the *shanashil* (*mashrabiya*) as a prominent element.

Studies of individual elements follow the same pattern. Abdulkareem [3] reviewed the Middle-Eastern courtyard house as a climatic response and described the courtyard as a microclimate regulator: its shaded areas remain cool during the day, the thermal mass of the surrounding walls absorbs solar heat slowly, cooler air displaces hot air by convection at night, and plants and water features add evaporative cooling. Al-Hafith et al. [4] concentrated on courtyard geometry, in particular the height-to-width ratio, and reported that deeper courtyards in traditional Baghdad houses increase the shaded wall area and so reduce direct and diffuse solar radiation; Al-Hafith et al. [21] identified the width-to-height ratio as the most influential geometric property of courtyard thermal conditions. A further key aspect of passive Iraqi design is the high thermal mass of local materials such as

Received: 11-7-2026
Revised: 12- 10 -2026
Published: 31-12-2026

© 2026 The Author(s). This article is published under the Creative Commons Attribution-ShareAlike 4.0 International License (CC BY-SA 4.0). This license permits others to share, copy, distribute, remix, adapt, and build upon the material, provided they give appropriate credit to the original authors and source. Any adapted or derivative work must be distributed under the same CC BY-SA 4.0 license.

fired clay brick, plaster and timber. These materials absorb and store heat during the day, release it slowly at night, and so stabilise the indoor environment. Almumar and Almumar [5] noted a systematic use of external envelope materials in traditional houses: thick, heavy walls on sun-exposed shaded areas and lighter materials on upper floors to favour natural ventilation.

The main research question of this study is: *How can passive design strategies from traditional buildings be extracted and adapted to improve the sustainability of future architectural designs?* Its specific aim is to identify the contextual factors that lead to different outcomes when these strategies are adapted. To this end, the paper compares three cases that represent different adaptation approaches: the vernacular synthesis of the Al-Jawadi House (Case A), the engineering innovation of the moisturised wind catcher in the Karbala–Najaf house of 2013 (Case B), and the institutional scaling of the SEDH design of 2008 (Case C). The cases are worth comparing because they span a range of scales, from a single dwelling to a large administrative complex, and approximately twenty-five years of design and monitoring practice.

Contribution and novelty. The principles of passive cooling, such as integrating ventilation, shading and thermal mass, are established in bioclimatic design and this paper does not claim them as new. Its contribution is more specific. First, it compares three Iraqi projects of different scale (a house, an experimental wind catcher and an institutional building) against one set of criteria, which, in the literature reviewed here, has not been done for these cases. Second, it grades each reported value by its level of evidence, so that readers can see which design claims rest on long-term measurements and which rest only on design intent. Third, it turns the comparison into a design framework for Iraq in which each principle carries the numerical parameters reported in the cases, the scale at which it was applied, and the verification still required (Table 8). The paper does not present new experimental data.

The paper is organised as follows. Section 2 reviews the theoretical framework of passive design in traditional Iraqi houses. Section 3 describes the methodology, including the data sources, their provenance and the evaluation criteria. Section 4 describes the three cases. Section 5 presents the results and the comparative analysis, and Section 6 gives the conclusions, the proposed paradigm and the limitations of the study.

II. Theoretical Framework: Passive Design Strategies in Traditional Houses

The theoretical basis of this study is the view that traditional Mesopotamian architecture is an important example of bioclimatic design, in which the building envelope works as an environmental regulator without mechanical equipment. Al-Jawadi [6] describes the heritage house not as a simple shelter but as an integrated "cooling machine" that uses air movement and thermal inertia to maintain habitable conditions in a hot-arid climate where summer temperatures frequently exceed 45 °C.

The literature on passive design suggests that the effectiveness of vernacular strategies lies in their integration rather than in isolated components. In this paper the Baghdadi house is therefore analysed as a "Triadic Network" of three elements: the central courtyard (*al-hosh*), the wind catcher (*badgir* or *malqaf*) and the wooden lattice screens (*shanashil* or *mashrabiya*). In this conceptualisation the three elements form one system that relies on pressure-driven convective loops and radiative exchange to provide thermal comfort without mechanical intervention. The following subsections review the system on the basis of the published theoretical and empirical literature.

A. The Central Courtyard (Al-Hosh): Microclimate Regulation through Geometry and Buoyancy

The courtyard is the primary "thermal heart" and cold sink of the traditional dwelling. Two complementary physical processes govern its operation: nocturnal radiative cooling and stack ventilation. At night the courtyard floor and walls radiate stored heat towards the clear sky, which restores their capacity to absorb heat the next day. During the day, hot air rises and escapes over the high parapet walls and draws cooler, denser air from the shaded lower levels into the living spaces. Indoor temperatures in courtyard houses are commonly reported to be 8–12 °C below the outdoor ambient temperature [4]. Figure 1 shows a courtyard in a traditional Iraqi house.



Fig. 1. Courtyard of a traditional Iraqi house. (https://middle-east-online.com/en/basra-falls-apart-iraqis-yearn-past%C2%A0)

The effectiveness of this mechanism depends on the geometry of the courtyard. Al-Hafith et al. [4] examined this variable for the Baghdad context. According to the values reported in that work, a width-to-height ratio (R2) of 0.5–1.0

deepens the enclosure and increases the shaded area from 65% in shallow designs to 88%; a width-to-length ratio (R1) of 0.3–0.5, with a rectangular plan elongated along the east–west axis, gives a further 10–20% increase in self-shading compared with a square plan; and a perimeter-to-height ratio (R3) below 4.0 favours the cold-sink effect. The related study by Al-Hafith et al. [21] likewise found the width-to-height ratio to be the most influential geometric factor.

B. The Wind Catcher (Badgir/Malqaf): High-Pressure Intake and Capillary Cooling

While the courtyard handles the low-pressure exhaust through buoyancy, the system needs a high-pressure intake to draw fresh external air into the house. This role is fulfilled by the *badgir*, a ventilation tower that is oriented towards the prevailing north-westerly *Shamal* winds. Figure 2 illustrates typical wind-catcher and opening typologies of traditional Iraqi houses, and Figure 3 shows the airflow mechanism of a wind catcher through the house during the day and at night.

