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Research Article

Optimizing Environmental Performance in a Contemporary Hybrid Villa in Baghdad: A Design Builder Simulation of Vernacular Architecture Integration

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Abstract:

This study examines the integration of traditional architectural elements—"Shanasheel," "Bad-Geer," and "Al-Hosh"—into a hybrid contemporary villa in Baghdad's arid/dry climate. The research starts with employing an observational fieldwork alongside dynamic thermal simulations to analyze and contrast traditional Baghdadi homes with contemporary Iraqi residences. "DesignBuilder" software was employed to simulate operative temperature, solar gain, cooling load, daylight factor, and natural ventilation. The evaluation results indicated that the inclusion of vernacular components markedly has enhanced the thermal performance of hybrid villa, which interior peak temperatures reduced from 40°C to 31-35 ° C and solar gain decreased from 9.2 kW to 4.1 kW. Moreover, the cooling load experienced an 8% decrease. "Shanasheel" augmented daylighting and diminished solar heat gain, whilst "Bad-Geer" facilitated natural ventilation. The research emphasizes on the capability of vernacular architecture in improving energy efficiency and thermal comfort when used in design approaches of contemporary projects, promoting a hybrid methodology that integrates traditional and contemporary construction methods. The research's Recommendations include the integration of passive cooling techniques, the reintroduction of shade devices, and the modification of building rules to promote sustainable practices.

1. Introduction

Recently, the convergence of vernacular ancient architectural principles and contemporary design has attracted considerable attention, especially when regarding to understand sustainability and thermal comfort in hot areas. This study seeks to explore how traditional construction methods and the use of materials, commonly present in vernacular architecture, might improve the environmental sustainability of contemporary buildings. Although the study will emphasize the prospective advantages of incorporating these traditional features, a significant deficiency in quantitative data and the range of geographic regions examined persists. This study will focus on three vernacular architectural components—"Shanasheel," "Bad-Geer," and "Al-Hosh"—and their efficacy in enhancing the performance of contemporary dwellings in Baghdad, Iraq.

This study employs a research methodology that includes both observational fieldwork and dynamic thermal simulations to provide a comprehensive analysis of traditional Baghdadi houses in comparison to contemporary Iraqi residences. A hybrid villa, integrating elements from both architectural forms (Vernacular & Modern), serves as the focal focus of this inquiry. During the observational phase that was conducted in July 2024, the HOBO data loggers were employed to help record temperature, humidity levels, and air velocity during that fix dates. Also, simulation tests were conducted using DesignBuilder software to check how well the designed hybrid villa performed with the environment in terms of operating temperature, solar gain, cooling loads, daylight factor, and natural ventilation levels.
Initial findings from this research suggest that conventional architectural components are essential for improving thermal comfort and decreasing energy usage in residential structures. The

incorporation of "Shanasheel," "Bad-Geer," and "Al-Hosh" can significantly improve thermal comfort during peak temperatures, and reduce solar gain. This demonstrates the efficacy of passive cooling solutions. This study promotes the incorporation of vernacular design concepts into modern architecture, highlighting the necessity for sustainable and culturally pertinent constructed environments. Moreover, it tackles the difficulties related to the implementation of these classical components, encompassing material selection and adaptation to contemporary construction methodologies. The research aims to enhance existing knowledge of sustainable design by advocating for a hybrid strategy that incorporates the most effective elements of both traditional and contemporary construction techniques.

A comprehensive literature analysis was conducted to ascertain current knowledge regarding vernacular architecture and its use in contemporary design, particularly in relation to sustainable building materials, construction techniques, and cultural influences. The review underscored numerous studies and publications that jointly accentuate the potential of vernacular architecture in fostering sustainability. Nonetheless, it highlighted considerable shortcomings in the literature, including the cursory examination of certain subjects and constraints in geographic scope.

The researcher recognized an urgent requirement for further quantitative studies evaluating the environmental advantages of vernacular-style structures, alongside qualitative studies investigating their effects on users and cultural surroundings. Policy analysis and interdisciplinary cooperation could enhance the incorporation of vernacular architectural notions into contemporary architectural practices. This strategy seeks to promote sustainable and culturally attuned constructed settings, ultimately benefiting both the ecosystem and local communities. The literature evaluation included several pivotal works that established a robust basis for the researcher's investigation into the integration of vernacular architecture VA in contemporary designs. Some of the previous literature that helped improving the research's methodology; as [1] conducted a significant study on the shading effects of traditional Iraqi architecture, demonstrating how traditional designs employ compact shapes and courtyards to attain thermal comfort. Also, [2] examined the environmental efficacy of ancient courtyard residences in Baghdad, highlighting the significance of passive systems for improving natural heating, cooling, and ventilation. Additional research, including [3], and [4], which they further investigated the effectiveness of traditional architectural components in enhancing energy efficiency and fostering social contact. Correspondingly, [5] studied low energy housing design in Baghdad, highlighting efficient energy conservation through improved insulation and window design, while noting climate data limitations. Finally, [6] explored sustainability in Iraqi vernacular architecture, emphasizing vernacular techniques for modern designs but faced challenges in assessing sustainability standards and data availability. Despite the increasing interest in vernacular architecture and its significance for modern design, this can indicate that numerous studies are constrained in their depth, geographic coverage, and quantitative data. The comparative examination of these publications elucidated their various strengths and flaws, providing vital insights into the contemporary research environment of vernacular architecture. The assessment highlighted the need for additional research to fill current gaps by investigating the role of vernacular architecture in promoting sustainability. According for what have been presented the research's will be as follows;

1.1 Research Problem

The research problem addresses the insufficient quantitative data and empirical studies on the performance of integrated vernacular architectural elements, specifically "Shanasheel," "Bad-Geer," and "Al-Hosh," in enhancing thermal comfort and sustainability in contemporary residential buildings in Baghdad. This gap impedes the effective application of traditional architectural knowledge in modern design practices.

