International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw,
Poland 00-773
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ARTICLE TITLE	CULTURAL AND BIOCLIMATIC INSIGHTS FROM THE VERNACULAR ARCHITECTURE OF THE CASBAH OF ALGIERS: A MODEL FOR SUSTAINABLE FUTURE
ARTICLE INFO	Roufaida Benbrahim, Leila Sriti. (2025) Cultural and Bioclimatic Insights From The Vernacular Architecture of The Casbah of Algiers: A Model for Sustainable Future. *International Journal of Innovative Technologies in Social Science*. 1(45). doi: 10.31435/ijitss.1(45).2025.3110
DOI	https://doi.org/10.31435/ijitss.1(45).2025.3110
RECEIVED	11 December 2024
ACCEPTED	19 March 2025
PUBLISHED	26 March 2025
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CULTURAL AND BIOCLIMATIC INSIGHTS FROM THE VERNACULAR ARCHITECTURE OF THE CASBAH OF ALGIERS: A MODEL FOR SUSTAINABLE FUTURE

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ABSTRACT

The Casbah of Algiers, a UNESCO World Heritage site, exemplifies the ingenuity of Mediterranean vernacular architecture and the enduring interplay between built form, climate, and culture. This study explores the bioclimatic principles inherent in the urban fabric and architectural typologies of the Casbah, emphasizing their relevance to sustainable design in Mediterranean climates. It examines how traditional construction techniques, spatial organization, and local materials optimize thermal comfort and energy efficiency while supporting vibrant cultural and social practices. Through on-site observations, photographic documentation, and an examination of socio-cultural dynamics, the research assesses the resilience of the architecture and community of the Casbah. The findings highlight the effectiveness of compact urban morphology, shaded courtyards, thick masonry walls, and community-centred spaces in providing passive cooling, fostering social cohesion, and conserving energy, thereby reducing dependence on mechanical systems. The study advocates integrating these bioclimatic and cultural strategies into contemporary urban design to create resilient and environmentally harmonious spaces that honour cultural heritage while addressing modern challenges. By bridging traditional knowledge, social practices, and modern approaches, this research contributes to the discourse on sustainable development, underscoring the enduring value of vernacular architecture for climate-responsive, socially inclusive, and culturally rooted design solutions.

KEYWORDS

Casbah of Algiers, Vernacular Architecture, Bioclimatic Design, Mediterranean Climate, Thermal Comfort, Social Cohesion

CITATION

Roufaida Benbrahim, Leila Sriti. (2025) Cultural and Bioclimatic Insights From The Vernacular Architecture of The Casbah of Algiers: A Model for Sustainable Future. *International Journal of Innovative Technologies in Social Science*. 1(45). doi: 10.31435/ijitss.1(45).2025.3110

1. Introduction

The Casbah of Algiers, a UNESCO World Heritage site since 1992, epitomizes the brilliance of Mediterranean vernacular architecture and urban planning. Its intricate design reflects centuries of cultural, social, and environmental adaptations, making it a remarkable case of sustainable heritage. Situated on the slopes overlooking the Mediterranean, the Casbah is renowned for its compact urban fabric, harmoniously integrating architectural ingenuity with socio-cultural practices [1][2]. Its origins trace back to the Zirid period in the 10th century when it began as a small settlement. However, its most significant transformation occurred during the Ottoman era, when it evolved into a fortified citadel and a thriving hub for trade, governance, and culture [2]. André Ravéreau, in his seminal work *La Casbah d'Alger*, emphasized its urban coherence, describing it as "a city created by its site," showcasing a design deeply intertwined with its geography. The

morphology of the Casbah, characterized by narrow streets, dense housing clusters, and a hierarchical organization, reflected the need for defence, privacy, and climate adaptability [3][4].

The vernacular architecture of the Casbah demonstrates an advanced understanding of bioclimatic principles tailored to its hot-summer Mediterranean climate (Csa). Central courtyards, or Wast al-Dâr, function as thermal regulators, facilitating natural ventilation and minimizing heat gain [1][5]. Thick masonry walls constructed from limestone and terracotta provide thermal insulation, while shaded terraces and small openings reduce solar exposure [5][6]. Locally sourced materials, such as cedarwood and lime, further enhance the ecological sustainability of its structures [2][7]. The spatial organization of the Casbah fosters social cohesion within a dense urban framework. Glovin [6] highlighted the strategic orientation of buildings to optimize sunlight while mitigating the impact of prevailing winds. These architectural solutions ensured thermal comfort without relying on mechanical systems, offering lessons for contemporary sustainable design.

The colonial era profoundly changed the urban and architectural fabric of the Casbah. French colonization (1830–1962) introduced modernist planning principles, disrupting the traditional coherence of the medina. Large-scale demolitions and the construction of new roads led to the marginalization of the socio-economic role of the Casbah [8][9]. Post-independence, the Casbah faced additional challenges, including overpopulation and unsupervised renovations, further compromising its structural integrity [10]. A recent study highlights the challenges of urban renewal in the Casbah and proposes strategies for revitalizing urban voids while preserving their historical essence [10].