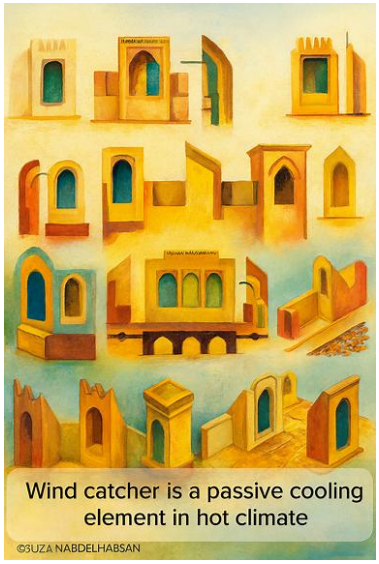


Fig. 2. Wind-catcher and opening typologies in traditional Iraqi architecture (AI-assisted conceptual illustration; not to scale).

According to Al-Jawadi [6], the performance of a wind catcher is governed by three main factors: its height, its cross-sectional area and its internal partitioning. The tower normally rises 3–6 m above the roofline (and up to 25–26 m in minaret adaptations so that it captures laminar wind flow and strengthens the stack effect. Al-Jawadi [6] further reports that cross-sections larger than 2 m² are needed to supply enough air for contemporary comfort levels, whereas traditional small-scale towers (below 0.20 m²) were largely abandoned because of their low air volume.

A significant advance is the distinction between dry and moisturised systems. Al-Jawadi and Darwish [7] report that moisturised wind catchers add a material-science dimension: light-coloured, highly porous yellow bricks fired at 750–1150 °C maximise capillary action and provide the pore structure needed to wick water up the tower walls for evaporative cooling, whereas over-fired or reddish bricks lack this porosity and deteriorate under repeated wetting and drying. In quantitative terms, [7] reports that dry systems, which rely on pressure and laminar airflow of 1.5–2.5 m/s, lower the air temperature by 5–10 °C, while moisturised systems with capillary-active bricks achieve reductions of 12–26 °C.

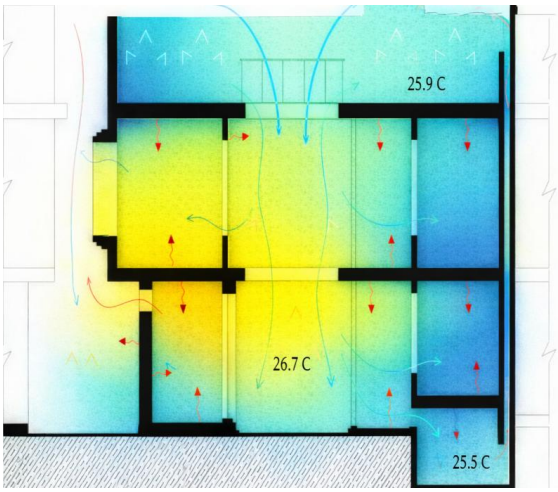


Fig. 3. Conceptual airflow through a wind catcher in a traditional house during day and night (AI-modified illustration). The temperatures shown are indicative only and are not simulation results of this study.

C. The Shanashil: Solar Filtration and Induced Ventilation

The *shanashil* acts as the final filter of the Triadic Network at the interface between the exterior microclimate and the interior living spaces. It is regarded here not as decorative carpentry but as a climatic device. First, as a solar-shading device, its geometric lattice intercepts direct solar radiation. A simulation-based study [8] reports that the traditional *shanashil* reduced direct solar radiation on the façade by 42% and the solar gain by up to 38%.

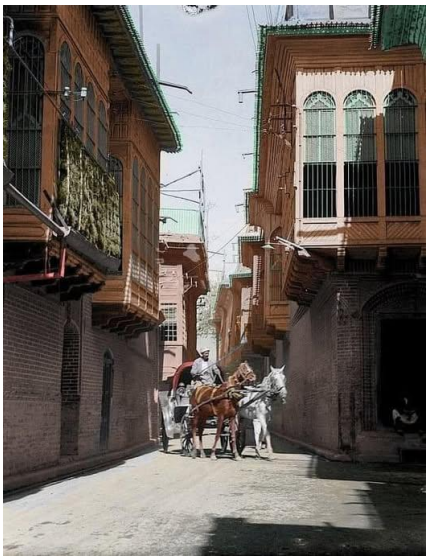


Fig. 4. Traditional *shanashil* on the façades of an old Baghdad street (based on a real traditional house).

Second, the lattice contributes to airflow. It creates a pressure gradient across the opening that is reported to induce single-sided ventilation even at low external wind speeds or when

the wind strikes at oblique angles. In addition, porous clay jars placed behind the lattice work as an indirect evaporative cooler and temper the air before it enters the transitional zones [9–13].

D. Transitional Shaded Zones (Iwan and Liwan) and the Thermal Mass Envelope

The system is completed by intermediate buffer spaces and a high-inertia envelope. The *iwan* and *liwan*, semi-open arched halls, are transitional zones that distribute the cooled air. The literature emphasises that the main *liwan* is almost always oriented to the north, so that it receives the cooled air from the courtyard while limiting direct solar gain. This configuration gives the incoming air the volume it needs to slow down, circulate and cool the adjacent enclosed rooms [13–19].



Fig. 5. The *iwan* and *liwan* overlooking the courtyard (based on a real traditional house).

Regarding materials, the framework relies on the principle of thermal inertia. A building envelope of 50–100 cm thick mud-brick walls (or modern equivalents) introduces a time lag of 4–6 hours, which delays the transfer of the external peak heat into the interior until the outdoor air has cooled during the night [6].

III. METHODOLOGY

A. Research Design

This study uses a qualitative, comparative multiple-case study design based on documentary (secondary) analysis. A case-study design suits the "how" and "why" questions that drive this research, namely how traditional strategies are adapted and why they succeed or fail in different modern contexts. Each case is a real building studied in its actual setting.

The study did **not** carry out new field measurements, simulations or occupant surveys. All design data and all performance values for Cases A–C are taken from the published or archival sources listed in Table 1 and are reported as they appear in those sources. The contribution of this study is the structured extraction, cross-case comparison and synthesis of these data.