1.2 Research Hypothesis

Incorporating vernacular architectural elements into a contemporary hybrid villa in Baghdad will improve thermal performance, decrease energy consumption, and enhance occupant comfort compared to a villa lacking these vernacular features.

1.3 Research Objectives

1.Validate simulation findings with observational data from traditional and modern residential buildings in Baghdad.

2.Quantitatively evaluate the thermal performance of a hybrid villa in Baghdad using DesignBuilder simulation software.

3.Compare the thermal performance of the hybrid villa with a model lacking vernacular elements.

4.Analyze the impact of vernacular elements on daylight factor and natural ventilation in the hybrid villa.
5.Provide recommendations for integrating vernacular architectural principles into contemporary residential designs in arid climates.

1.4 Research Importance

The research topic is vital for developing sustainable building solutions in hot, arid climates, aiding energy conservation and climate change mitigation. It offers empirical support for incorporating vernacular architecture into modern design, thus connecting traditional knowledge with contemporary practices. The findings will influence architectural design, building codes, and policy, fostering sustainable and culturally relevant environments in Baghdad and similar areas while preserving Iraqi architectural heritage.

1.5 Research Justifications

The increasing demand for energy-efficient buildings in Baghdad, in light of climate change challenges, underscores the significance of this research, emphasizing the necessity for sustainable architectural solutions. The unique climatic and cultural characteristics of the city provide an exceptional opportunity to evaluate the effectiveness of vernacular architecture. To ensure precise assessments of performance, it is advisable to utilize advanced simulation tools such as DesignBuilder. Observational data, conversely, provides the simulation results with a real-world context, ensuring their accuracy.

1.6 Research Methodology

The research employs a multi- approcach methodology, starts by incorporating observational fieldwork to collect environmental data from both traditional and contemporary house designs in Baghdad, next, a simulation through applying DesignBuilder software to a model and evaluate its thermal and environmental performance of a hybrid villa, and finally a comparative analysis to assess the performance of the simulated villa with and without vernacular architectural features.

2. Material and Methods

This stage of the investigation will analyze the thermal efficiency of traditional Baghdadi homes compared to contemporary Iraqi residences during the extreme summer temperatures in Baghdad. In July 2024, the research utilized HOBO Temperature/Relative Humidity Data Loggers to methodically monitor indoor climate conditions, focusing on temperature, humidity, and air velocity. The findings demonstrate that traditional homes, characterized by features such as courtyards, windcatchers, and sturdy mud-brick walls, effectively maintain thermal comfort and humidity levels. Conversely, contemporary residences constructed with modern materials encounter difficulties associated with increased heat absorption and greater reliance on energy resources. The analysis of the collected data highlights the importance of integrating traditional architectural features into modern designs approaches to enhance energy efficiency and occupant comfort within the built environment. A comprehensive thermal simulation of a hybrid villa that incorporates both traditional and modern architectural elements, which will examine the potential advantages of integrating these distinct styles. The study advocates for an integrated approach in design, highlighting the importance of sustainability and resilience in tackling climate-related issues.

2.1 Observation Phase

A study was conducted in July 2024, during Baghdad's summer season, to compare traditional Baghdadi homes with contemporary Iraqi homes, (figure 1). The findings indicate significant variations in the effectiveness of these two architectural styles in managing heat, humidity, and air flow within the interior environment. A HOBO Temperature/Relative Humidity Data Logger was used to monitor the environmental performance in both types of residences as a component of the study. The primary emphasis was on the impact of various elements of home designs on thermal comfort within Baghdad, where temperatures frequently exceed 50°C, which is concerned as harsh climate zone.

Observation Phase of the selected houses

The research required to assess and comprehend the thermal conditions present both indoors and outdoors in the two types of houses, emphasizing the distinctions in architectural methodologies. Traditional Baghdadi houses exhibit distinctive vernacular features, including “Shanasheel” (wooden window), “Bad-Geer” (windcatcher), and a central courtyard referred to as “Al-Hosh.” In contrast, contemporary Iraqi houses embody modern design principles, frequently emphasizing aesthetics and swift construction while often overlooking climatic factors. The data collection phase entailed the strategic placement of data loggers in distinct zones of both residences to

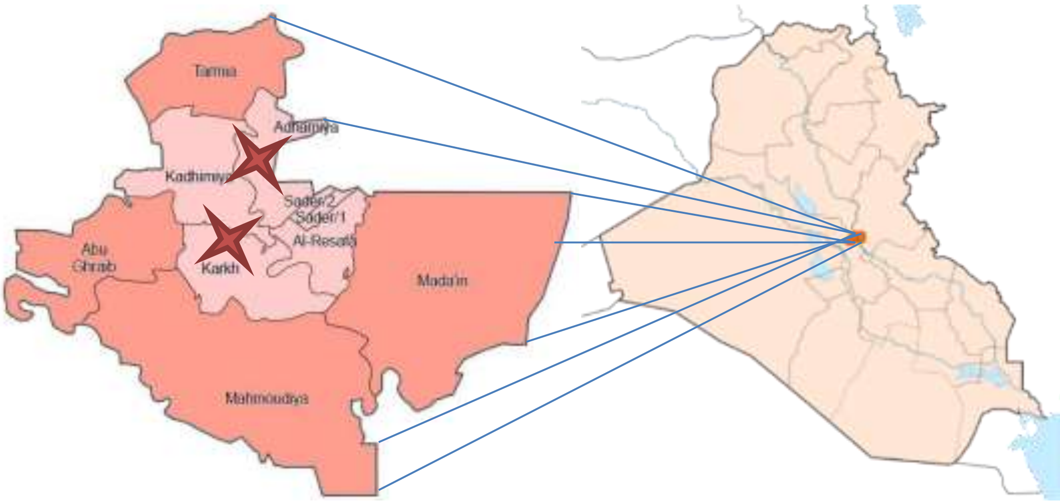

Figure 1. *Study area within Baghdad.*

Figure 2. *Baghdadi House - Location Al-A'dhamiyah*

systematically gather temperature and humidity data at hourly intervals during the month of July.

