SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 1.1, (2026), pp. 2934-2947
Open Access. Online & Print

DOI: 10.5281/zenodo.121126213

A PROPOSED METHODOLOGY FOR INTEGRATING VERNACULAR ARCHITECTURE AND ENVIRONMENTAL ARCHITECTURE TO IMPROVE ENERGY PERFORMANCE IN MOSQUE BUILDINGS IN THE DAKHLA OASIS, EGYPT

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Received: 25/10/2025
Accepted: 12/01/2026

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ABSTRACT

The Dakhla Oasis, located in the Egyptian desert, showcases how the ingenuity of human construction allowed communities to develop in an environment of extreme heat and lack of rainfall for thousands of years. Simply put, vernacular architecture is the architectural style of an area based on the stone, wood, earth, or plant materials present in that same area. Consequently, this architecture is deeply connected to its context, reflecting and profoundly influenced by its distinctive geographical and cultural characteristics. It is unique in the world and serves as a means of affirming local identity. The main objective of the research was to study improving energy efficiency in the vernacular architecture of mosques in the Islamic city of Al-Qasr in the Dakhla Oasis in the New Valley. This was done by an analytical study of vernacular architecture and environmental architecture standards and the extent of their application in mosques in the Islamic village of Al-Qasr in the Dakhla Oasis in the New Valley, using simulation via the design builder v7.0 program to improve energy efficiency through the application of local materials, wall thickness and opening ratios in the different facades. The results indicate that the use of local materials with a wall thickness of 40 cm improves the energy efficiency of the mosque building in the Islamic village of Al-Qasr in the Dakhla Oasis compared to traditional mosques with a contemporary design.

KEYWORDS: Vernacular architecture – Environmental architecture – Energy efficiency – Dakhla Oasis – Mosque buildings.

1. INTRODUCTION

The Dakhla Oasis is an extraordinary representation of how urban development can adapt to extreme environmental conditions. The oasis reflects the creative ability to develop vernacular architecture developed from historic building practices in response to the difficulties presented by poor environmental conditions for human survival and development and has therefore been established through generations. The Dakhla Oasis is more than a place to live; it has developed into a complete living system; a living ecosystem that allows for the coexistence of man with the harsh environment and has a significant role in preserving the social and cultural aspects of the community living in the oasis. This architecture, as thinkers like Hassan Fathy have noted, is not the individual creation of a single architect, but rather the product of collective wisdom accumulated over generations, drawn from long experience to achieve near-perfect design and environmental solutions using minimal available resources. (Fathy, 1973) .A prime example of this type of architecture is the Islamic city of Qasr, characterized by its compact urban design its narrow-shaded alleyways, and its mud-brick buildings with thick walls. These distinctive forms are not only an expression of an authentic local identity, but they also provide thermal comfort with the least possible energy consumption, making them a living model of integration between environmental function and cultural specificity (Shokry, 2009) .With the accelerating pace of modernization and globalization, inherited knowledge has begun to decline and gradually disappear. As in many regions around the world, the Dakhla Oasis has witnessed a significant shift towards modern building styles based on reinforced concrete and fired brick materials and methods incompatible with the oasis's natural environment. Modern buildings frequently neglect to account for their regional climate. As a result, their interior spaces are often exposed to poor thermal comfort conditions and rely almost entirely on the use of highly energy-dependent mechanical HVAC (heating, ventilation and air conditioning) systems, further exacerbating the already exorbitant financial and environmental pressures on the oasis community (Gabr & El-Assal, 2022). For many regions, this change has created both an energy and environmental crisis, as well as eroding the unique cultural and architectural identity that has historically defined the oasis over centuries. Eco-Architecture is based on scientific methodology and contemporary innovation, in order to address the same underlying principles of Traditional Architecture, with respect to creating buildings that are integrated within their respective environments; minimizing resource and energy usage; and providing a healthy and comfortable environment for the occupants of the building. Current methods of designing Environmental Architecture utilize advanced technologies for the development of the buildings themselves, including thermal performance simulation software, Materials Lifecycle Analyses (LCA), and passive solar design principles to produce optimal solutions that achieve the greatest degree of efficiency (Kibert, 2016).

Research Problem:

The absence of a methodology to promote contemporary environmental architecture and integrate it with vernacular architectural elements of mosques in the Islamic city of Al-Qasr in order to achieve design solutions suitable for the climate of the Dakhla Oasis in the New Valley region.

Research Objectives:

- Integrating and effectively combining modern environmental architecture techniques with existing vernacular architecture techniques for mosques in the Islamic village of Al-Qasr, to develop climate-friendly designs in the Dakhla Oasis, New Valley.

- Studying how to utilize traditional architectural techniques to develop energy-efficient designs for mosques in the Islamic village of Al-Qasr, Dakhla Oasis, New Valley.

Research Questions:

A- How can energy efficiency be improved in the vernacular architecture of mosques in the Islamic city of Al-Qasr in the Dakhla Oasis of the New Valley?

B- How can the vocabulary of contemporary environmental architecture be integrated with the vocabulary of vernacular architecture of mosques in the Islamic city of Al-Qasr to reach design solutions that are compatible with the climate in the Dakhla Oasis in the New Valley?