The Casbah remains a cultural and architectural heritage repository, offering insights into sustainable urbanism. Studies by Nicol and Humphreys [12] emphasize the adaptive nature of traditional architecture in achieving thermal comfort. Their research aligns with the findings of Lesbet [11], who noted the social and environmental harmony embedded in the Casbah design. Recent studies, such as those by Hany and Alaa [13], highlight the potential of integrating bioclimatic strategies into modern Mediterranean architecture to optimize thermal comfort and energy efficiency. Additionally, research by Arrar et al. [14] compares traditional wall typologies in the Casbah, demonstrating the superior thermal and energy performance of materials like raw earth and terracotta over modern concrete.

This research highlights the relevance of traditional knowledge, bioclimatic principles, and socio-cultural practices in addressing contemporary urban challenges. Through on-site observations, photographic documentation, and an exploration of the vibrant cultural dynamics of the Casbah, the study underscores the value of its adaptive design and communal spaces. Moreover, it advocates for preserving the Casbah not merely as a cultural artefact but as a living model for sustainable urban development, showcasing how traditional architecture and community practices can inform resilient and climate-responsive design solutions in the face of global climate change.

2. Research Methodology

The research methodology is structured in two phases to explore the bioclimatic principles and socio-cultural dynamics of the Casbah of Algiers. The first phase analyzed the general context of the Casbah, its historical significance, architectural characteristics, and cultural practices. On-site data collection through field visits, photographic documentation, and observations identified key bioclimatic features, such as compact urban morphology, shaded courtyards (Wast al-Dâr), and thick masonry walls, emphasizing their roles in thermal comfort and energy efficiency. The spatial organization of the Casbah was also examined to understand its role in fostering social interactions and preserving cultural traditions.

The second phase involved evaluating these architectural and cultural features across different seasons. Summer observations focused on passive cooling strategies, while winter analysis assessed how traditional elements reduce heat loss and maintain comfort. This methodology highlights the ability of the Casbah to address climatic challenges while balancing environmental sustainability and cultural cohesion, offering valuable insights for sustainable urban development.

3. Case Study Description

This study focuses on a detailed evaluation of the climatic conditions in the Mediterranean city of Algiers, with particular attention given to the Casbah of Algiers, a UNESCO World Heritage site renowned for its historical and cultural importance (Fig. 1). Situated within the Csa climate zone of the Köppen-Geiger classification [15], Algiers experiences a hot-summer Mediterranean climate, marked by dry, warm summers and mild, wet winters. The coastal location contributes to its moderated temperature fluctuations, although

urban density and traditional urban forms within the Casbah shape a unique microclimate. These characteristics pose challenges and opportunities for designing thermally efficient spaces in the Casbah [15].

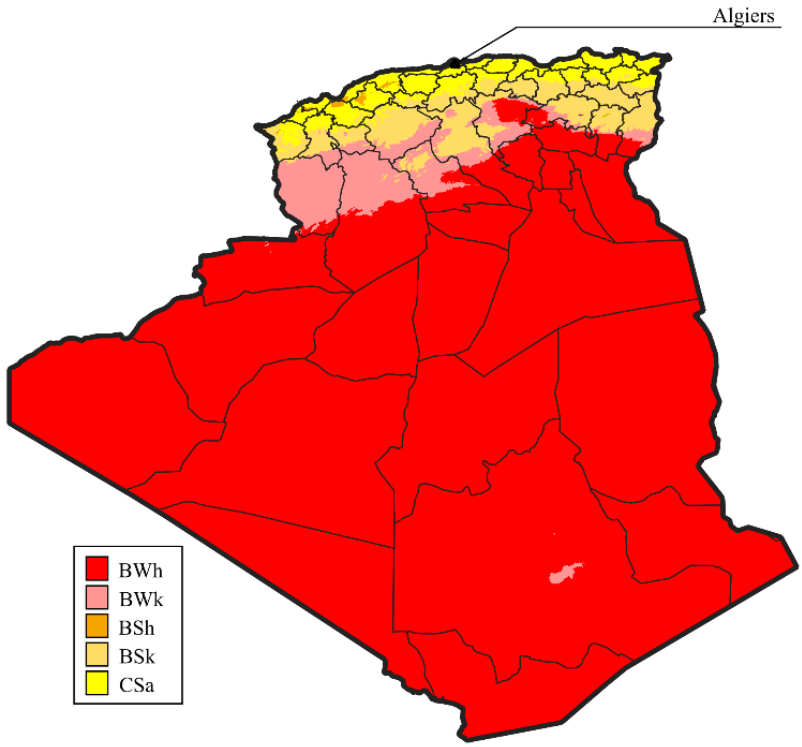

Fig 1. *Map illustrating the geographical location of Algiers within Algeria and its classification under the Köppen-Geiger climate zones.*

The hourly temperature chart (Fig. 2) highlights the pronounced diurnal and seasonal variations that characterize Algiers' climate. During the summer months (June to September), midday temperatures regularly exceed 35°C, while nighttime cooling provides relief. Conversely, winter temperatures remain relatively stable, ranging between 5°C and 15°C, reflecting the moderating influence of the Mediterranean Sea. Such variations emphasize the need for passive thermal strategies in the Casbah, such as thick walls and narrow streets, which help reduce exposure to extreme temperatures.