Traditional Baghdadi House

The traditional Baghdadi house, situated within the dense urban environment of Al-A'dhamiyah, included a central courtyard that functioned as a thermal regulator, facilitating air circulation and evaporative cooling. The design of the house was structured around this courtyard, featuring robust mud-brick walls that offered superior insulation (figure 2).

The traditional Baghdadi house serves as a significant representation of centuries of adaptation to climate and expression of cultural identity. The inward-focused design, centered on the “Al-Hosh” courtyard, establishes a microclimate that maintains cooler temperatures compared to the surrounding area. The substantial mud brick walls effectively impede heat transfer, ensuring cooler indoor temperatures throughout the day while gradually releasing accumulated heat during the night. The roof, designed with wooden beams and reed mats, significantly improves thermal capacity. On the other hand, the “Shanasheel” offers shading while facilitating the entry of diffused light and ventilation, whereas the “Bad-Geer” adeptly harnesses prevailing winds to enhance the cooling of interior spaces. This architectural style exemplifies a cohesive interaction with the surrounding environment, employing materials and methods sourced locally that enhance sustainability.

Modern Iraqi House

In contrast, the modern Iraqi residence, completed in 2020, is situated in a newly developed suburban region and is constructed using materials such as concrete and steel. The contemporary materials exhibit reduced efficacy in managing internal temperature regulation. The compartmentalized layout of the house, along with the presence of large windows that were frequently installed without regard for solar orientation, led to considerable heat gain throughout day (Figure 3).

Figure 3. *Selected Contemporary House - Al-Mansoor location*

In contrast, the contemporary Iraqi house exemplifies current architectural trends that emphasize efficient construction and visual attractiveness. Constructed with reduced wall thickness and a limited use of thermally insulating materials, these houses face challenges in sustaining comfortable indoor temperatures. The design is characterized by a more segmented structure, which leads to restricted natural airflow and cross-ventilation. Large windows, frequently lacking adequate insulation, result in considerable heat gain, which in turn creates a substantial dependence on air conditioning systems to maintain thermal comfort.

Tools and Techniques

The used Data Logger (table 1) was employed due to its precision and capability to track environmental conditions over prolonged durations. The data loggers were systematically positioned in both residences to collect real-time data regarding variations in temperature and humidity. The loggers of the traditional house were situated close to the courtyard, within rooms featuring “Shanasheel,” and along the “Bad-Geer” path. In contrast, the loggers of the contemporary house were located in living areas and bedrooms that incorporated extensive glazing openings.

Table 1. *Data logger device details.*

Category	**Details**
Device Name	HOBO U23 Pro v2 Temp/RH Data Logger
Models	U23-001A (internal), U23-002A (external)
Purpose	Temp/RH monitoring in various environments
Key Features	Weatherproof, high accuracy, fast response
Temp Range	-40°C to 70°C
Temp Accuracy	±0.25°C (-40°C to 0°C), ±0.2°C (0°C to 70°C)
RH Range	0 to 100% RH
RH Accuracy	±2.5% (10-90% RH), ±5% (outside this range)
Response Time	10 min (U23-001A), 3 min (U23-002A)
Memory	21,000 measurements
Battery Life	3 years (1-min intervals, user-replaceable)
Interface	USB (HOBO ware required)
Dimensions	10.2 x 5.1 x 2.5 cm, 54 g
Cable Length (U23-002A)	1.8 meters PVC
Environmental Rating	Outdoor/condensing environments
Application Areas	Energy efficiency, sustainability, climate studies
Device pictures	

Data collecting

The data collection process entailed careful observation of temperature, humidity levels, and air-velocity in both types of houses. The traditional Baghdadi house demonstrated a more consistent indoor climate, with average temperatures fluctuating between 32°C and 36°C, whereas the contemporary house encountered broader temperature variations, spanning from 38.2°C to 41.5°C (table 2). The dependence on mechanical cooling systems in contemporary residences has led to increased energy usage and diminished comfort levels in living environments.

Analysis of Temperature

The comparative temperature analysis demonstrated that the traditional Baghdadi house successfully managed indoor temperatures in the face of external heat conditions. The robust walls

Table 2. *Summary of Collected Data.*

Date	Traditional House (°C)	Modern House (°C)	Traditional House Humidity (%)	Modern House Humidity (%)
01 July	33.5	38.2	38.0	23.0
07 July	32.0	39.0	37.0	22.0
14 July	34.0	40.5	39.5	24.0
21 July	35.5	41.0	40.0	25.5
30 July	36.0	42.5	41.5	26.0

