

Sustainable heritage planning: Bani Hammad Qalaa, M'sila, Algeria

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ABSTRACT

Every society holds a unique position in world history. The central Maghreb (Algeria) has been the cradle of numerous successive civilizations, with historical stages reflecting diverse cultural influences. From prehistoric times through Numidian, Roman, Vandal, and Byzantine settlements, the region experienced Islamic conquests that led to the establishment of the Middle Maghreb State.

This study provides a forward-looking perspective on preserving this physical heritage while integrating it with contemporary urban development, without compromising historical and cultural identity. The research employs the **LEED-ND Energy Leadership and Eco-Design System** alongside urban and architectural planning to evaluate the performance of the archaeological city "**Bani Hammad Qalaa**" during its peak. The study identifies heritage sustainability indicators to guide its revitalization and support urban heritage preservation.

Findings highlight the importance of combining sustainable design with historical conservation, offering strategies for maintaining the cultural significance and functional potential of heritage cities. This approach may serve as a model for similar archaeological sites seeking sustainable integration into modern urban environments.

Keywords: Heritage city "Bani Hammad Qalaa", LEED-ND Energy Leadership and Eco-Design System, sustainability indicators, urban heritage preservation, archaeological site management.

1. Introduction

Algeria, located in the central Maghreb region of North Africa, represents a significant yet underexplored context in historical research, particularly regarding its Islamic heritage. While modern historical studies have predominantly focused on the French colonial period and the post-independence era, the long centuries during which Algeria developed under the influence of major Islamic states remain relatively neglected (Marçais, 1942; Hilali El-Mili, 1980). These centuries were formative in shaping the country's cultural, social, and urban identity, contributing to the broader legacy of Islamic civilization in the Maghreb.

The **Hammadid state (1014–1152 CE)** constitutes a critical chapter in this heritage. Emerging as a dynastic offshoot of the Sanhaja Berbers, the Hammadid dynasty established a capital at **Bani Hammad Qalaa, M'sila, Algeria**, which quickly developed into a flourishing urban and cultural center. The city reflected the architectural ingenuity, environmental adaptation, and social organization characteristic of Islamic urbanism, producing an urban fabric that was not only highly functional but also expressive of the cultural identity and values of its inhabitants (Doublier, 1913; Owais, 1965).

Despite its historical significance, the Hammadid state has received limited attention in both historical and archaeological scholarship. Most references are scattered across chronicles, travelogues, geographical accounts, and general histories of the Maghreb (Bourouiba, 1995; Djilali, 1982). Only a handful of studies have addressed the city of Bani Hammad Qalaa in depth, leaving substantial gaps in understanding its urban, architectural, and cultural dimensions (Marçais, 1942; Hilali El-Mili, 1980). Consequently, much of the urban legacy of the Hammadid state remains understudied, and its significance in the evolution of Islamic urbanism in North Africa has yet to be fully appreciated.

Contemporary urban development in the Maâdjid municipality and surrounding areas presents both challenges and opportunities for integrating heritage conservation with modern planning. Traditional urban fabrics were historically shaped by local environmental conditions, community practices, and cultural norms, resulting in sustainable and adaptive cities (Marçais, 1942). In contrast, modern urbanization often relies on standardized scientific models and advanced technological tools, producing urban environments that frequently lack cultural identity, exhibit environmental challenges, and overexploit non-renewable resources (Bourouiba, 1995).

Given this context, the present study addresses the critical challenge of **balancing urban expansion with heritage preservation**. It focuses on **Bani Hammad Qalaa**, a UNESCO-classified heritage site, aiming to evaluate its architectural and urban legacy through **sustainability indicators** and contemporary frameworks such as the **LEED-ND Energy Leadership and Eco-Design System**. This approach not only highlights the relevance of traditional urban patterns for modern planning but also emphasizes the importance of sustaining cultural identity, environmental stewardship, and socio-economic well-being in heritage cities (Owais, 1965; Djilali, 1982).