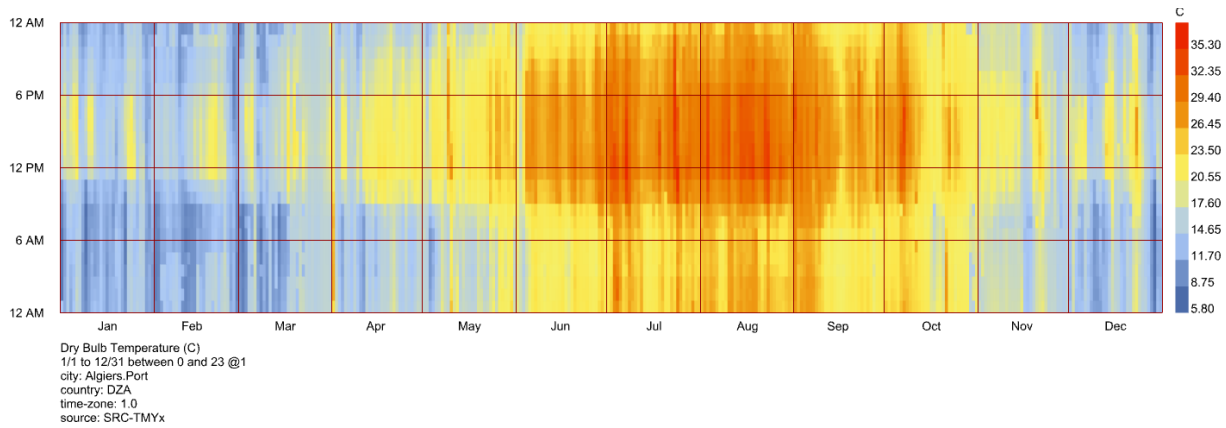

Fig 2. *Hourly temperature distribution chart for the city of Algiers.*

The dense architecture of the Casbah and elevated terrain play a significant role in shaping its microclimate. Narrow alleys and interconnected buildings offer effective shading and promote airflow, mitigating heat during peak summer periods. Wind patterns, visualized in the wind rose (Fig. 3), reveal that

predominant winds from the Northeast (NE) and East-Northeast (ENE) directions enhance natural ventilation throughout the Casbah. Wind speeds typically range between 2 to 6 m/s, with calmer conditions observed less than 8% of the time. This consistent airflow aligns with the spatial layout of the Casbah, optimizing cooling through cross-ventilation and reducing reliance on mechanical systems.

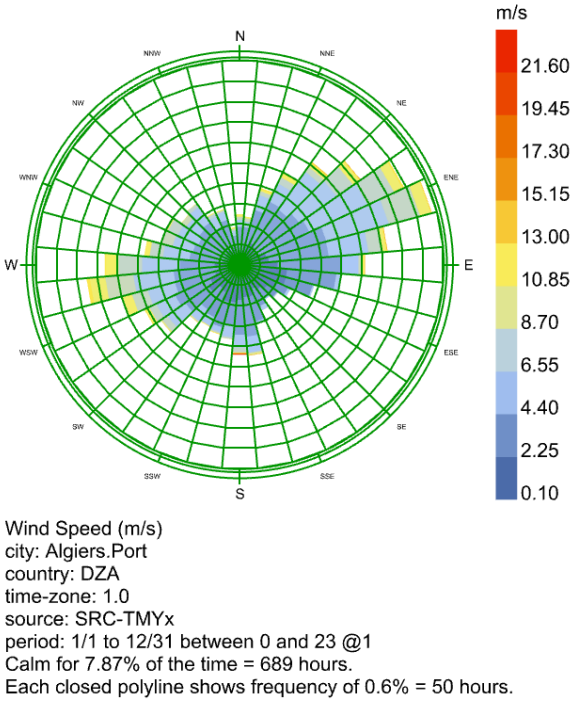

Fig 3. *The Algiers wind rose diagram depicts predominant wind directions, speeds, and calm conditions.*

Houses with thick walls demonstrate remarkable thermal inertia, maintaining a stable indoor temperature despite fluctuations outside. Seasonal analysis through the monthly temperature chart (Fig. 4) shows that July and August are the hottest months, with average temperatures peaking around 28°C to 30°C, while January is the coldest, averaging 12°C. Solar radiation is another critical factor, peaking in June at 6.8 kWh/m² and dipping to 2.9 kWh/m² in December. These conditions reinforce the importance of the urban morphology of the Casbah in limiting solar heat gain through shaded courtyards (Wast al-Dâr) and narrow streets while simultaneously providing winter warmth through solar capture.