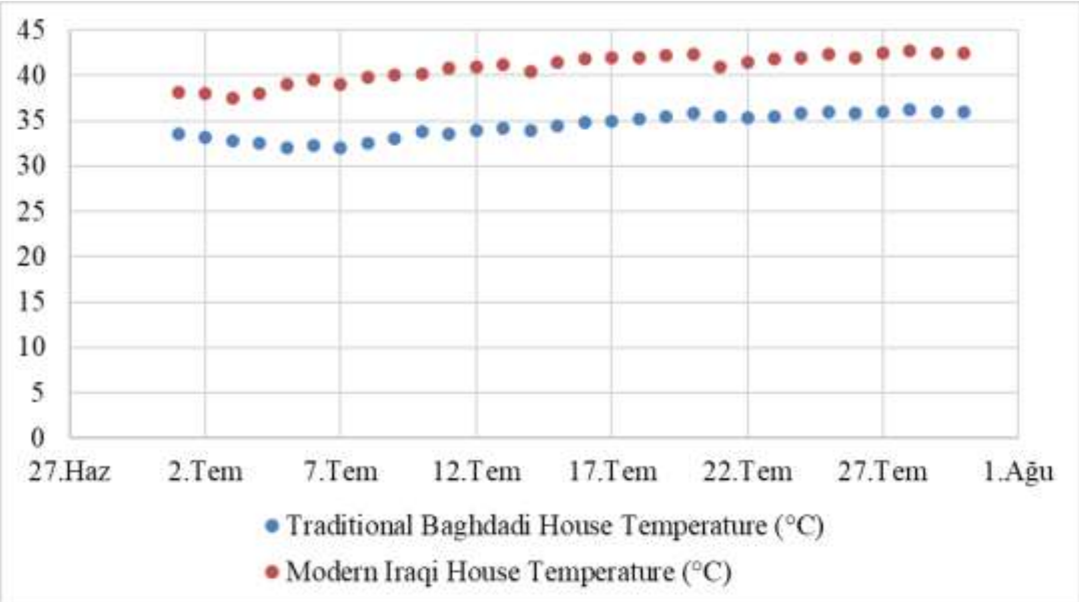

Figure 4*. Temperature Fluctuations for (1st to 30th of July).*

Table 3*. Average temperature for observed houses.*

Date Range	Traditional House Temp (°C)	Modern House Temp (°C)
July 1-5	32.8 ± 0.6	38.5 ± 0.6
July 6-10	32.7 ± 0.7	39.7 ± 0.9
July 11-15	34.0 ± 0.5	41.0 ± 0.4
July 16-20	35.3 ± 0.4	42.1 ± 0.2
July 21-25	35.6 ± 0.3	41.7 ± 0.6
July 26-30	36.0 ± 0.2	42.6 ± 0.3

and courtyard layout fostered a consistent indoor climate, whereas the design of the modern house resulted in increased temperature variations and discomfort. During the hottest recorded day, the traditional house sustained an indoor temperature of 34.5°C, whereas the modern house, despite being equipped with air conditioning, experienced a temperature of 41.5°C as a result of energy blackouts. (Figure 4 and Table 3)

Analysis of Humidity

The traditional house exhibited effective humidity management, maintaining an average relative humidity of 44.8%. The natural ventilation facilitated by the “Bad-Geer” and the evaporative cooling effects of the courtyard contributed to the maintenance of stable humidity levels. In contrast, the modern residence underwent notable variations in humidity, frequently declining to uncomfortable levels as a result of dependence on mechanical cooling systems (Figure 5 and Table 4).

Analysis of Indoor Air Velocity

The examination of indoor air velocity underscored the efficacy of conventional design components in improving natural ventilation. The “Bad-Geer” demonstrated superior air velocities, especially during peak afternoon hours, whereas the “Shanasheel” offered a more balanced airflow (table 5). In contrast, the modern residence demonstrated persistently low air velocities in all device positioned locations, which constrained natural ventilation and heightened dependence on mechanical systems (table 6).

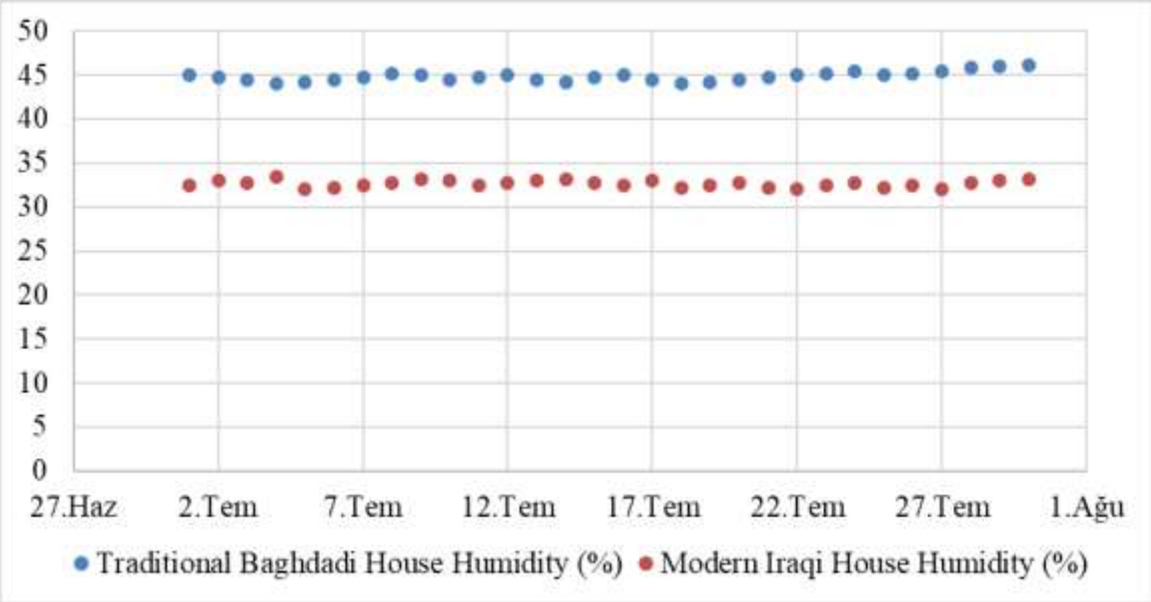

Figure 5. *The Relative Humidity only for (July 1st to 30th).*

Table 4. *Relative Humidity Variations of the observed houses.*

Date Range	**Traditional House Humidity (%)**	**Modern House Humidity (%)**
July 1-5	44.5 ± 0.3	32.8 ± 0.6
July 6-10	44.7 ± 0.3	32.6 ± 0.4
July 11-15	44.7 ± 0.3	32.8 ± 0.3
July 16-20	44.6 ± 0.4	32.4 ± 0.4
July 21-25	45.1 ± 0.3	32.4 ± 0.3
July 26-30	45.6 ± 0.3	32.7 ± 0.5