Research Hypothesis:

Developing a methodology to enhance the vocabulary of contemporary environmental architecture and its integration with vernacular architecture leads to design solutions that are climate-friendly and improve the energy efficiency of the exterior facades of mosques in the Islamic city of Al-Qasr in the Dakhla Oasis, New Valley Governorate.

Methodology:

To achieve the research objectives, a theoretical approach is employed, reviewing previous studies, their findings, their impact on the current study, the need for the current study, and the concepts used. An analytical approach is also used to examine the vocabulary of contemporary environmental architecture and its integration with vernacular architecture of mosques in the Islamic city of Al-Qasr to arrive at climate-friendly design solutions in the Dakhla Oasis, New Valley Governorate. The applied approach was used using a simulation methodology with the Design Builder v7.0 program to improve energy efficiency by applying local materials, wall thickness, and opening ratios in the facades. The simulation results for each case were analyzed, and the results were compared to achieve the research objective and prove the hypothesis.

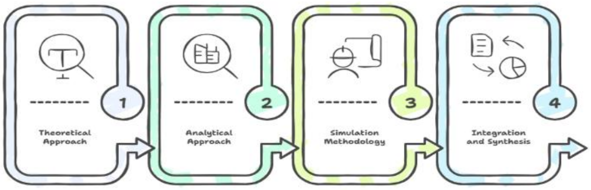

Figure (1) illustrates Research Methodology

Literature Review

To understand the architectural legacy of the Dakhla Oasis and its historical significance, the **first** step is the comprehensive study of the intrinsic value of local architecture. The study of local architecture includes the innovative methods employed by traditional builders, as well as their long-lasting effect on the Dakhla Oasis. A significant addition to the field is Marwa Dabaia's PhD dissertation (2011), an original and extensive exploration of the topic. In addition to cataloging the architectural styles of the Township of Blat, Dabaia's work describes the architectural knowledge that has been passed down to today from previous generations. By using an integrated case study approach that encompassed in-depth field surveys, construction drawings, analysis of the urban environment, and interviews with local residents and artisans, Dabaia's dissertation presents an image of local architecture as being much more than just a method of constructing buildings. As Dabaia notes, local architecture represents a rapidly changing social phenomenon, and is influenced by the environment (climate), materials, and cultural context. Furthermore, the study demonstrates how design components (thick walls, roofs of palm fronds and mud bricks, small openings, and clustered urbanized structures) integrate, so that the accumulated properties create a system that will effectively draw heat out of the environment and retain it in a thermal efficient manner. At the level of the urban landscape, Hanaa Shukry's study (2009) provides an overview of the organization of the urban fabric of the Western Desert oases and has a few important implications for how urban fabric can be effectively integrated into the local environment. The research stressed the importance of a "local approach" to the design of the built environment . This underscores the need for further study to understand how the environmental performance of an individual structure is impacted by its surrounding community. Research conducted by Darwish and El-Deeb in 2023 also focused on developing new built environment materials by palm trees that have been pruned. Utilizing a "Rooted Theory Approach" to the study, they identified instances throughout history when those materials were used for roofing and fencing and where they are being used today in eco-tourism projects as prefabricated panels. This study is significant because it provides an example of how traditional building materials can be adapted to meet the demands of modern sustainable architecture and create environmentally friendly alternatives to continuously enhance the design practices of today.

Diagnosing the Crisis: The Reasons for Deterioration and Loss (understanding the need to protect this heritage and its causes) through Analysis of Underlying causes.

In this section, we will look at many factors involved with loss and/or abandonment of traditional style architecture. An example of this work is found in a research article, by Elhami and Ibrahim (2022), which does an extensive analysis into the deterioration of mud brick cisterns located within the area of the Dakhla Oasis, like the prior example, which compares successful strategies of construction between Saudi Arabia and Morocco and concludes that the problem of deterioration extends beyond the materials and methods of construction used within the structures. The authors also identified systemic issues, such as governmental indifference towards the heritage of these regions, no safeguards or policies in place for heritage assistance, lack of public recognition of the importance of these heritage sites, and lack of funds available to maintain and/or restore traditional structures as being the largest hindrance towards preserving the heritage of these regions. The authors also recommended a more holistic approach to address all of these challenges, both technical and architectural, and additionally looked at the socio-economic and institutional issues related to the problems of these heritage sites.

The second comparison study, conducted by Jabr and El-Assal (2022), used surveys and interviews to capture residents' opinions of the heritage sites located within their community. The results indicated that although many of the people interviewed acknowledged that mud brick houses have environmental and thermal advantages, they nevertheless preferred to live in a concrete house built in a modern style. Therefore, we must develop environmentally sustainable solutions that align with the aesthetic preferences and social aspirations of the local population. Saif et al. (2020) took a more comprehensive view of this situation and demonstrated how the loss of traditional heritage has been affected by the many adverse effects of globalization. The predominance of modern architectural trends has resulted in the dilution of national and local architectural forms, combined with an overall lack of effective development strategies specific to desert areas, creating a crisis within the architectural development of those areas. One potential solution would be to implement an integrated development strategy based on "urban marketing." By promoting the unique architectural styles found in oasis areas as a valuable cultural and economic resource, these areas may attract tourists and investment, playing a key role in the sustainable development of these areas.