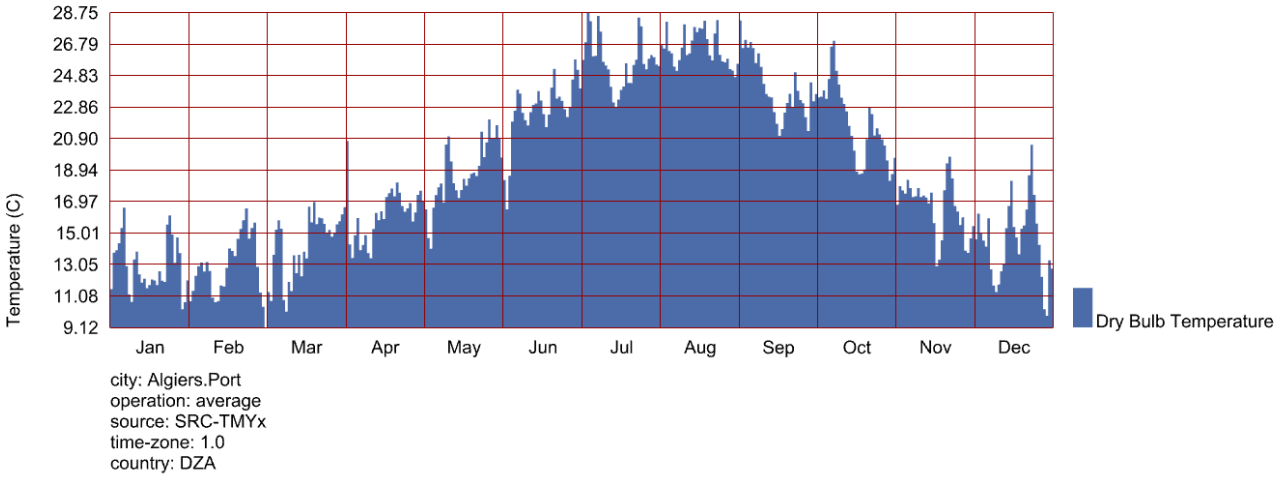

Fig 4. *Monthly temperature trends for Algiers, highlighting seasonal averages and their implications for climatic performance.*

4. Typologies of Dwellings in the Casbah of Algiers

The typologies of dwellings in the Casbah of Algiers reflect a rich architectural heritage shaped by the socio-cultural of the site and environmental context. These houses showcase diverse forms of spatial organization, with variations arising from functional, spatial, and social requirements. Three main typologies dominate the urban fabric of the Casbah, each with unique architectural and functional characteristics.

4.1. Wast al-Dâr Houses (Houses with Central Courtyards)

The Wast al-Dâr house is the most prevalent typology in the Casbah and epitomizes the introverted nature of the traditional Algerian home. These houses are centred around a patio, a geometric courtyard surrounded by galleries or arcades that provide access to adjacent rooms. This central space facilitates natural ventilation and daylighting, enhancing indoor comfort.[4] (Fig. 5)

The house typically has two levels, connected vertically by a staircase and horizontally by galleries (*s'hin*), which serve as transitional spaces. The layout harmonizes with the shape of the terrain, reflecting a highly adaptive architectural approach. The patio is the focal point for social and domestic activities, promoting privacy and thermal regulation.[4] (Fig. 6).

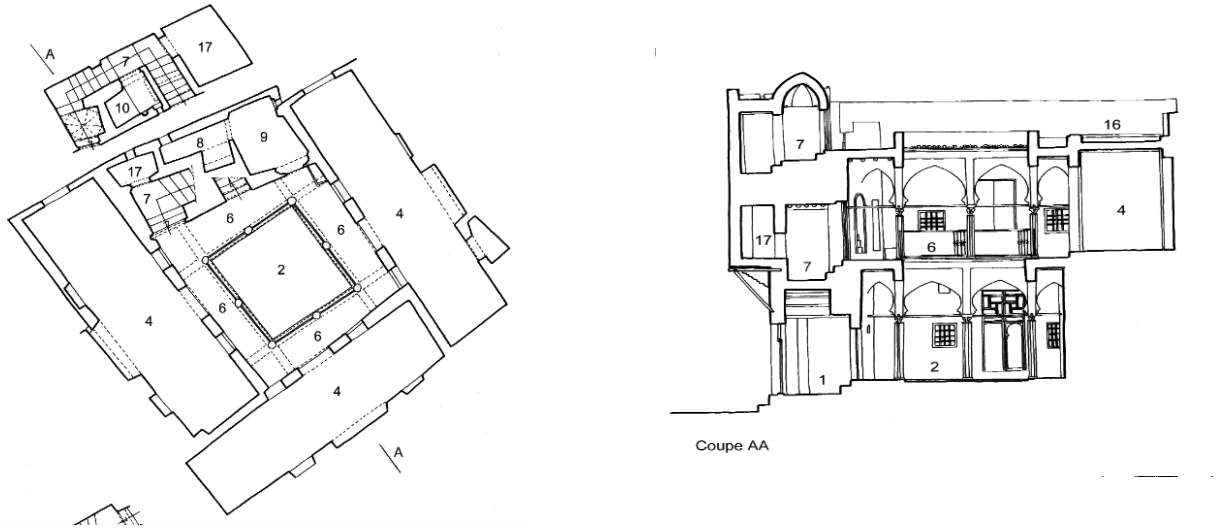

Fig 5. *Wast al-Dar House. [4]*

Fig 6. *View of the Central Courtyard (Wast al-Dâr).*

4.2. Chebâk Houses (Houses with Air Shafts)

The Chebâk house is a smaller typology characterized by a semi-covered or fully covered central space (*Wast al-Dâr*), which incorporates a chebâk, is a rectangular opening in the floor that allows light and air to penetrate the lower levels. This design is particularly suited to compact parcels and addresses the need for ventilation and daylighting in dense urban areas. [4] (Fig. 7)