B. Case Selection

Three cases were chosen by **purposeful sampling for maximum variation** in scale and architectural intent. A project was eligible if it (i) is located in Iraq's hot-arid climate (Baghdad or the Karbala–Najaf region); (ii) deliberately applies at least one traditional passive strategy; (iii) has design data documented in a peer-reviewed or institutional source; and (iv) differs from the other cases in scale or adaptation approach. The selected cases are:

- **Case A: Al-Jawadi House (Baghdad).** A two-storey residence that represents the **vernacular approach**, with an inward-looking plan, a central courtyard, a developed wind catcher and a thermally massive envelope. It is documented through about twenty years of monitoring and utility records (1988–1990 bills are cited) and was published in 2011 [6].
- **Case B: Karbala–Najaf wind-catcher house (2013).** A small experimental building (described as a rest house on the Karbala–Najaf road) that represents the **engineering approach**: it modernises the traditional *malqaf* as a moisturised "wet column" of porous bricks and water pipes. It is documented by a 10-day monitoring campaign in September 2013 [7].
- **Case C: Sunni Endowment Department Headquarters, SEDH (Baghdad, 2008 design).** A large administrative complex that represents the **institutional approach**, scaling traditional principles through a double-skin glass envelope, solar chimneys and wind catchers. It is documented by the competition design of 2008 [20].

C. Data Sources and Provenance

Table 1 separates the data that originate in earlier publications from the work done in this study. No performance value in this paper is a new measurement; where a value is quoted, the source is given.

D. Evaluation Criteria and Analysis Procedure

Each case was assessed against six criteria:

- **C1, passive strategies employed:** courtyard, wind catcher, solar shading (*shanashil* or sun breakers), thermal mass and insulation, evaporative cooling, and buffer spaces.

Table 1. Data sources and provenance

Case	Data used	Source	Period covered	Generated by this study?
A	Design and construction data; long-term indoor temperature records (peak month: August); annual electricity use; utility bills	Al-Jawadi (2011) [6]	About 20 years; bills 1988–1990	No (secondary data)
B	Wind-catcher specifications; field measurements of air temperature, relative humidity, air velocity and air-exchange time	Al-Jawadi and Darwish (2016) [7]	10 days, September 2013	No (secondary data)
C	Competition design documents: plans, elevations, description of environmental treatments and technologies	Al-Jawadi and Al-Bukhari (2008) [20]	Design stage, 2008	No (archival data)
Background	Theory of courtyard, wind catcher, *shanashil*, *iwan* and thermal mass	Literature [1–5, 8–19, 21]	Not applicable	No
Synthesis	Data extraction, coding against the criteria in Section 3.4, comparison tables (Tables 6 and 7), derivation of principles; redrawn or AI-assisted conceptual figures (Figures 2 and 3)	This study	Not applicable	Yes

- **C2, reported thermal performance:** indoor air temperature, temperature difference from outdoors, relative humidity, air velocity and air-exchange time.
- **C3, reported energy performance:** annual electricity consumption and the type of mechanical cooling still needed.
- **C4, envelope characteristics:** wall type and thickness, U-value, glazing ratio and shading.
- **C5, scale and context:** building size, function and organisational setting.
- **C6, level of evidence:** *Level 1*, long-term measured field data; *Level 2*, short-term measured field data; *Level 3*, design-stage documentation with no measured performance.

The procedure had four steps: (1) extract the data for each case from its source; (2) record every value as reported, together with its measurement period and conditions; (3) code the strategies of each case against C1–C5 and assign the evidence level (C6); and (4) compare the cases in a cross-case matrix (Table 7) and derive design principles that are explicitly tied to the evidence level behind them (Section 6). Because the three sources used different monitoring protocols, the values were compared qualitatively and no statistical comparison was attempted.

E. Limitations of the Method

- The study relies on secondary data. The instruments, sampling intervals and measurement accuracy are those of the original studies [6, 7] and are not re-examined here.
- The three primary sources [6, 7, 20] share a common author or research group. Independent verification of the reported performance is therefore not available.
- Case C has no measured performance data, so conclusions about it are limited to design intent.
- No baseline (a conventional reference building) is reported for Case A, so relative energy savings cannot be calculated from the available data (see Section 5.3).
- Three cases cannot support statistical generalisation; the findings are analytical generalisations that need further testing.

IV. Case Descriptions

The following subsections describe each case as documented in its source. All values in Sections 4.1–4.3 are the reported values of the cited sources.

A. Case A: The Al-Jawadi House (Baghdad, Iraq)

Al-Jawadi [6] presents a synthesis of more than two decades of applied research aimed at a residential model suited to hot-arid regions, with emphasis on Baghdad (Figures 6–8). The model combines traditional vernacular elements with contemporary scientific principles to obtain thermal comfort at low operating energy. According to [6], field measurements over a 20-year period show that the model keeps indoor temperatures within the human comfort zone while consuming no more than 14,000 kWh of electricity per year for all domestic purposes, including lighting, heating and cooling. The design received the "Hadi Advisory

Committee for Energy" award for best environmental design [6].

1. Project identity and general description

The model is a two-storey dwelling on a restricted plot, with emphasis on structural efficiency and thermal insulation.

(a) Spatial and planning data

- **Site area:** 200 m² (10 m × 20 m).
- **Built area:** 150 m² per floor, 300 m² in total.
- **Spatial distribution:** four bedrooms, a reception hall, a living area, a study, a kitchen, a storage room, three bathrooms and an internal courtyard garden.
- **Design typology:** an inward-looking plan that privileges the central courtyard and minimises external openings as protection against the extreme climate.

(b) Construction specifications and materials

Materials were selected mainly for high thermal resistance and thermal lag. Table 2 lists the specifications reported in [6].

Table 2. Specifications and thermal performance of the structural elements of Case A (source: [6])

Structural element	Specification and materials	Reported thermal performance
External walls	24 cm thick Thermostone masonry units.	Insulation reported as equivalent to twice that of conventional construction materials.
Roof assembly	Reinforced concrete slab (15 cm), waterproofing membrane, polystyrene insulation (4 cm), river sand (10 cm) and concrete tiles (3 cm).	U-value of 0.265 (units as reported in the source).
External windows	Openings limited to 15% of the floor area or 25% of the external wall area.	Reduces radiative heat gain.