Third - Solution Development: A Heritage Preservation and Sustainable Development Perspective – When the previous section covers identifying problems, and what the different methods of preserving cultural heritage and developing a more sustainable environment is to create solutions, therefore this section addresses the types of practical approaches/tools used to accomplish sustainable development through implementing solutions. Both conceptually and with regard to planning, Sun's (2022) study regarding the Implementation of the Historic Urban Landscape Approach in China demonstrates how local communities interpret, develop, and implement sustainable solutions based on environmental considerations. The importance of managing change in historical urban areas is reinforced by examining their history, their natural and cultural elements, and the need to include all stakeholders in the decision-making process. This framework can also be applied to the Dakhla Oasis, as it seeks to develop environmental projects while maintaining the Dakhla Oasis's unique character and identity as a historical and culturally significant site. On a broader scale, Vijaya Lakshmi's (2023) work on Heritage Conservation In India and Stankov et al.'s (2019) Sustainable Cultural Tourism include important concepts and information. Key concepts in these publications include adaptive reuse, which promotes the reuse of heritage structures, and social and cultural capital, which recognize the importance of heritage practices and social dynamics to a project. These principles provide a theoretical foundation for understanding the importance of preserving the Dakhla area's local architectural heritage.

Summary of Previous Studies and the Research Gap

Previous literature demonstrates a relatively complete and well-balanced body of knowledge regarding the value of vernacular architecture in the Dakhla Oasis region, as well as numerous examples of how it deteriorates. The environmental and cultural value continues to receive much documentation, as well as in-depth studies of the causes for its deterioration. Therefore, new and unique methodologies and/or methods for preserving and developing the vernacular architecture of the Dakhla Oasis include the historical urban landscape methodology and participatory action research methodology. In addition, authors agree that the solution to the future of vernacular architecture will not be to return to tradition rigidly or to completely rely on imported modern architecture. Rather, the authors contend that a syncretic methodology is the most effective methodology for integrating traditional wisdom with contemporary developments to achieve successful preservation and/or future developments. However, while there have been many studies documenting preservation efforts, there is still a lack of a clear research gap. Several studies have mentioned the convergence of the objectives of vernacular architecture and environmental architecture but without a comprehensive, systematic, and direct comparison between them. Therefore, future research will need to be conducted to provide such a detailed comparison and analysis of the basic principles, foundations and applications of both vernacular architecture and environmental architecture, with both quantitative and qualitative measures based on specified criteria, including thermal performance, carbon footprint of materials, resource use efficiency, community acceptance, and economic cost. While vernacular architecture has been approached by most researchers from the perspective of heritage and anthropology, the environmental perspective has been taken primarily from a scientific/technical view. This study seeks to bridge that gap.

Research Terms

Vernacular architecture is an architectural style based on local needs, building materials, and traditions. It evolves over time to reflect the environmental, cultural, technological, economic, and historical context in which it originated. Despite the difficulty of reconciling, it with the regulatory and popular demands of the five factors mentioned, this type of architecture still plays a role in architecture and design, particularly in local branches. Vernacular architecture can be compared to formal architecture, which is characterized by design elements deliberately incorporated for aesthetic purposes that transcend the functional requirements of the building**. Arboleda, G. (2006).** What is vernacular architecture? Ethnoarch: Indigenous and Vernacular.

Vernacular architecture is the built environment (city, architecture, and interior spaces) created based on the needs of the community. This architectural style is built according to the natural environment (geography, topography, location, climate, local building materials, labor expertise, and construction techniques) to meet the material, economic, social, and cultural standards of the population**. Salman, M. (2018).** Sustainability and Vernacular Architecture: Rethinking What Identity Is. Urban and Architectural Heritage Conservation within Sustainability, 13.

Environmental Architecture:

the design of structures and spaces with the natural environment in mind. In other words, environmental architects consider the local climate, geography, and ecosystem when planning and constructing buildings and other man-made structures. By doing so, they aim to create more sustainable and eco-friendly designs that minimize the negative impact on the environment.

Vernacular Architectural Features of Mosques in the Islamic Village of Al-Qasr in the Dakhla Oasis

Based on field studies and specialized research, the vernacular architectural features of mosques in the Islamic village of Al-Qasr can be identified as follows:

First: Planning and Space

Table (1) illustrates Planning and Space

Features	Description	function	References
Organic integration with the urban fabric	The mosque is fully integrated with the surrounding building mass without any clear external separation or distinction.	- Maintaining urban density - Creating an integrated climate system - Promoting privacy and community integration	Shokry (2009); Dabaieh (2011)
The inner courtyard (sahn)	Open central or side courtyard, often irregularly shaped	- Natural ventilation and lighting - Nighttime radiant cooling - A space for social activities	Fathy (1973); Dabaieh (2011)
Spatial Gradient	Spatial sequence from general to specific: Street → Passage → Courtyard → Prayer Room	- Spiritual preparation for worshippers - Noise isolation - Gradual climate control	Hakim (1986); Dabaieh (2011)
Planning Simplicity	A simple rectangular or square shape without complications	- Easy to build - Flexible use - Low cost	Rudofsky (1964); Dabaieh (2011)

Second: Structural Elements and Construction:

Table (2) illustrates Structural Elements and Construction:

Features	Description	function	References
Thick load-bearing walls	Walls 50-80 cm thick made of mud bricks (clay bricks)	- High thermal mass - Natural thermal insulation - Structural stability	Fathy (1973); Dabaieh (2011)
Flat roofs with palm fronds	Palm trunk veins + a layer of palm fronds + a thick layer of clay	- Effective thermal insulation - Use of locally sourced, renewable materials - Flexible implementation	Darwish & Eldeeb (2023); Dabaieh (2011)
Wooden columns and clay bricks	Columns made from local palm or acacia trunks	- Ceiling support - Interior space division - Natural aesthetic element	Fathy (1973); Dabaieh (2011)
domes and small vaults	Small mud domes in some sophisticated mosques	- Load distribution - Improved acoustics - A distinctive aesthetic element	Michell (1995); Dabaieh (2011)

Third: Architectural and Climatic Elements:

Table (3) illustrates Architectural and Climatic Elements:

Features	Description	function	References
small high openings	Small windows high on the walls, with stone lintels	- Reduce solar heat gain - Allow indirect light - Maintain privacy	Fathy (1973); Givoni (1998)
wooden mashrabiya	Wooden windows carved from palm trunks (rare in mosques)	- Light dimming - Ventilation with privacy - Simple evaporative cooling	Dabaieh (2011); Darwish & Eldeeb (2023)
The scatterbox (primitive windcatcher)	Upper vents oriented towards the prevailing wind direction	- Bringing in cool air - Expelling hot air - Improving natural ventilation	Fathy (1973); Bahadori (1978)
Shaded courtyards	Parts of the courtyard are covered with light reed roofs.	- Providing shaded areas - Comfortable waiting areas - Reducing the heat in the courtyard	Shokry (2009); Dabaieh (2011)

Fourth: Functional and Aesthetic Elements:

Table (4) illustrates Functional and Aesthetic Elements:

Features	Description	function	References
simple mihrab	A niche in the qibla wall, with or without simple stucco decorations.	- Determining the direction of prayer - Focusing the attention of worshippers - A simple aesthetic element	Michell (1995); Dabaieh (2011)
wooden or clay pulpit	A wooden pulpit with several steps, made of carved palm wood.	- The preacher's place - A fixed functional element - Aesthetic and heritage value	Dabaieh (2011); Gabr & El-Assal (2022)
The Muezzin's Platform	A small, raised platform in the corner	- Takbir (saying "Allahu Akbar") during prayer - Guiding worshippers - A simple functional element	Michell (1995); Dabaieh (2011)
Qur'an cabinet	A niche in the wall or a simple wooden cabinet	- Preserves copies of the Quran - Easy access - Protection from the elements	Dabaieh (2011)

Fifth: Water and Service Elements:

Table (5) illustrates Water and Service Elements

Features	Description	function	References
ablution basin	A stone or clay basin in the courtyard or a separate entrance	- Group ablution - Local evaporative cooling - Social element	Fathy (1973); Dabaieh (2011)
well or cistern	An underground water reservoir to collect scarce rainwater	- Water storage for ablution - Underground thermal balance - Water resource sustainability	Dabaieh (2011); Gabr & El-Assal (2022)
ablution area	A covered or semi-covered place for ablution	- Privacy during ablution - Protection from the elements - Organization of the ablution process	Dabaieh (2011)

Sixth: Materials and Finishes :

Table (6) illustrates Materials and Finishes:

Features	Description	function	References
Clay as a basic material	A mixture of clay, straw, and water	- Excellent thermal compatibility - Local availability - Repairability	Fathy (1973); Houben & Guillaud (1994)
Palm fronds and leaves	Ceilings, fillings, and decorative elements	- Lightweight thermal insulation - Flexible shaping - Renewable materials	Darwish & Eldeeb (2023); Dabaieh (2011)

sandstone	In the bases, columns, and lintels	- Durability and strength - Thermal stability - Aesthetic value	Dabaieh (2011); Shokry (2009)
natural colors	Earthy colors (brown, yellow, clay white)	- Harmony with the environment - Partial reflection of sunlight - Distinctive visual identity	Dabaieh (2011); Gabr & El-Assal (2022)

Seventh: Underlying Design Principles:

Table (7) illustrates Underlying Design Principles:

Principle	The application in the mosques of Al-Qasr Islamic village	References
climate response	Each component is designed to withstand the harsh desert climate.	Fathy (1973); Givoni (1998)
Local Sustainability	Using local renewable materials and simple techniques	Dabaieh (2011); Darwish & Eldeeb (2023)
Flexibility and adaptability	The ability of buildings to expand and modify according to needs	Hakim (1986); Dabaieh (2011)
Simplicity and functionality	The design is free of excessive ornamentation.	Rudofsky (1964); Dabaieh (2011)
community participation	The mosque was built with the participation of the villagers.	Dabaieh (2013); Gabr & El-Assal (2022)

Proposed methodology:

Table (8)illustrates the proposed methodology for integrating vernacular and environmental architecture to improve the energy performance of the building envelopes of mosques in the Islamic city of Al-Qasr in the Dakhla Oasis, New Valley.