Depending on the topography, the house spans two levels and may include a terrace or a basement. Ground-level spaces are typically reserved for service functions, while the upper floors house living quarters. The house may sometimes include commercial spaces or storage areas at the base, reflecting its multifunctional nature. [4] (Fig. 8)

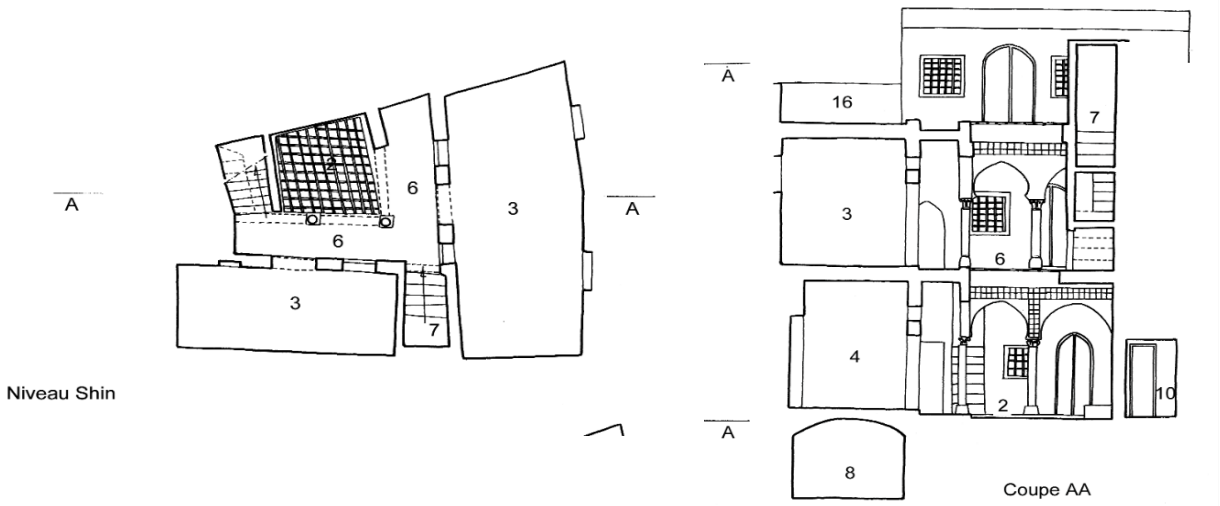

Fig 7. *Chebbak House. [4]*

Fig 8. *View of the Chebâk.*

4.3. Alwî Houses (Vertical Houses without Patios)

The *Alwî* house, or "Al Aloui," is a vertical dwelling designed for small, narrow plots resulting from high urban density. It lacks a *Wast ed-Dar* (central patio) or chebâk (grated opening) and is characterized by its compact dimensions and multi-level organization around a central staircase, reflecting its name, which denotes "elevation" or "height." (Fig. 9) These houses often feature large openings facing the street to compensate for the absence of internal courtyards. They may be built above a shop, a *Sqiffa* (vestibule), a stable, or even a space belonging to a neighbouring house. This typology is a practical solution for maximizing space in densely populated areas. [4] (Fig. 10)

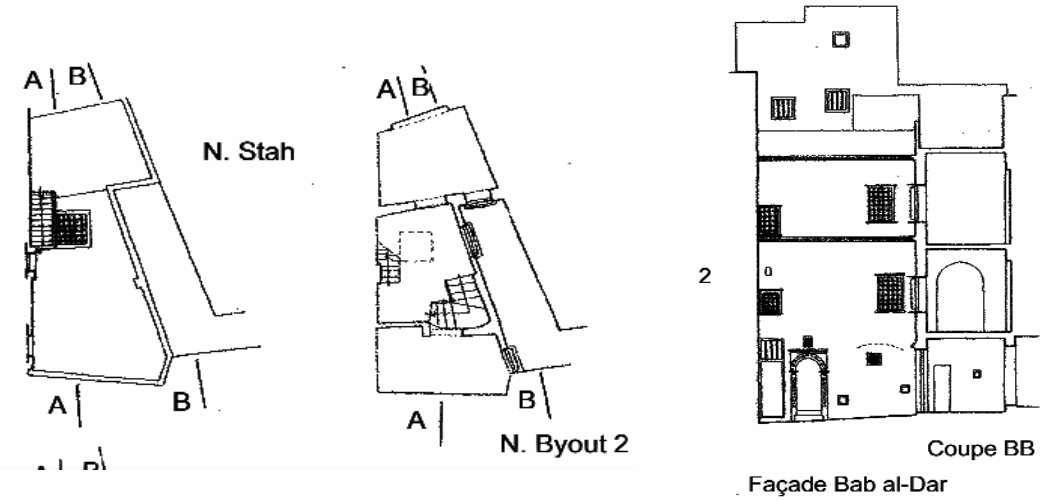

Fig 9. *Alwî Type House. [4]*

Fig 10. *Interior View of an Alwî House.*

The diversity of dwelling typologies in the Casbah reflects a pragmatic response to the social, cultural, and environmental conditions of the site. The Wast al-Dâr typology emphasizes thermal comfort and social interaction, the Chebâk typology innovatively adapts to spatial constraints with efficient ventilation, and the Alwî typology maximizes vertical space in high-density areas. These designs illustrate the resilience and adaptability of the architecture of the Casbah, offering valuable insights for sustainable urban development.