2. Bioclimatic design strategies

According to [6], the performance of the model depends on a set of environmental features that work together as a passive cooling system.

(a) Developed wind catchers

- **Cross-sectional area:** more than 2 m², which increases the volume of captured air.
- **Height:** the tower extends 2 m above the roofline, to capture cleaner, cooler and less dusty air at higher velocity.
- **Operation:** the towers discharge air directly into the internal courtyard, which creates a pressure difference and induces air movement through the interior spaces. The air movement lowers the perceived "effective temperature" below the thermometer reading.

(b) The internal courtyard (*al-hosh*)

- **Cool-air reservoir:** porous brick flooring supports a "cool-air pool" formed by nocturnal radiative cooling and daytime shading.
- **Self-shading geometry:** the vertical sections of the courtyard are stepped to shade the walls during long summer days.
- **Evaporative cooling:** vegetation, including *Asparagus* climbers up to 5 m high, and water fountains raise relative humidity and lower local air temperature by up to 12 °C compared with equivalent exposed external gardens [6].

(c) Sun breakers

- Brick sun breakers on the façade are reported to give a shading efficiency above 90% at the summer solstice while admitting about 25% of solar radiation in winter [6].

3. Reported thermal performance and energy consumption

The long-term field measurements reported in [6], in particular those of August, the hottest month, are summarised below.

- **Thermal comfort:** indoor temperatures stayed within the human comfort range for most of the year, at 24–28 °C. At the summer peak only simple, low-capacity air-conditioning units were needed to keep the house habitable.
- **Energy consumption:** annual electricity use was about 14,000 kWh. Utility bills for 1988–1990 are cited as evidence of a low dependence on electricity for cooling and heating [6]. The source does not report a conventional reference building, so no percentage saving can be derived from it.
- **Thermal stability:** the plotted records show strongly attenuated temperature swings in the courtyard and interior spaces compared with the large oscillations outdoors (on the roof and in the exterior garden). The source attributes this stability to the combined effect of thermal inertia, convective cooling and solar shading.

B. Case B: The Karbala–Najaf Wind-Catcher House (Iraq)

Case B is a house on the Karbala–Najaf road with a wind catcher. It is an applied investigation into reviving and developing wind catchers (*badgirs*) as a healthy, sustainable alternative to mechanical ventilation [7]. Traditional Iraqi wind catchers were of limited efficiency because their cross-sections did not exceed 0.20 m², and they were consequently replaced by air-conditioning units and fans.

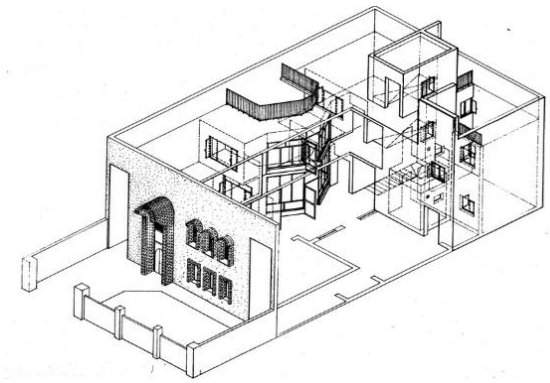


Fig. 6. Isometric view of the Al-Jawadi House (source: [6]).



Fig. 7. Elevation of the Al-Jawadi House (source: [6]).

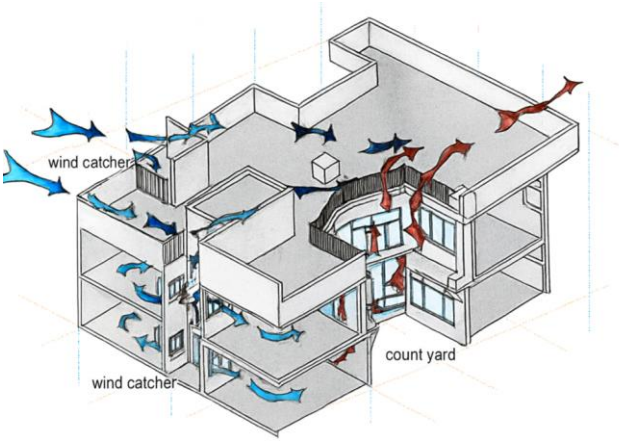


Fig. 8. Air circulation through the wind catcher and courtyard of the Al-Jawadi House (source: [6]).

The developed model has a large cross-section (more than 2 m²) and an internal wall-moisturising system that uses specially manufactured porous bricks of high capillary action. The field results reported in [7] indicate that the system lowered the indoor temperature by up to 12 °C relative to the outdoor temperature on peak summer days (43 °C), while relative humidity stayed moderate (29–35%). The house is shown in Figures 9–11.

1. Project identity and general description

Wind catchers are a healthy and climate-responsive feature of traditional housing, but their use has declined in contemporary architecture for the following reasons [7]:

- **Limited size:** the cross-section of traditional wind catchers did not exceed 0.20 m², which is insufficient for modern thermal-comfort requirements.
- **Reliance on mechanical systems:** the introduction of fans and air conditioning led to the gradual abandonment of wind catchers, although [7] associates mechanical devices with negative physiological effects, such as an increase in positive ions linked to lethargy and depression.
- **"Sick building syndrome":** mechanical ventilation can produce excessively dry or humid air, noise and heat emission to the outdoors, which affects both occupant health and the urban microclimate [7].

2. The developed wind catcher

The new model addresses these limitations through the following interventions [7]:

- **Increased cross-section:** a cross-section above 2 m² supplies enough air for thermal comfort.
- **Sustainable moisturising system:** the system imitates traditional evaporative cooling (which relied on ground moisture) by moistening the internal tower walls, which are lined with porous brick to promote capillary action.
- **Selection of the optimal model:** the optimal shape was chosen from several tested prototypes as the most climatically balanced, and it also avoids the whistling noise associated with high air velocities in covered models.