Phase	Objective	Methodology	Research Tools	Expected outputs	References
Phase One: Documentation and Analysis	Understanding the historical, climatic, and social context	**Field study and documentation:** 1- architectural survey of existing mosques 2- Analysis of the local climate (temperature, humidity, wind) 3- Interviews with residents and artisans	1. Digital cameras, climate measuring devices 2. Questionnaires, interview guides 3. Climate analysis software (Climate Consultant)	1. A database of existing mosques 2. A detailed climate map 3. A list of colloquial terms used	Dabaieh (2011) ، Shokry (2009) ، Givoni (1998)
Phase Two: Evaluating Current Performance	Measuring the efficiency of the current outer casing	**Measurement and Evaluation:** 1. Measurement of the thermal performance of elements (walls, ceilings, openings) 2. Analysis of the environmental cost of materials used 3. Evaluation of thermal comfort for worshippers	1. Thermal imaging cameras, U-value measuring devices 2. Life cycle analysis (LCA) of materials 3. Thermal comfort questionnaires	1. Thermal Performance Report 2. Energy Efficiency Assessment 3. Current Thermal Comfort Indicators	Santamouris (2014) ، ASHRAE (2017) ،ISO 7730
Phase Three: Integration Analysis	Identifying points of convergence and divergence	**Systematic Comparative Analysis:**	1. Energy simulation (EnergyPlus, DesignBuilder)	1. Quantity comparison table 2. Environmental-economic assessment	Lechner (2014), Kibert (2016),

	between the two approaches	1. Comparison of the thermal performance of traditional and modern units 2. Evaluation of economic cost and life cycle	2. Lifecycle cost analysis (LCCA)		Calkins (2009)
Phase Four: Participatory Design	Developing socially acceptable hybrid solutions	**Participatory Action Research (PAR):** 1- Community Design Workshops 2- Group Discussion and Evaluation Sessions	1. Physical and digital models 2. Community engagement tools 3. Interactive surveys	1. Community-proposed designs 2. Tested prototypes 3. Needs and aspirations map	Dabaieh (2013) ، Houben & Guillaud (1994)
Phase Five: Simulation and Testing	Verifying the effectiveness of the proposed solutions	**Simulating the performance of the Building Envelope:** 1. Thermal simulation 2. Natural lighting simulation	1. Simulation software (EnergyPlus,) 2. Climate simulation labs	1. Improved performance reports 2. Proposed design improvements 3. Measurable performance metrics	Olgyay (2015) ، Allard (1998), Jelle et al. (2012)
Phase Six: Development and Implementation	Develop an applied design guide	**Developing a hybrid design framework:** 1. Technical specifications guide 2. Reproducible design models 3.Implementation and training plan	1. Illustrated technical guides 2. Detailed implementation documents 3. Training programs	1. Design Guide for Desert Mosques 2. Approved Construction Models 3. Training Program for Craftsmen	Edwards (2014), Goulding et al. (1992)
Phase Seven: Monitoring and Evaluation	Ensuring long-term sustainability	**Post-Operational Evaluation (POE):** 1. Monitoring Actual Performance 2. Assessing Community Satisfaction 3. Evaluating Cost-Benefits	1. Continuous monitoring devices 2. Follow-up questionnaires 3. Time-based data analysis	1. Annual performance reports 2. Maintenance and development recommendations 3. Integrated impact measurement model	CABA (2018) ، Preiser & Vischer (2005)

Proposed integration matrix for Building Envelope of mosques in the Islamic city of Al-Qasr in the Dakhla Oasis, New Valley:

Table (9)illustrates Proposed integration matrix for Building Envelope of mosques in the Islamic city of Al-Qasr in the Dakhla Oasis, New Valley.

Building Envelope Element	**Vernacular architecture features**	**Features of contemporary environmental architecture**	**Proposed integration model**	**References**
Exterior Walls	Thick mud bricks (50-80 cm)	External thermal insulation (ETICS)	**Hybrid wall: Internal clay layer + thermal insulation (rock wool) + treated external clay layer**	Houben & Guillaud (1994), Baetens et al. (2011)
Roofs	Palm roots + palm fronds + clay	Green roofs + reflective insulation	**Multi-layered roof: palm slats + advanced thermal insulation + reflective layer + native vegetation cover**	Köhler & Kaiser (2021) ، Darwish & Eldeeb (2023)
Openings and windows	Small, high windows + wooden mashrabiya	Low-emissivity double glazing + smart solar breakers	**Hybrid system: Small windows with advanced glazing + adjustable wooden mashrabiya + external sunshades**	Elghamry & Hassan (2020) ،ASHRAE (2017)
ventilation system	Upper openings + central courtyard	Thermal ventilation towers +	**Hybrid ventilation system: Modified open patio + enhanced**	Allard (1998) ،Watt (1986)

		evaporative cooling systems	**ventilation towers + indirect evaporative cooling systems**	
Materials and elements	Local renewable materials (clay, palm)	Recycled materials + technologically advanced	**Hybrid material: Heat-treated clay bricks + Compounds from treated palm waste**	Darwish & Eldeeb (2023) ،Kibert (2016)
Energy Management	Natural shading + traditional ventilation	Solar power systems + smart management	**Hybrid management system: Traditional shading supported by integrated solar systems with intelligent occupancy control**	Jelle et al. (2012), CABA (2018)

Case Study: Nasr al-Din Mosque – Al-Qasr Islamic Village, Dakhla Oasis, New Valley Governorate:

The village contains a mosque dating back to the first century AH, with a wooden minaret from the Ayyubid era. The minaret consists of three stories, reaching a height of approximately 21 meters, and features wooden thresholds decorated with verses from the Quran at its entrance. The village remains in good condition; all its houses are standing, and the library, the entire mosque, and the narrow streets are constructed of mud bricks and wooden beams.