5. Bioclimatic and Socio-Cultural Strategies in the Architecture of the Casbah of Algiers

5.1. Site and Orientation

The vernacular architecture of the Casbah of Algiers demonstrates a remarkable adaptation to its site and climate. One of the most defining aspects of the design of the Casbah is its integration with the natural topography. The stepped configuration of buildings follows the slope of the terrain, enhancing stability and natural drainage. The southeast orientation of the houses allows them to capture morning sunlight, providing warmth during winter mornings while minimizing overheating in the afternoon. Furthermore, the northwest-facing alignment protects the buildings from dominant cold winter winds, contributing to indoor thermal comfort. This combination of site integration and orientation ensures an optimal balance between sunlight exposure and wind protection. (Fig. 11).

Fig 11. *Topographical and Urban Layout of the Casbah of Algiers.*

5.2. Compact Urban Morphology

The dense urban morphology of the Casbah plays a significant role in shaping its microclimate. (Fig. 12) Houses are tightly packed together, creating a compact urban form that minimizes the exposure of external surfaces to extreme temperatures. This shared-wall construction reduces heat loss in winter and limits solar gain in summer, while the narrow, winding streets provide continuous shading and create a cooler outdoor environment. These design features are essential in mitigating the effects of the hot-summer Mediterranean climate. (Fig. 13)

Fig 12. *Sectional View of the Compact Urban Morphology of the Casbah. [16]*

Fig 13. *View of the Casbah of Algiers*

5.3. Building Materials and Construction

Using locally available materials and traditional construction techniques further enhances the thermal performance of the buildings of the Casbah. Thick terracotta walls (Fig. 14) provide excellent thermal inertia, keeping interiors cool during the day and warm at night. (Fig. 15) Roofs are constructed with thick layers of mud and lime plaster [7], adding insulation and mitigating temperature fluctuations. (Fig. 16) Central courtyards, often paved with marble [16], reduce solar absorption and enhance air circulation, ensuring a cooler microclimate within the homes.

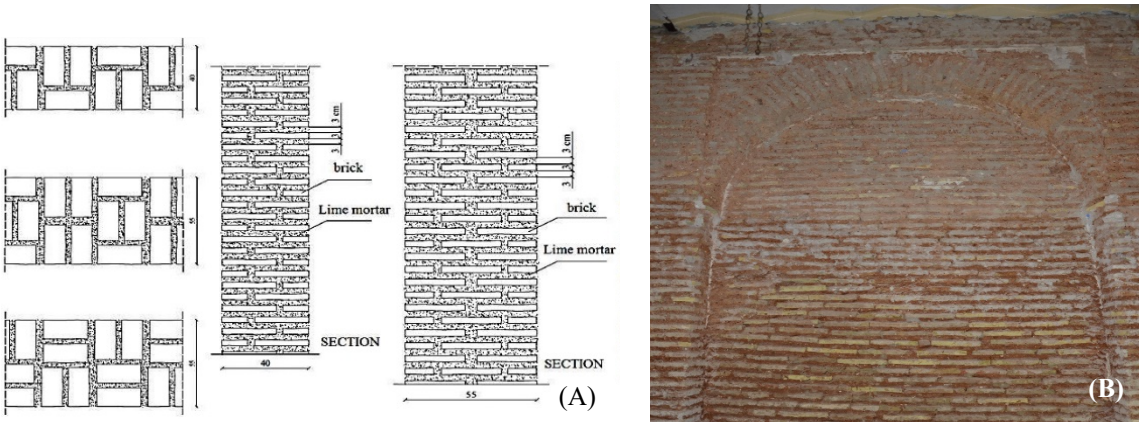

Fig 14. *Details of Wall Construction in the Casbah of Algiers (A) [7], Wall materials (B)*

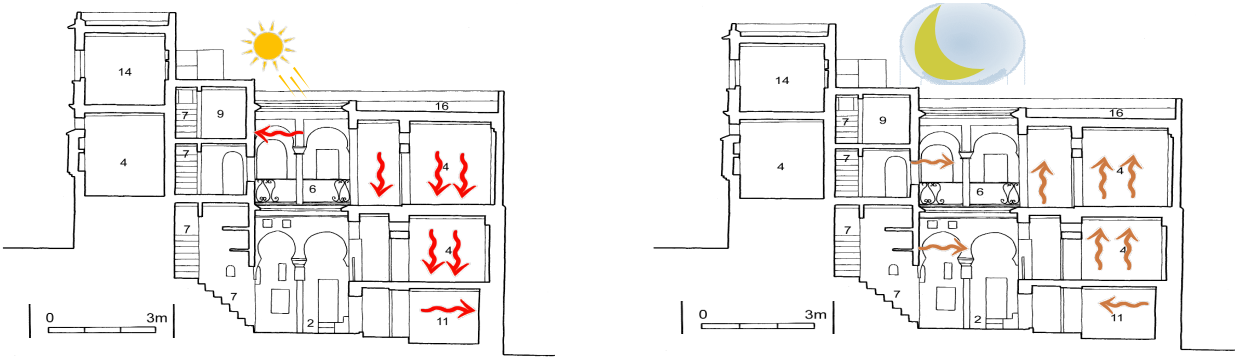

Fig 15. *Thermal Inertia and Ventilation Mechanisms in the Casbah (a) During the Day and (b) During the Night*