3. Technical and construction specifications

(a) Structural components of the wind catcher. Table 3 lists the components and specifications reported in [7].

Table 3. Components and technical specifications of the experimental wind catcher of Case B (source: [7])

Component	Technical specification
Internal dimensions	2.5 m × 1.75 m.
External walls	Thermostone masonry (20 cm thick) for thermal insulation, rendered with cement on the exterior and interior surfaces.
Waterproofing	Internal coating with cold bitumen (three layers) to prevent moisture migration into the main structural walls.
Internal lining	Light-coloured yellow perforated bricks fired at 750–1150 °C for maximum capillary porosity.
Foundation	Salt-resistant concrete basin of 3.25 m × 2.5 m to collect surplus water.

(b) Moisturising and control system

- **Spray pipes:** a perforated plastic pipe system (4 mm holes at 10 cm spacing) at the top of the brick lining.

- **Water tanks:** a 500-litre primary tank connected to a 2,000-litre auxiliary tank with a flow regulator.
- **Air distribution:** the air inlet to the living space has four adjustable dampers that regulate airflow according to demand [7].

4. Reported field measurements

According to [7], readings were recorded over a continuous 10-day period in September 2013, when outdoor temperatures reached about 43–43.5 °C.

(a) Thermal performance

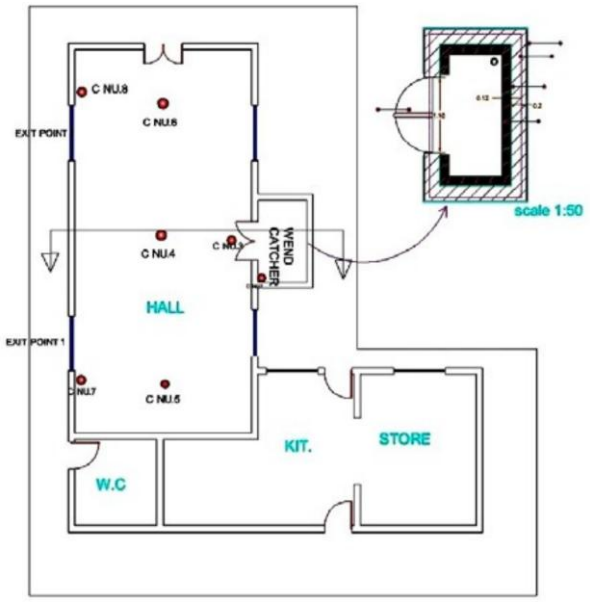
- **Peak external temperature:** 43 °C (at 3:00 PM).
- **Peak internal temperature:** 31.4 °C (at 4:00 PM).
- **Temperature difference:** about 12 °C (43 − 31.4 = 11.6 °C), reported to remain fairly constant during daylight hours.

(b) Relative humidity. Internal relative humidity ranged from 29% to 35%, although the saturated brick lining reached up to 90%. The source concludes that the system cools the incoming air without raising indoor humidity to uncomfortable levels [7].

(c) Air velocity and air exchange. Internal air velocity ranged from 0.5 m/s at night to 3.5 m/s at midday. The cross-section of the wind catcher is reported to replace the air volume of the space completely within 1–8 minutes [7].



(a)



(b)

Fig. 9. Case B: exterior view of the wind catcher (a) and house plan showing the wind catcher and the labelled measurement points (b) (source: [7]).

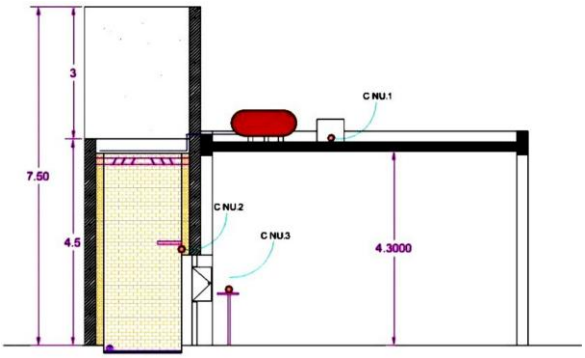


Fig. 10. Case B: section through the house and the wind catcher (source: [7]).



Fig. 11. Case B: window opening of the wind catcher with the porous brick lining (source: [7]).

C. Case C: The Sunni Endowment Department Headquarters, SEDH (Baghdad, Iraq)

Case C is the first-place entry in the 2008 architectural design competition for the SEDH. The design was prepared by an academic team of the Department of Architectural Engineering at the University of Technology and the site is next to the Umm Al-Qura Mosque in the Al-Ghazaliya district of Baghdad. It is presented as a synthesis of heritage and contemporary expression with emphasis on climate-responsive architecture and green-building principles. According to [20], the project is designed to reduce energy consumption through advanced technologies, to use natural lighting through fibre-optic systems, and to apply thermal-control and natural-ventilation strategies. **This case is documented at design stage only; the source reports design intent and no measured performance.**

1. Project identity and general description

The building was conceived as the headquarters of the SEDH, with emphasis on functional efficiency, aesthetic quality and environmental performance [20].

- **Design team:** Prof. Dr. Miqdad Haidar Al-Jawadi and Asst. Lect. Ahmed Luay Al-Bukhari (University of Technology).
- **Location:** Baghdad, Umm Al-Qura Mosque site, Al-Ghazaliya district.
- **Structure:** four floors and a basement level; about 6,000 m² per level; about 240 rooms.
- **Facilities:** large halls for meetings and events; a cafeteria and a banking facility; a basement car park of about 5,000 m²; an internal atrium of more than 1,000 m² with central fountains; and a roof garden of about 4,500 m².
- **Aesthetic and functional features:** a glass bridge on the third floor and glass elevators overlooking the atrium.

2. Bioclimatic and environmental treatments

Climatic response is the foundation of the design, which includes engineering solutions intended to reduce thermal emissions and improve energy efficiency [20].

(a) Orientation and massing. The building is a rectangular mass with its long axis along the south-east–north-west direction, which is intended to limit solar gain in summer and to benefit from solar exposure in winter.