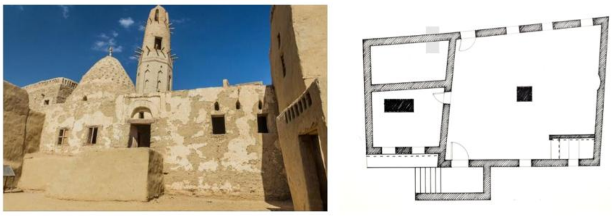

Figure (2) illustrates A sketch illustrating the floor plan of Nasr al-Din Mosque in the Islamic village of al-Qasr in the Dakhla Oasis in the New Valley

Figure (3) illustrates the mosque is built of mud bricks and is distinguished by its architectural simplicity. It contains a pulpitand a mihrab

The mosque is built of mud bricks and is distinguished by its architectural simplicity. It contains a pulpit that has been restored several times, and a mihrab (prayer niche) built of mud bricks and whitewashed with quicklime. The mosque's roof is made of palm fronds and palm leaves. The mosque's minaret is one of its most prominent features, standing approximately 21 meters tall. It follows the style of minarets from the Ayyubid era and consists of three stories. Historically, it was used for observation and monitoring the movements of those approaching the walls of Qasr, which was the capital of the oases during the Islamic period.

The architect who completed the mosque's construction in the Egyptian oases possessed unique skills that arose from the harsh environmental conditions and the need to provide housing and buildings suited to the desert climate. The architecture of the oases reflects the ingenuity of local builders, who were able to blend aesthetic function with climatic and environmental needs, resulting in an authentic architectural style adapted to the desert environment.

Building Materials Used in the Construction of Nasr El-Din Mosque in the New Valley:

Nasr El-Din Mosque is one of the oldest historical mosques in the Egyptian oases. It was built using local materials suited to the desert climate. The following are the materials used in its construction, with an explanation of each:

Mud Bricks (Clay Mixed with Straw): Mud bricks are made from clay, straw, and water. They are molded and left to dry in the sun. They offer excellent thermal insulation, helping to keep the mosque cool in the summer and warm in the winter.

- A durable yet lightweight material compared to stone, making it easier to use in construction.

- It is available locally on the oases, making it economically and environmentally friendly material.

Figure (4) illustrates the use of mud bricks in Nasr al-Din Mosque

2- Climate-adapted architectural design: Buildings are characterized by thick walls that insulate against heat, and therefore narrow streets and closely packed buildings are designed to provide shade and reduce the intensity of the sun, which is known as the "organic planning" style of cities.

Figure (5) illustrates Buildings are characterized by thick walls that insulate against heat

3- White Quicklime: Quicklime (calcium oxide) is extracted from limestone and, after being slaked with water, becomes slaked lime. This is used in painting and coating interior and exterior walls, giving them a white color that reflects sunlight, thus helping to reduce heat absorption.

- It has antiseptic properties that prevent the growth of fungi and insects on walls.

- It is resistant to corrosion and increases the lifespan of mud buildings when used as a protective layer.

Figure (6) illustrates Lime is used to paint and clad interior and exterior walls, giving them a white color that reflects sunlight.

4- Palm fronds and spathes:

Palm fronds and spathes (the inner stalks of the fronds) are used for roofing. They help to reduce the sun's heat by allowing air to circulate between the fibers, thus maintaining ventilation in the mosque.

- This material is abundant in oases and is easy to use and replace.

- It is flexible and durable, which helps in creating a stable and lightweight roof.

Figure (7) illustrates Palm fronds and spathes (the .inner stalks of the fronds) are used for roofing

5- Wood (Tamarisk and Palm):

Tamarisk and palm wood were used in the manufacture of doors, windows, and roof beams due to their good resistance to moisture, making them suitable for the deserted environment.

- They are lightweight yet strong, making them suitable for supporting the mosque's structure without adding to the load on the mud walls.

- They are used in carvings and decorations, where geometric patterns and Quranic verses are carved onto the doors.

Figure (8) illustrates Tamarisk and palm wood were used in the manufacture of doors, windows, and roof beams

The Minaret:

Height: Approximately 21 meters, the tallest in the Egyptian oases. It is built of mud bricks and covered with a layer of lime. It is round and narrows as it rises, according to the traditional Islamic style of the oases.

Figure (9) illustrates The Minaret in Nasr al-Din Mosque in the Islamic village of al-Qasr in the New Valley

The Dome:

Its circumference is approximately 10 meters, proportionate to the mosque's interior space.
- It is hemispherical, constructed of mud bricks and covered with a layer of whitewash.
- It contains small ventilation openings, which help reduce the heat inside the mosque.

- It acts as an architectural element to distribute loads and reduce pressure on the walls, while also providing natural ventilation and lighting for the mosque.