Fig 16. *View of the Roof Structure in the Casbah of Algiers*

5.4. Natural Ventilation and Shading

Natural ventilation and shading are integral components of the architectural strategy of the Casbah. Central courtyards, known as Wast al-Dâr, act as thermal regulators, allowing cooler night air to replace warm daytime air. (Fig. 17) The placement of small windows and openings ensures adequate ventilation while limiting direct solar gain. Overhangs, arcades, and rooftop terraces create shaded areas protecting from intense summer sunlight.

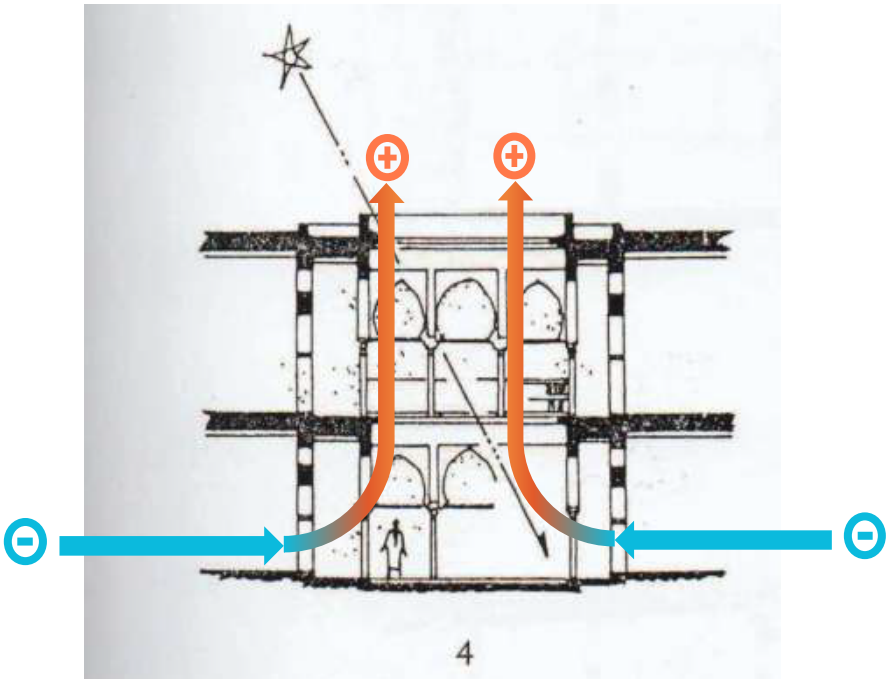

Fig 17. *Ventilation Mechanism in the Casbah*

5.5. Functional Zoning and Social Cohesion

The traditional houses of the Casbah of Algiers are intricately designed around a central patio, or *Wast ed-Dar* (fig.18), which serves as the core of social and functional life, ensuring ventilation, light, and a communal gathering space. Surrounding galleries and apartments maintain a hierarchy of privacy, balancing family intimacy with accessibility. Semi-enclosed niches (*K'bou*) (fig.19) and rooftops enhance usability,

adapting to climatic conditions by promoting airflow and offering shaded spaces. The ground floor typically contains service areas like kitchens and storage, while decorative elements such as tiles and arches reflect cultural identity and aesthetics.[2] This functional zoning fosters social cohesion by integrating communal and private needs while addressing environmental challenges, creating a sustainable living environment.

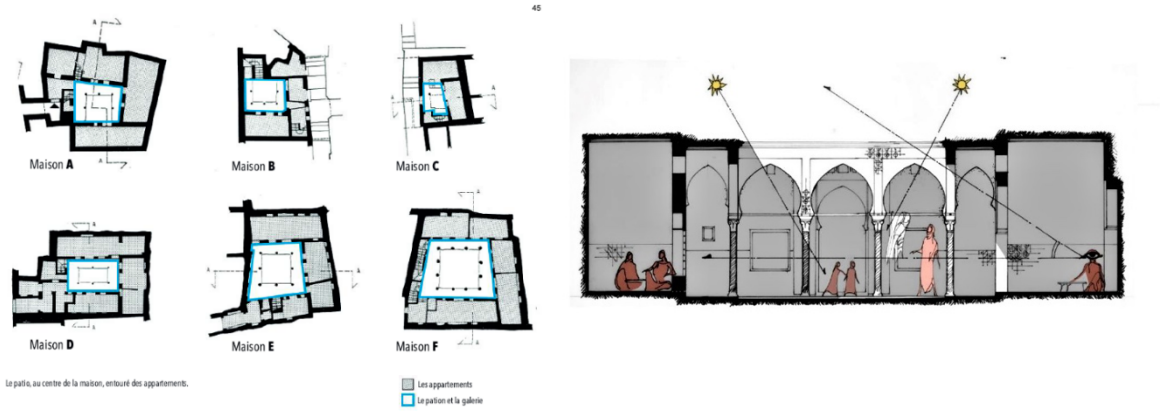

Fig 18. *Functional Zoning and Social Dynamics in Traditional Casbah Dwellings.[17]*