2

Table 5. *Indoor Air-Velocity - Vernacular House (July 2024).*

Date-July	**Courtyard (Al-Hosh)**	**Room-1 (Shanasheel)**	**Room-2 (Bad-Geer)**
1	1.1 m/s	1.8 m/s	2.5 m/s
7	0.9 m/s	1.6 m/s	2.2 m/s
14	0.9 m/s	1.9 m/s	2.6 m/s
21	0.8 m/s	1.7 m/s	2.3 m/s
28	1.0 m/s	1.9 m/s	2.7 m/s

Table 6. *Indoor Air-Velocity Contemporary House (July 2024).*

Date-July	**Living Room (Large Windows)**	**Bedroom (Thin Walls)**	**Corridor (Open Layout)**
2	0.5 m/s	0.2 m/s	0.4 m/s
8	0.6 m/s	0.3 m/s	0.5 m/s
15	0.7 m/s	0.4 m/s	0.6 m/s
22	0.8 m/s	0.5 m/s	0.6 m/s
29	0.9 m/s	0.6 m/s	0.7 m/s

According to the collected data from the observed houses, the study's findings highlight the significance of incorporating traditional architectural elements into modern designs to improve thermal comfort and promote sustainability. The passive cooling techniques of the Baghdadi house, including the incorporation of courtyards and the use of thick walls that works as an insulation layer, serve as a valuable model for the development of energy-efficient homes in hot climates. The modern Iraqi residence, though visually attractive, does not exhibit the same level of climatic adaptability as its traditional counterparts. The dependence on mechanical cooling systems leads to heightened energy usage and adversely affects occupant comfort in instances of power outages or system malfunctions.

The research is a road map for architectural design in Baghdad and other similar climates; by incorporating traditional elements into modern designs, which enables architects to create built environments that improve energy efficiency and comfort. the research established that the integration of these VA elements reduces reliance on mechanical cooling systems, enhance indoor air quality, and promote sustainable living practices. Therefore, the research has realized that the traditional house utilizes vernacular design principles, which demonstrate a sustainable approach to address the challenges posed by extreme heat that is essential in the context of climate change. on the other hand, contemporary house design is subjected on modern materials and aesthetics that highlights the need for an architectural approach that is more responsive to local climate limitations. therefore, it is important for architects, to combine passive cooling techniques of the past with modern building methods, this methodology has the capacity to enhance the creation of more resilient and energy-efficient homes, which are better prepared to address the challenges presented by climate change while also elevating occupant comfort. It is recommended to undertake further research to explore the lasting benefits of these hybrid designs, focusing on energy efficiency, environmental impacts, and occupant well-being.

2.2 Dynamic Simulation phase

The researchers conducted a detailed examination of a hybrid villa in Baghdad, Iraq, employing a dynamic thermal simulation to assess the impact of incorporating traditional vernacular architectural elements such as "Shanasheel," "Bad-Geer," and "Al-Hosh" on the building's overall performance. The research employed sophisticated simulation software known as DesignBuilder, utilizing EnergyPlus, to examine various performance metrics, including operating temperature (OT), daylight factor (DF), solar gain (SG), cooling load (CL), energy consumption (EC), and natural ventilation (NV). The simulations were carried out under two separate scenarios: one that omitted the

Table 7. *Hybrid Villa Location details.*

Category	**Parameter**	**Details**	**Notes**
Location	Climate Zone	Hot-dry (BWh, Köppen–Geiger)	Hot summers, mild winters
	Coordinates	33.33° N, 44.38° E	Central Baghdad
	Elevation	~34 m	Near sea level
	Weather Data Source	Baghdad Weather File Used in DesignBuilder simulation	
Building	Type	Hybrid Villa	traditional & contemporary
	Floor Area	300 m²	
	Floors	2 floors	Ground & upper level
	Facade Orientation	North-South,	Optimized for passive cooling
Materials & Design	Modern Materials	Insulated brick, double glazing	Walls, windows
	Vernacular Materials	Wood, Clay, Local Stone	Traditional elements
	“Shanasheel”	Shading device	Reduces solar heat gain
	“Bad-Geer”	Wind guides	Enhances natural ventilation
	“Al-Hosh”	Open-air, shaded microclimate	Improves thermal comfort
HVAC & Occupancy	Cooling System	Central Air Conditioning	May–September usage
	NV	Bad-Geer & Courtyard	Passive cooling strategies
	Occupancy Schedule	Residential use	Daily cooling usage
	Heat Gains	Appliances, lighting, occupants	Simulated internal energy loads
Performance	OT	Hottest days monitoring	Thermal comfort target
	CL (kWh)	Simulated for July	Energy demand reduction focus
	SG (kW)	With/without VA	Shading impact analysis
	DF	Living areas & courtyards	Reduces artificial lighting need
	Airflow	Bad-Geer, NV impact	Indoor air quality assessment
Simulation	Software	DesignBuilder (EnergyPlus)	Thermal, lighting, airflow
	Duration	Full year, hourly	peak summer months only
	Grid Size	Medium resolution	accuracy & computation
	Climate Adaptations	VA features in extreme heat	Adapting to Baghdad’s climate
	EC (kWh)	HVAC, lighting, appliance tracking	Energy consumption analysis