Figure (10) illustrates the dome in Nasr al-Din Mosque in the Islamic village of al-Qasr in the New Valley

A simulation study of the case of Sheikh Nasr al-Din Mosque in the Islamic village of al-Qasr in the Dakhla Oasis in the New Valley:
Thermal Performance Assessment of the Case Study:

The thermal performance assessment of faculty spaces serves as an indicator of the extent to which these spaces achieve thermal comfort. This comfort is influenced by the choice of materials which the building envelope must fulfill. After clarifying the principles of green building design and analyzing the building materials used, a comparison is made to determine the extent to which the materials used in the building envelope achieve thermal comfort within the spaces of the Sheikh Nasr El-Din Mosque in the Islamic village of Al-Qasr, Dakhla Oasis, New Valley, Egypt. This comparison considers both the materials used in the walls and the proportion of openings, aiming to achieve energy efficiency in the spaces of the Sheikh Nasr El-Din Mosque in the Islamic village of Al-Qasr, Dakhla Oasis, New Valley, Egypt.

The following methods were used to gather information for the case studies:

- Field visits, photographic documentation, and research observations.
- Architectural and aerial maps of case studies.
- Previous research and studies that addressed the case studies.

Methodology of the Applied Study:

- Analysis of climatic data for the study area.
- Analytical description of the building under study (architectural description, description of existing building materials, occupancy rate, opening ratios, and orientation).
- Assessment of the baseline condition using simulation, specifically for the spatial models of the Sheikh Nasr El-Din Mosque building in the Islamic village of Al-Qasr in the Dakhla Oasis, New Valley Governorate, Egypt, the study site, using the Design Builder v7.0 simulation software, followed by evaluation.
- Developing alternatives by testing the proposed methodology for the case studies using appropriate treatments. Orientation, materials, and opening ratios were studied to obtain the best results using simulation software to analyze the building's thermal performance.
- Comparison and discussion of the results.

This method allows for the evaluation of different alternatives and material options to select the best solutions that contribute to meeting comfort requirements and providing a suitable environment for patients. This simulation aims to:

- Study the effect of building materials on the thermal comfort of the spaces within the Sheikh Nasr El-Din Mosque building in Al-Qasr Islamic Village, Dakhla Oasis, New Valley, Egypt.
- Analyze the materials used in the existing faculty offices and their impact on the internal environment.
- Simulate the cooling loads required in the existing building and propose alternatives.
- Estimate energy savings using various alternatives, whether design-related or material-based.

Analysis of the spaces within the Sheikh Nasr El-Din Mosque building in Al-Qasr Islamic Village, Dakhla Oasis, New Valley, Egypt. This analysis is conducted through:

- Analysis of the climatic data for the New Valley region.
- The climatic data for the New Valley region was collected using Climate Consultant 6.0 software.

A psychometric chart:

A psychometric chart illustrates the relationship between temperature and relative humidity on the horizontal and vertical axes, respectively. It helps identify the characteristics of the New Valley's climate by determining the thermal comfort zone in relation to temperature and humidity, as well as occupancy rates, including clothing types and activity levels, as shown in Figure (11).

The psychometric map of thermal comfort

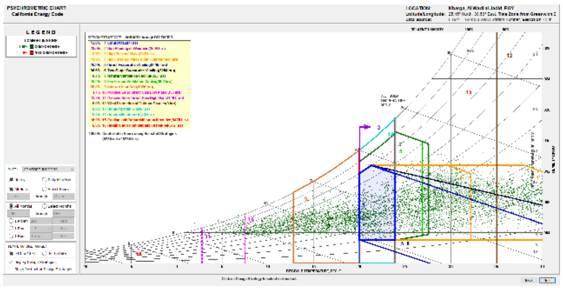

Figure (11) shows the psychometric map of thermal comfort for the case study in the Climate Consultant 6.0 program.
Source: http://www.energy-design-tools.aud.ucla.edu/climate-consultant/request-climate-consultant.php 7/9/2025

1- Evaluation of the spatial model of the Sheikh Nasr El-Din Mosque building in Al-Qasr Islamic Village, Dakhla Oasis, New Valley, Egypt, using simulation. This is done through:
A- Simulation Methodology:

The building's specifications and dimensions are entered into the software, and a simulation model is created that mimics the building's reality. This model simulates all aspects of the building's energy consumption, as shown in the following model taken from Design Builder v7.0, a program that analyzes all inputs in the case study.

B- Building Operation Data: * Activities: - Building Operation Period: Operating hours per day, from 10:00 AM to 9:00 PM every week. (- Density 0.55. - Clothing: Winter = 0.9 clo, Summer = 0.49 clo.)

- Burn Rate for Space Users (Standing/Walking) = 1.0. * Operating Schedule Adjustment: From 10:00 AM to 9:00 PM every week.