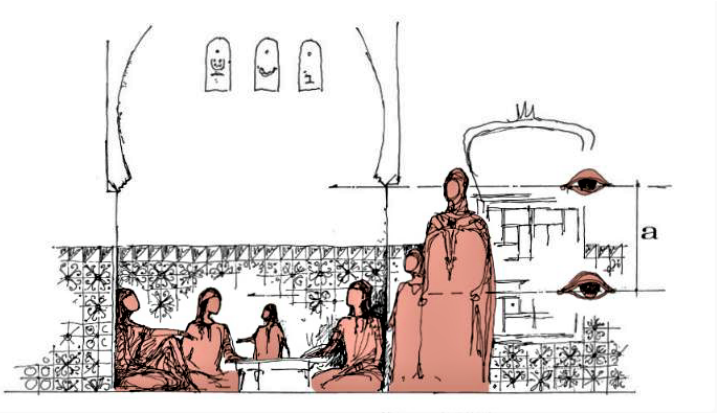

Fig 19. *The K'bou: A Transitional Space in Traditional Casbah Dwellings. [17]*

5.6. Cultural and Social Practices in the Casbah of Algiers

The Casbah of Algiers, beyond its architectural marvels, is a vibrant repository of cultural and social practices that have evolved over centuries. This UNESCO World Heritage site has traditionally been a focal point for communal interaction, religious observance, and artisanal craftsmanship. The social fabric of the Casbah is deeply intertwined with its spatial organization, with Wast al-Dâr (central courtyards) serving as communal hubs for families and neighbours. These courtyards host gatherings, celebrations, and daily interactions, reinforcing strong community ties and social cohesion [10]. Religious practices also play a pivotal role in the identity of the Casbah. The neighbourhood mosques, often within walking distance, serve as places of worship and venues for education and social discourse. (fig.20) The call to prayer punctuates daily life, structuring the rhythm of community activities. Similarly, Sufi traditions, including Dhikr ceremonies, contribute to the spiritual and cultural richness of the area [2]. The Casbah has historically been a center for artisanal production, with workshops specializing in ceramics, textiles, and metalwork. Often passed down through generations, these crafts are integral to the local economy and cultural expression. Weekly markets, or souks, further embody the communal spirit, bringing residents together to trade goods and share news [10]. Despite modern pressures and urban challenges, these practices remain an enduring testament to the resilience of the cultural heritage of the Casbah. Their preservation is crucial for maintaining this historic urban social and cultural vitality of the landscape, offering lessons in the symbiosis of community, culture, and architecture.

Fig 20. *Ali Bitchin Mosque: A Testament to Ottoman Architecture in Algiers*

6. Conclusions

This study investigated the bioclimatic principles and socio-cultural practices embedded in the vernacular architecture of the Casbah of Algiers, a UNESCO World Heritage site in a Mediterranean climate. The research highlights how this historic urban fabric has adapted to warm, dry summers and mild, wet winters, showcasing sustainable architectural solutions that harmonize with the local environment. Through a comprehensive analysis of traditional design strategies, including compact urban morphology, central courtyards (Wast al-Dâr), shaded terraces, and thick masonry walls, the study reveals the exceptional capacity to achieve thermal comfort, energy efficiency and social cohesion of the Casbah.

The findings demonstrate that the architecture of the Casbah utilizes passive cooling techniques and optimized spatial organization to create a microclimate that reduces exposure to temperature extremes while enhancing airflow and ventilation. At the same time, the enduring cultural and social practices within the Casbah, such as the use of shared courtyards for communal gatherings, religious observances in neighbourhood mosques, and artisanal craftsmanship in local workshops, contribute to its role as a living, vibrant community. This combination of architectural ingenuity and cultural resilience reinforces the relevance of the Casbah as a model for sustainable, culturally rooted urban development.

The Casbah offers invaluable lessons for creating environmentally responsive, socially inclusive, and culturally significant spaces. It highlights the need for a multi-scalar approach where urban planning, architectural elements, material choices, and community engagement work together to address climatic and societal challenges. Architects and urban planners can draw inspiration from the Casbah to develop guidelines that preserve cultural heritage while meeting contemporary demands for climate-resilient and socially cohesive urban environments.

In conclusion, the Casbah of Algiers exemplifies how traditional wisdom, bioclimatic principles, and vibrant social practices can be harmoniously combined to create sustainable and adaptable urban strategies. Its ability to balance functionality, cultural significance, and environmental responsiveness makes it a vital reference for shaping resilient urban futures, particularly in regions with Mediterranean climates. This research advocates for a general approach to architecture, where energy efficiency, thermal comfort, and cultural vitality coexist seamlessly.

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