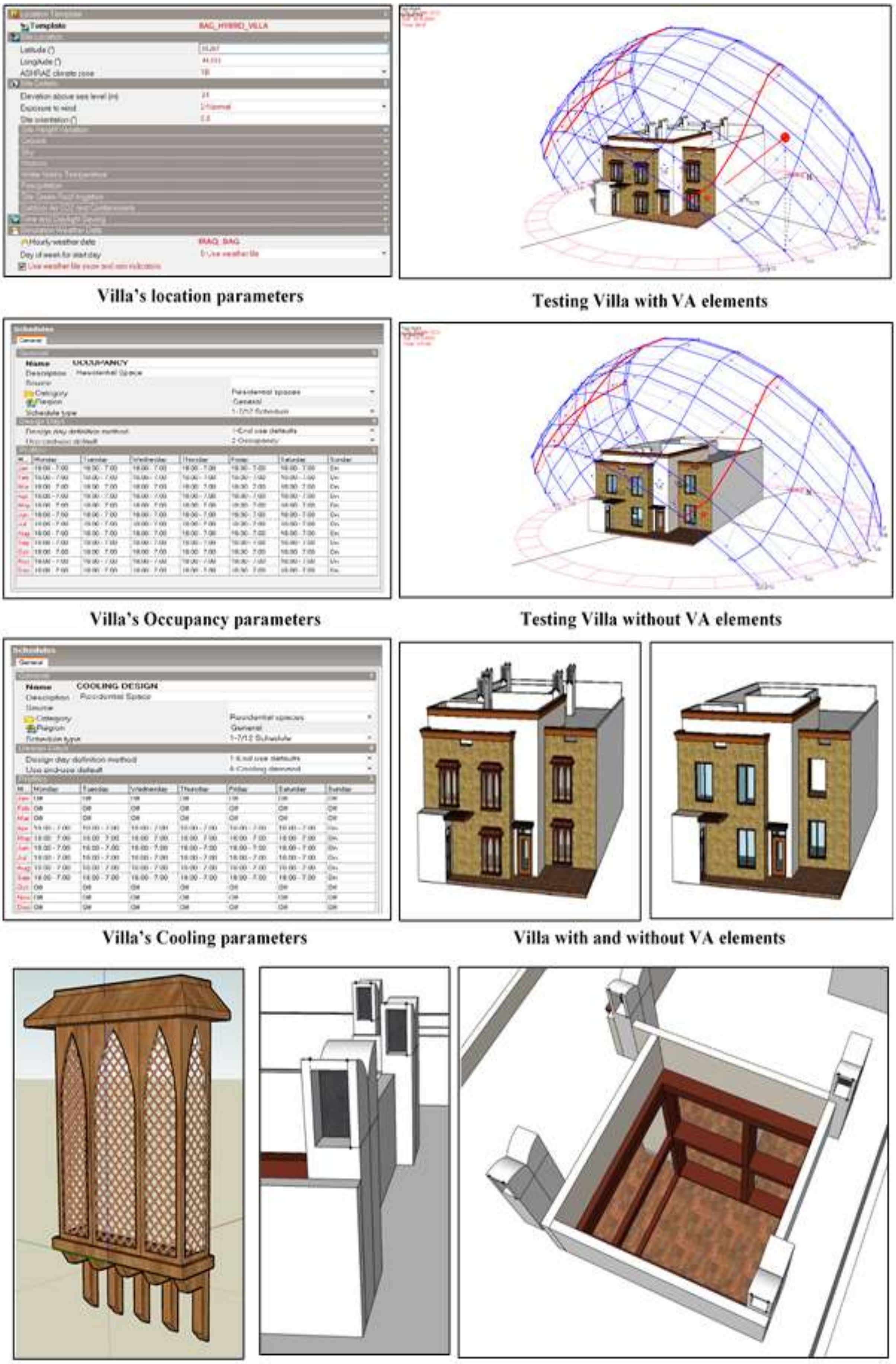

Figure 6. *Project testing moods with included VA elements*

integration of vernacular elements and another that incorporated them.

Context of Location and Design

The villa is located in the Al-Mansoor district of Baghdad that is in a hot-desert climate, categorized as "BWh" according to the Köppen–Geiger classification system [7]. The research incorporated average weather data pertinent to Baghdad into the simulation software to guarantee precise outcomes. The hybrid villa design integrates contemporary materials, including insulated concrete blocks and glass, alongside traditional components made from locally sourced materials. We developed the "Bad-Geer" system to enhance airflow, while the "Shanasheel" served as a shading mechanism to decrease solar heat gain.

Details of the Simulation

The total floor area of the villa measures 300 m², distributed over two levels, with a facade aligned in a north-south direction. The simulation integrated standard occupancy patterns, with a particular emphasis on air conditioning utilization during the warmer months spanning from May to September. The research sought to evaluate the potential benefits of incorporating vernacular elements in enhancing the sustainability and comfort of the villa, during 2024 July the hottest month of the year (Table 7 and Figure 6).

3. Results and Discussions

3.1 Results of Performing Metrics

Operative Temperature (OT) and Solar Gain (SG)

During the initial simulation, which omitted conventional components, the interior OT reached a maximum of 40°C on July 21, the year's hottest day, markedly surpassing the comfort range of 22°C to 28°C. The solar gain, as observed through the expansive modern windows, reached 9.2 kW, suggesting a significant dependence on mechanical cooling systems to ensure occupant comfort. In contrast, the second simulation that incorporated the vernacular elements demonstrated a significant reduction in peak interior temperatures, which ranged from 31°C to 35°C, along with a decrease in SG to 4.1 kW. This illustrated the efficacy of conventional components in minimizing heat infiltration and enhancing thermal comfort (Figure 7 and Table 8).