(b) Double-skin glass envelope

- An external glass façade is placed 70 cm beyond the internal room walls.
- The system uses double reflective glazing, designed to reflect solar radiation in summer and to help dissipate excess heat.
- In winter the glass envelope acts as a thermal buffer that, according to the design description, protects against night-time cooling for up to 14 hours and so reduces heating demand.

(c) Ventilation and thermal control

- **Solar chimneys and wind catchers:** located on the roof, they are designed to extract hot air and replace it with cooler ambient air.
- **Concrete walkways:** the glass envelope is mounted on concrete walkways separated from the main building by 5 cm gaps, which are intended to prevent thermal bridging and let heated air rise to the solar chimneys.
- **Sun breakers:** the walkways act as shading devices in summer, when the solar altitude is high, and admit the sun in winter, when it is low [20].

3. Green technologies and advanced systems

The project integrates the technologies listed in Table 4 to improve environmental performance [20].

Table 4. Environmental technologies of the SEDH design (source: [20])

Technology	Description and function
Fibre-optic lighting	A daylighting system that collects daylight at the roof and transmits it through optical fibres to the basement and meeting halls, to reduce the use of artificial lighting.
Roof gardens	Reduce the thermal load on the flat roof and give natural thermal insulation.
Vegetation treatments	Climbing plants in the internal atrium cover concrete surfaces, to reduce heat transfer and improve indoor air quality.
Natural ventilation	Passive air movement provides fresh air during periods of moderate weather.
Centralised air conditioning	A central system in the basement with several units that operate according to demand or occupancy.

4. Summary of environmental features

Table 5 summarises the main environmental and technological measures of the SEDH design. The "intended benefit" column reflects the design description [20] and is not a measured result.

Table 5. Environmental features of the SEDH design and their intended benefits (source: [20])

Environmental feature	Design implementation	Intended benefit
Building orientation	Long axis aligned south-east–north-west.	Limits summer solar gain; benefits from winter solar exposure.

Environmental feature	Design implementation	Intended benefit
Double-skin glass façade	External glass envelope with a 70 cm air gap; double reflective glazing.	Reduces cooling loads (not quantified in the source); winter thermal buffer of up to 14 hours.
Solar chimneys	Roof-mounted extraction towers.	Remove hot air and promote natural convective cooling.
Concrete walkways	5 cm separation gaps from the main structure.	Prevent thermal bridging; act as seasonal sun breakers.
Fibre-optic lighting	Daylight capture and transmission through optical fibres.	Reduces artificial lighting energy.
Roof gardens	4,500 m² of vegetated roof.	Adds thermal insulation; reduces the urban heat island effect.
Internal atrium	More than 1,000 m² with fountains and climbing vegetation.	Supports natural ventilation; gives evaporative cooling.



Fig. 12. SEDH front elevation (source: [20]).

V. Results and Comparative Analysis

A. Reported Performance Indicators

Table 6 brings together the performance indicators reported for the three cases, with the evidence level assigned in this study (criterion C6). The values are those of the cited sources and are not new measurements. They are not strictly comparable because the monitoring periods and protocols differ.

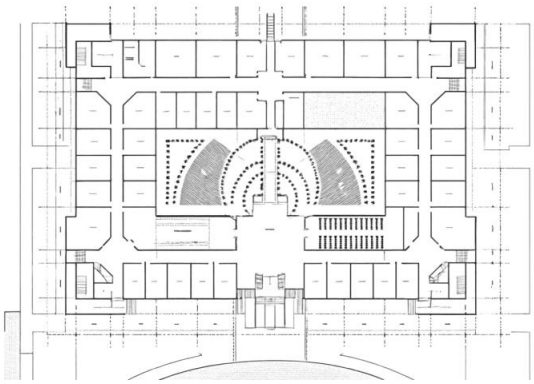


Fig. 13. SEDH ground-floor plan (source: [20]).



Fig. 14. SEDH perspective view (source: [20]).

Table 6. Performance indicators reported in the sources, by case

Indicator	Case A [6]	Case B [7]	Case C [20]
Evidence level (C6)	Level 1: long-term field data	Level 2: short-term field data	Level 3: design stage only
Monitoring period	About 20 years (August is the peak month)	10 days in September 2013	None
Indoor temperature	24–28 °C	Peak 31.4 °C (at 4:00 PM)	Not reported
Outdoor peak	Not reported as a single value	43 °C (at 3:00 PM)	Not reported
Difference from outdoors	Courtyard planting: up to 12 °C below an exposed external garden	About 12 °C (11.6 °C from the peak values)	Not reported
Relative humidity	Not reported	29–35% (lining up to 90%)	Not reported
Air velocity	Not reported	0.5–3.5 m/s	Not reported
Air-exchange time	Not reported	1–8 minutes	Not reported
Annual electricity use	About 14,000 kWh (all domestic uses)	Not reported	Not reported

B. Comparative Analysis of Passive Strategies

Table 7 compares how the three cases adapt and apply traditional passive strategies. It is limited to features that are described in the case sources (Section 4).

C. Discussion

Three observations follow from the comparison. First, the two cases with measured data (A and B) both show an indoor environment markedly cooler than outdoors, but they achieve it with different combinations of strategies: Case A through

an integrated courtyard, wind-catcher, shading and insulation system, and Case B through a single moisturised wind catcher. This agrees with the theoretical expectation (Section 2) that the effect depends on how the elements are combined, but the data do not allow the contribution of each element to be separated.

Second, the amount of evidence declines as the project scale increases. The residential model has twenty years of records, the experimental wind catcher has ten days, and the institutional building has none. The proposition that the paradigm is scalable to large buildings is therefore a design hypothesis supported by Case C, not a verified result.

Third, the energy result of Case A cannot be expressed as a percentage saving. The source reports an annual electricity use of about 14,000 kWh for all domestic purposes but no conventional reference house or reference consumption. A claim such as a 40–60% reduction in cooling load would require a stated baseline (measured or simulated) and a calculation, and neither is available in the sources; no such figure is claimed in this paper. Establishing a baseline is a priority for future work (Section 6).