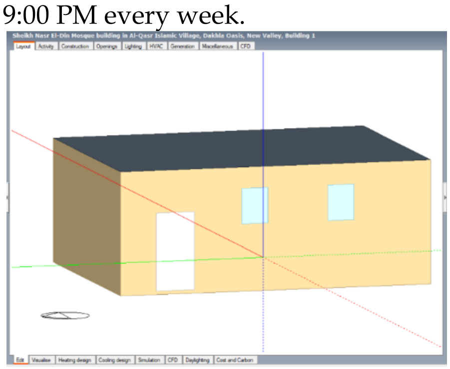

Figure (12) shows model of the Sheikh Nasr El-Din Mosque building in Al-Qasr Islamic Village, Dakhla Oasis, New Valleyof the case study in the Design Builder 7.0 program. Source: https://designbuilder.co.uk/ 7-3-2025

2- Discussion of results:

- **Frist Case**: the energy consumption results for the case study, Sheikh Nasr El-Din Mosque in Al-Qasr Islamic Village, Dakhla Oasis, New Valley, by measuring the elements of vernacular architecture with varying wall thicknesses: 50 cm for the basic case and 25 cm for the wall thickness.

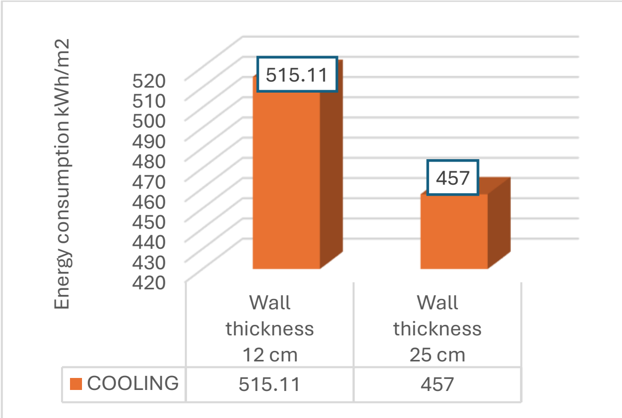

Figure (13) illustrates the energy consumption results for the case study, Sheikh Nasr El-Din Mosque in Al-Qasr Islamic Village, Dakhla Oasis, New Valley, by measuring the elements of vernacular architecture with varying wall thicknesses: 50 cm for the basic case and 25 cm for the wall thickness.

In the first case, the results of the Sheikh Nasr al-Din building model in the Islamic village of al-Qasr in the Dakhla Oasis of the New Valley show that, with a mud-brick wall thickness of 50 cm (the baseline case), the annual energy consumption reaches 451.84 kWh per square meter. On the other hand, a 25 cm wall consumes 457 kWh per square meter, which is 1.13% more than the baseline 50 cm mud-brick wall.

- **The second case:** the Energy consumption results were obtained for a case study of the Sheikh Nasr El-Din Mosque in Al-Qasr Islamic Village, Dakhla Oasis, New Valley, by measuring the environmental architectural elements at different wall thicknesses: 50 cm + 10 cm thermal insulation and 25 cm wall thickness + 10 cm thermal insulation.

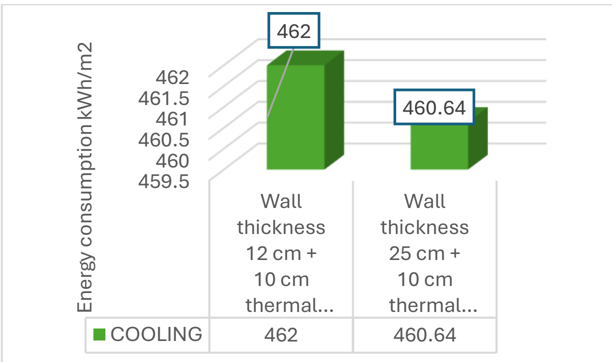

Figure (14) illustrates the Energy consumption results were obtained for a case study of the Sheikh Nasr El-Din Mosque in Al-Qasr Islamic Village, Dakhla Oasis, New Valley, by measuring the environmental architectural elements at different wall thicknesses: 50 cm + 10 cm thermal insulation and 25 cm wall thickness + 10 cm thermal insulation.

In the second case, the results of the Sheikh Nasr El-Din building model in the Islamic village of Al-Qasr in the Dakhla Oasis of the New Valley, with a mud-brick wall thickness of 50 cm + 10 cm of thermal insulation using Environmental principles, show an annual energy consumption rate of 452.4 kWh per square meter. On the other hand, a wall with a thickness of 25 cm + 10 cm of thermal insulation consumes 460.64 kWh per square meter, which is 1.8% more than the case of a 50 cm mud-brick wall + 10 cm of thermal insulation.

By discussing the results of the first case, which is vernacular architecture using a 50 cm thick mud-brick wall, and the results of the second case, which is eco-friendly architecture using thermal insulation with walls, we find that there is a convergence of results and integration between the two approaches. The difference in energy consumption results between the first and second cases is very small.

3- Recommendations:

1. For designers: It is preferable to use heat-retaining materials—such as improved mud bricks or clay bricks—in the walls of mosques in the New Valley instead of cement bricks, which do not retain coolness.
2. For mosque management: Air conditioning should be turned on for only twenty minutes before the call to prayer and switched off immediately after the prayer ends. Doors and windows should be left open during the transitional periods to allow fresh air in.
3. Code development: A chapter on desert heritage buildings should be added to the Egyptian Energy Efficiency Code. This chapter should be based on thermal simulation models, not solely on fixed U-values.
4. The old architectural style of Al-Qasr village should be preserved without altering its colors or horizontal lines.

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