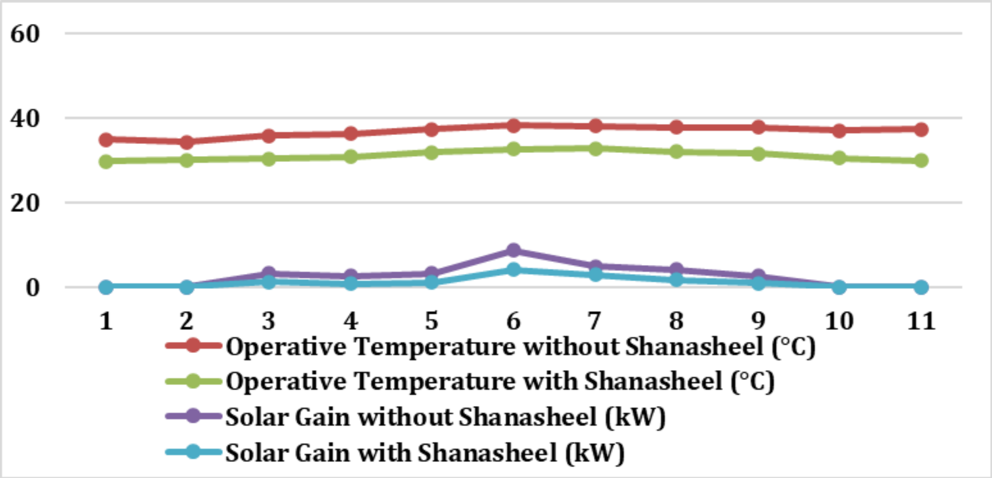

Figure 7 *differences in OT and SG.*

Table 8. *OT & SG collected data within fixed timeline.*

Time (hrs)	OT Without (VA elements) (°C)	OT With (VA elements) (°C)	SG without (VA elements) (kW)	SG With (VA elements) (kW)
2	34.96	29.89	0	0
4	34.4	30.12	0	0
6	35.91	30.48	3.29	1.2
8	36.39	30.91	2.59	0.84
10	37.48	31.92	3.26	1.11
12	38.31	32.67	8.68	4.08
14	38.17	32.91	4.95	2.99
16	37.81	32.03	4.08	1.65
18	37.91	31.65	2.58	0.97
20	37.08	30.58	0	0
22	37.37	30.05	0	0

Cooling Load (CL)

The preliminary simulation, which excluded conventional components, documented a cooling load of 4200 kWh during July, as shown in Figure 8, which underscoring the building's reliance on mechanical cooling systems. The combination of “Shanasheel” and “Bad-Geer” resulted in a reduction of the cooling load to 3850 kWh, indicating an 8% decrease see Figure 9. This reduction highlights the capacity of vernacular architecture to improve energy efficiency in modern designs as shown in Figure 10.