VI. CONCLUSIONS

The Proposed Paradigm

This study compared three Iraqi projects that adapt traditional passive design strategies, using the design data and performance values reported in the published and archival sources for each. The comparison supports the view that the vernacular approach, built on the Triadic Network of courtyard (*al-hosh*), wind catcher (*badgir*) and lattice screens (*shanashil*), is a credible basis for energy-conscious design in hot-arid Iraq. The strength of that support differs from case to case, as summarised below.

Table 7. Comparative analysis of passive design strategies in the three cases

Feature	Case A: Al-Jawadi House	Case B: Karbala–Najaf wind-catcher house	Case C: SEDH
Primary strategy	**Integrated system:** wind catcher, courtyard, shading and insulated envelope work together.	**Technological innovation:** the wind catcher is modernised through material science and moisturising.	**Scaling:** traditional principles are applied to a large administrative building through a double-skin envelope, solar chimneys and an atrium.
Ventilation	Developed wind catchers (cross-section above 2 m², 2 m above the roof) discharge air into the courtyard.	"Wet column" wind catcher (cross-section above 2 m²) with porous brick lining and spray pipes; adjustable dampers.	Roof-mounted solar chimneys and wind catchers extract hot air.
Thermal mass and envelope	24 cm Thermostone walls; insulated roof (U-value 0.265); openings limited to 15% of the floor area.	Thermostone tower walls (20 cm) with a porous brick lining and bitumen waterproofing.	Double-skin reflective glass 70 cm from the walls; concrete walkways separated by 5 cm gaps.
Microclimate and shading	Courtyard with porous flooring, vegetation and fountains; brick sun breakers (shading above 90% in summer).	Evaporative cooling of the supply air by the moistened lining.	Walkways as seasonal sun breakers; atrium with fountains and climbing plants; roof gardens.
Reported outcome	Indoor 24–28 °C; about 14,000 kWh per year (Level 1).	About 12 °C reduction at a 43 °C outdoor peak (Level 2).	Design intent only; no measured outcome (Level 3).

Case A (Al-Jawadi House, Level 1 evidence). The reported twenty-year record indicates that a combination of high-resistance Thermostone envelope, developed wind catchers and an inward-oriented courtyard can keep indoor temperatures at 24–28 °C with an annual electricity use of about 14,000 kWh for all domestic purposes, using only low-capacity air conditioning at the summer peak. Without a baseline, the savings relative to conventional houses cannot be quantified.

Case B (Karbala–Najaf wind-catcher house, Level 2 evidence). In a 10-day campaign in September 2013, a moisturised wind catcher with a cross-section above 2 m² and a porous brick lining fired at 750–1150 °C reduced the indoor peak to 31.4 °C against a 43 °C outdoor peak (about 12 °C), with relative humidity of 29–35%, air velocity of 0.5–3.5 m/s and an air-exchange time of 1–8 minutes. The result is promising, but it comes from a short period and a single building, and the thermal comfort of occupants was not assessed against a standard.

Case C (SEDH, Level 3 evidence). The design shows how double-skin glazing, solar chimneys, an atrium, roof gardens and daylighting can be combined with traditional principles in a large administrative building. Its environmental benefits are design intentions and remain to be verified by measurement or simulation.

From this comparison the study proposes five design principles. Each is stated together with the evidence behind it:

1. **Systemic integration** (Cases A and B). The wind catcher, courtyard and *shanashil* work best as one convective system; the pressurised intake of the wind catcher needs the exhaust path of the courtyard. Case A is the main evidence; the separate effect of each element has not been isolated.
2. **Material specificity** (Cases A and B). Thermal and hygroscopic properties of materials matter: Thermostone masonry, a roof of low reported U-value (0.265), and capillary-active bricks fired at 750–1150 °C.
3. **Geometric optimisation** (literature; Cases A and B). Courtyard proportions, the height and cross-section of wind catchers (above 2 m² in Cases A and B) and shading geometry are functional determinants of performance. The courtyard ratios cited in Section 2.1 come from the literature [4, 21] and were not tested in the three cases.
4. **Management of effective temperature** (Cases A and B). Air movement (0.5–3.5 m/s in Case B) and moderate humidity (29–35%) can lower the perceived temperature below the measured air temperature. Occupant comfort votes were not collected in the sources, so this principle is partly inferential.
5. **Scalability and adaptability** (Case C, hypothesis). Traditional strategies can be combined with modern technologies such as fibre-optic lighting and centralised air conditioning in a large building. This remains a design hypothesis until performance data for Case C or similar buildings are available.

From principles to practice. Table 8 turns the five principles into a framework that a designer can apply. For a new project in a hot-arid Iraqi setting, the sequence is: (1) choose the strategy set that matches the project scale; (2) start from the parameter values reported for that strategy in Table 8; (3) check the proposal against the evidence level and note which parts are unverified; and (4) plan the monitoring needed to verify the performance after construction. The parameters are starting values taken from the reported cases and the literature, not validated design rules.

Table 8. Design framework: principles, reported parameters, scale of application and verification needed

Principle	Parameters reported in the cases or literature	Scale of application	Evidence level	Verification still needed
1. Systemic integration	Wind-catcher intake discharging into a central courtyard; shaded openings; brick sun breakers (Case A: tower above 2 m² and 2 m above the roof).	House	Level 1	Isolate the contribution of each element by calibrated simulation.
2. Material specificity	Thermostone walls of 20–24 cm; roof U-value of 0.265 (reported units); openings limited to 15% of the floor area; porous yellow bricks fired at 750–1150 °C for moisturised towers.	House; small experimental building	Level 1–2	Durability of the lining and water consumption of the moisturising system (not reported in [7]).
3. Geometric optimisation	Wind-catcher cross-section above 2 m² (traditional towers up to 0.20 m²); courtyard width-to-height ratio of 0.5–1.0 and east–west elongation [4]	House; courtyard buildings	Level 1–2 and literature	Parametric testing of courtyard and tower dimensions under Iraqi climate data.
4. Effective-temperature management	Internal air velocity of 0.5–3.5 m/s and relative humidity of 29–35% with a moisturised tower (Case B).	Small building	Level 2	Occupant comfort surveys and longer monitoring, including the whole cooling season.