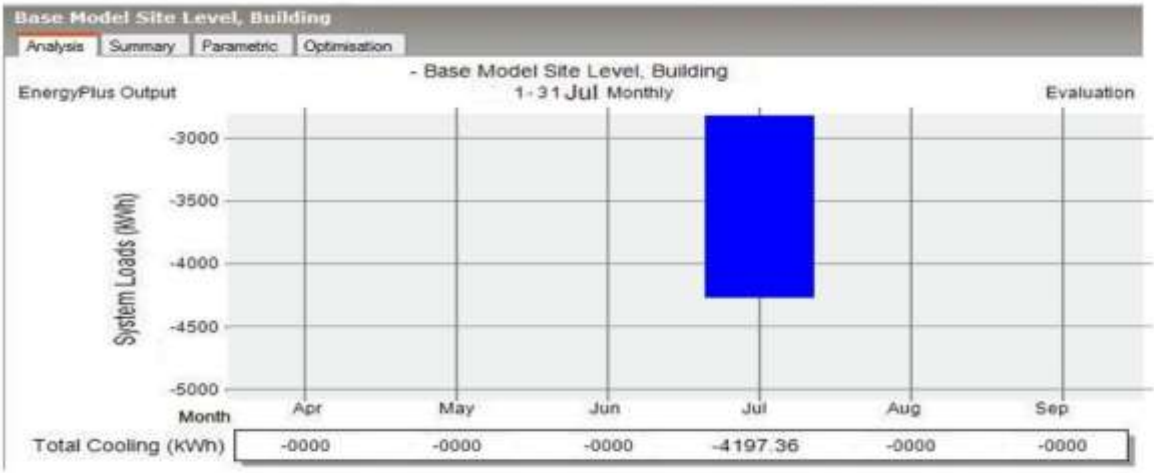

Figure 8. *Simulation Without using VA elements.*

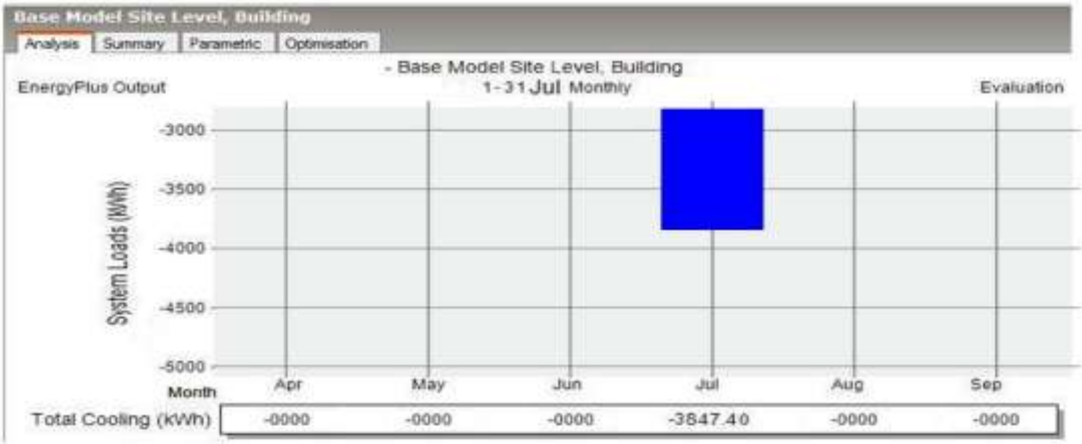

Figure 9. *Simulation With using VA elements.*

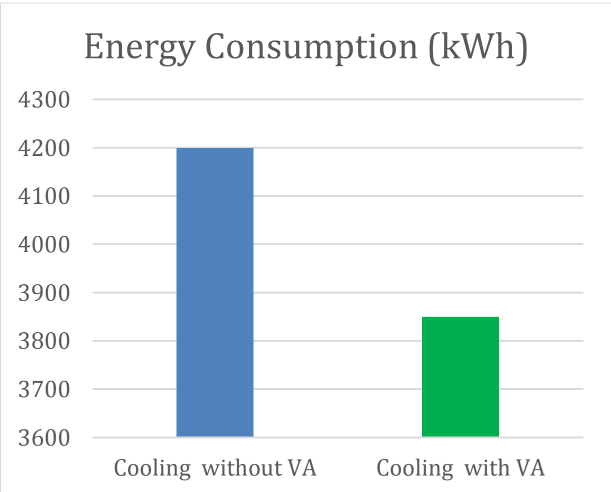

Figure 10. *EC when with or without the use of VA elements.*

Daylight Factor (DF) and Natural Ventilation (NV)

The integration of the VA element "Shanasheel" markedly enhanced sunlighting while preserving ensuring thermal comfort.

This VA component successfully diffused direct sunlight, thus reducing glare and alleviating temperature increases in residential spaces. while, the “Bad-Geer” facilitated natural airflow, which enhanced indoor air quality and reduced reliance on mechanical ventilation. The courtyard, referred to as “Al-Hosh,” served an important function in improving daylight access and managing thermal conditions, demonstrating the relationship between these elements.

Table 9. *Simulation results with/without VA elements.*

Comparative Factor	Without VA elements	with VA elements	Reduction (%)
OT during the year's hottest day (°C)	39.5°C to 43.0°C	33.8°C to 36.5°C	approx. 15%
Average DF	3.2	2.1	34.4%
Peak SG during the year's hottest day (kW)	11.5	3.2	72.2%
CL during the year's hottest month (kWh)	4200	3850	8%

3.2 Analysis of Simulation Results in Comparison

Examine the Table 9, below to analyze the comparative results of the simulation. This illustrates the significant impact of incorporating VA elements such as "Shanasheel," "Bad-Geer," and "Al-Hosh" into contemporary design, particularly in regions characterized by high temperatures, such as Iraq. The research indicates that these components contribute to sustainability initiatives by enhancing the thermal efficiency of buildings, thereby reducing the need for cooling and improving the DF.

The results indicate that the employment of "Shanasheel" leads to a reduction in indoor OT by approximately 15% during during peak summer conditions, which is crucial for mitigating heat gain. Despite a reduction of 34.4% in the daylight factor, this trade-off successfully reconciles the necessity for natural light with the requirement for shading, thereby minimizing glare and overheating while ensuring adequate illumination indoors. The maximum SG recorded on the hottest day is reduced by an impressive 72.2%, illustrating "Shanasheel's" ability to block direct sunlight while promoting airflow, thus significantly lowering cooling needs. Moreover, a significant 8% reduction in total CL during the peak month highlights its potential for energy conservation, particularly in large urban buildings.

3.3 Discussion

At the first sight of the findings, it can easily be underscored that the effectiveness of the integration of tradition design components with contemporary architecture, emphasizing their significance in enhancing environmental sustainability and occupant thermal comfort. The integration of "Bad-Geer" improves natural ventilation in the hybrid villa by promoting the movement of warmer air, which in turn enables cooler air to enter more efficiently. therefore, a notable reduction in the dependence on artificial ventilation systems is needed, also the collaboration between "Bad-Geer" and multiple VA components cultivates a self-regulating ecosystem that adapts to local climatic conditions. on the other hand, the "Al-Hosh," significantly contributes to the improvement of natural illumination within the built environment.

Moreover, "Al-Hosh" plays a significant role in the villa's microclimate by establishing a cooler, shaded environment that enhances overall thermal regulation, along promoting natural light into interior areas that help reduce reliance on artificial lighting, energy usage, and improves visual comfort.

The clear public interest in traditional architectural elements is demonstrated by participants' preferences for designs that incorporate cultural significance and environmental sustainability. There are persistent challenges associated with the costs involved in constructing "Shanasheel" and "Bad-Geer" using traditional materials, as well as the specialized skills required for their installation. Emerging alternative materials, including aluminum and composite panels, offer potential advantages; however, further research and analysis are required to assess their effectiveness regarding energy efficiency and durability.

4. Conclusions

The research's main finding is that integrating traditional architectural elements with modern design methodologies offers a viable and sustainable approach for residential built environments in hot climates. The combination of the selected VA significantly enhances thermal comfort, energy efficiency, and the quality of daylight. This integration exemplifies the blending of traditional components with contemporary performance criteria, while also preserving cultural significance. Future research should tickle the development of materials that are more cost-effective yet maintain the performance of used traditional features, ensuring that their functional advantages are preserved. Prior to advocating for the increased integration of these features in contemporary architecture, it is essential to conduct extensive longitudinal studies examining their impact on energy consumption and occupant comfort.

In conclusion, the incorporation of chosen VA elements demonstrates a cooperative approach to sustainable architectural design tailored for hot and dry climates. Each VA element serves a specific function: the "Shanasheel" provides shade, "Bad-

Geer" improves passive cooling, and "Al-Hosh" optimizes sunlight. Collectively, VA elements establish a setting that is self-regulating and energy-efficient, which illustrates the application of sustainable design in comparable contexts.

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- **Ethical approval:** The conducted research is not related to either human or animal use.
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