Principle	Parameters reported in the cases or literature	Scale of application	Evidence level	Verification still needed
5. Scalability and adaptability	Double-skin glass 70 cm from the walls; 5 cm gaps at concrete walkways; solar chimneys; atrium of more than 1,000 m²; 4,500 m² roof garden (Case C).	Institutional building	Level 3	Post-occupancy monitoring or simulation of energy use and indoor temperature.

Limitations and future work.

The study depends on secondary data, three sources by the same research group, three cases, and monitoring protocols that are not comparable. It therefore proposes a framework for design and further testing, not a validated model. Future work should (i) monitor the thermal and energy performance of institutional buildings such as the SEDH; (ii) compare Case A with a conventional reference house, measured or simulated under the same climate, to quantify energy savings; (iii) isolate the contribution of each element of the Triadic Network through calibrated simulation; and (iv) assess occupant thermal comfort against an accepted standard.

In conclusion, the traditional Baghdadi house offers a body of passive strategies that, according to the evidence reviewed here, can be adapted to contemporary Iraqi buildings and combined with modern technology. Making that adaptation reliable depends on stronger measured evidence, particularly for larger buildings.

REFERENCES

[1] Al-Mashhadani, O. A. I., & Eryildiz, D. I. (2025). The impact of eco-vernacular architectural elements on enhancing the contemporary residential areas of Baghdad. *Annals of Civil Engineering and Management, 2*(2). https://www.opastpublishers.com/open-access-articles/the-impact-of-ecovernacular-architectural-elements-on-enhancing-the-contemporary-residential-areas-of-baghdad-an-analytical-compar-9157.html

[2] Yahya, N. I. (2026). Learning from the past: Reinterpreting heritage for sustainable apartment buildings in Baghdad. *Frontiers of Architectural Research*. https://www.sciencedirect.com/science/article/pii/S2095263526000580

[3] Abdulkareem, H. A. (2016). Thermal comfort through the microclimates of the courtyard: A critical review of the Middle-Eastern courtyard house as a climatic response. *Procedia – Social and Behavioral Sciences, 216*, 662–674. https://www.sciencedirect.com/science/article/pii/S1877042815062345

[4] Al-Hafith, O., et al. (2020). *Optimizing the design of courtyard houses for passive cooling in hot, dry regions*. The University of Manchester. https://www.research.manchester.ac.uk/portal/files/185012574/FULL_TEXT.PDF

[5] Almumar, M. M. S., & Almumar, M. M. M. (2018). Understanding the performance of the Iraqi traditional courtyard house: Is there an order for the use of external envelope materials? https://www.academia.edu/37920194

[6] Al-Jawadi, M. H. (2011). Model of house design responsive to hot-dry climate. *Iraqi Journal of Architecture and Planning, 10*, 119–137.

[7] Al-Jawadi, M. H., & Darwish, A. F. (2016). The effect of moisturizing treatment of wind-catcher on internal thermal environment. *Iraqi Journal of Architecture and Planning, 15*(1), 10–18.

[8] Kadhim, Z. A., Hassan, S. A., & Muhammad, (2026). Improving environmental performance indicators (KPIs) of contemporary Iraqi housing through simulation-based reuse of traditional shenashil with integrated smart technologies. *Rafidain Journal of Engineering Sciences, 4*(1), 344–350. https://doi.org/10.61268/qba0hm50

[9] Bagasi, A. A., & Calautit, J. K. (2020). Experimental field study of the integration of passive and evaporative cooling techniques with Mashrabiya in hot climates. *Energy and Buildings, 225*, 110325.

[10] Elwan, M. M. (2020). The role of traditional lattice window "Mashrabiya" in delivering single-sided ventilation: A CFD study. *International Journal of Engineering Trends and Technology, 68*(9), 154–161.

[11] Marji, Z. M. (2021). *Principles and practices* [Student documentation]. Fab Academy 2021. https://fabacademy.org/2021/labs/techworks/students/zaid-marji

[12] "mashrabiya." *Oxford Reference*. Retrieved July 31, 2026, from https://www.oxfordreference.com/view/10.1093/oi/authority.20110803100138149.

[13] Afloogee, H. H. N., Shahedi, B., Mustafa, M. H., & Amjad, M. (2025). The capability of physical and spatial characteristics of traditional Iraqi architecture in contemporary architecture. *Journal of Mechanic in Architecture and Urban Environment Engineering*.

[14] Ahmed, B. J., & Jimenez-Bescos, C. (2020). An analysis on the benefits of vernacular architecture to design Passivhaus buildings in Kurdistan. In *Proceedings of the 54th International Conference of the Architectural Science Association (ANZAScA 2020)* (pp. 151–160).

[15] Yüksel, F. Ş. K., Melikoğlu Y., and Akalp S**.** (2025). Impact of iwan orientations on building energy performance: A case study. *International Journal of Global Warming*, 305–323.

[16] Habibi, A., Nikkar, M., & Shahali, H. (2025). Climate-Responsive Vernacular Architecture: Environmental and Cultural Adaptation Strategies in the Historic City of Lar. *International Journal of Architectural Engineering & Urban Planning*, *35*(4), 883.

[17] Mandilawi, A. S. (2012). *Climate response strategies in Baghdad region* [Master's thesis, University of Arizona].

[18] Haraty, Hayder & Raschid, Yazah & Mohd YUNOS, Mohd Yazid. (2018). Morphology of Islamic Traditional Iraqi Courtyard House Toward Holistic Islamic Approach in New Residential Development in Iraq. International Journal of Engineering and Technology(UAE). 7. 379-382. 10.14419/ijet.v7i3.7.18883.

[19] (n.d.). Daily inside removal in a traditional house. Chinese University of Hong Kong.

[20] Al-Jawadi, M. H., & Al-Bukhari, A. L. (2008). *Sunni Endowment Office building design* (First-place winner, 2008 project competition). University of Technology, Department of Architectural Engineering, Baghdad, Iraq.

[21] Al-Hafith, O., Satish, B. K., & de Wilde, P. (2022). Assessing annual thermal comfort extent in central courtyards: Baghdad as a case study. *Smart and Sustainable Built Environment*. https://doi.org/10.1108/SASBE-09-2021-0154