Ultimately, the study contributes to the discourse on **sustainable urban development and heritage management**, offering insights into how historic cities can inform contemporary planning practices, maintain cultural continuity, and achieve environmental resilience while accommodating modern urban growth.

2. Research Problem

The alignment of urban development objectives in historic cities with those of contemporary urban settlements is often challenging. In the case of **Maâdjid Municipality**, goals such as comfort, safety, well-being, and creativity were historically achieved through planning mechanisms and techniques developed by traditional communities. These methods relied on continuous field experience and everyday practices, resulting in an urban fabric that was well-adapted to its environment and reflective of the cultural identity of its society (Marçais, 1942; Hilali El-Mili, 1980).

In contrast, modern urban planning increasingly depends on specialized academic theories and advanced technological tools. While this approach can optimize efficiency, much of contemporary urban production lacks cultural identity and often generates environmental challenges, including the overexploitation of non-renewable natural resources (Bourouiba, 1995).

Consequently, our research problem revolves around the **dual challenge of managing urban expansion in Maâdjid Municipality** while preserving the architectural and urban heritage of

Bani Hammad Qalaa, a site classified as a UNESCO World Heritage. The study emphasizes the need to sustain the traditional architectural and urban patterns of the historic city amidst contemporary urban pressures.

3. Study Objective

The primary objective of this study is to **revitalize the architectural heritage of Bani Hammad Qalaa** without compromising its cultural identity, while aligning with modern urban development requirements. To achieve this, the study focuses on identifying and evaluating the **architectural and urban indicators** of the heritage site using the **LEED-ND Energy Leadership and Eco-Design System**. This approach aims to integrate traditional urban patterns with sustainable planning strategies, ensuring the long-term preservation and functionality of the historic city within a modern urban context (Owais, 1965; Djilali, 1982).

4. Significance of the Study and Justifications

- **Cultural Pride and Tourism Potential:** The Hammadid architectural and urban heritage represents a source of cultural pride and a significant tourist asset for the M'sila Province, extending beyond Maâdjid Municipality alone.
- **Preservation Urgency:** The deteriorating condition of Bani Hammad Qalaa—including physical degradation, environmental pollution, and declining tourism—highlights the urgent need for intervention and sustainable management.
- **Resource Optimization:** Limited financial resources necessitate the efficient use of local materials and capacities to revive the heritage site responsibly, ensuring its sustainable exploitation and long-term conservation (Bourouiba, 1995; Hilali El-Mili, 1980).

This study, therefore, addresses both the cultural and practical dimensions of heritage preservation, seeking to provide a framework for integrating traditional urban forms into contemporary planning while safeguarding environmental and cultural sustainability.

5. Key Concepts of the Study

1.5 The Heritage City: Bani Hammad Qalaa

The city of Bani Hammad Qalaa was founded by Prince Hammad ibn Bologh in ibn Ziri ibn Sanhaji in 398 AH / 1007 CE on Jebel Maâdjid as a military base for his troops, modeled initially on the city of Ashir. Within a few years, the settlement was elevated to the status of the Hammadid state capital in 408 AH / 1018 CE, becoming one of the prominent urban centers of Islamic North Africa (Bourouiba, 1995, pp. 6–7).

Bani Hammad Qalaa quickly gained fame that extended beyond the central Maghreb and the Islamic Maghreb, reaching the Arab Mashriq, Al-Andalus, and the western regions. The city is mentioned in numerous historical sources, including the works of the renowned historian Ibn Khaldun, who noted:

"...He founded the city of the fortress on Jebel Ketama in the year 98 AH. At that time, the Iyad tribes of Banu Hilal were settled there; the inhabitants of M'sila and Hamza were relocated, destroyed, and the Zenata tribes from Morocco were brought in. The city was fully established by the beginning of the fourth century AH..." (Ibn Khaldun, 309).

Similarly, Al-Bakri described the city as:

"...It is a large fortress with strong defenses. It was Arabized after the destruction of Kairouan, and most of the inhabitants of Ifriqiya moved there. Today, it is a destination for merchants

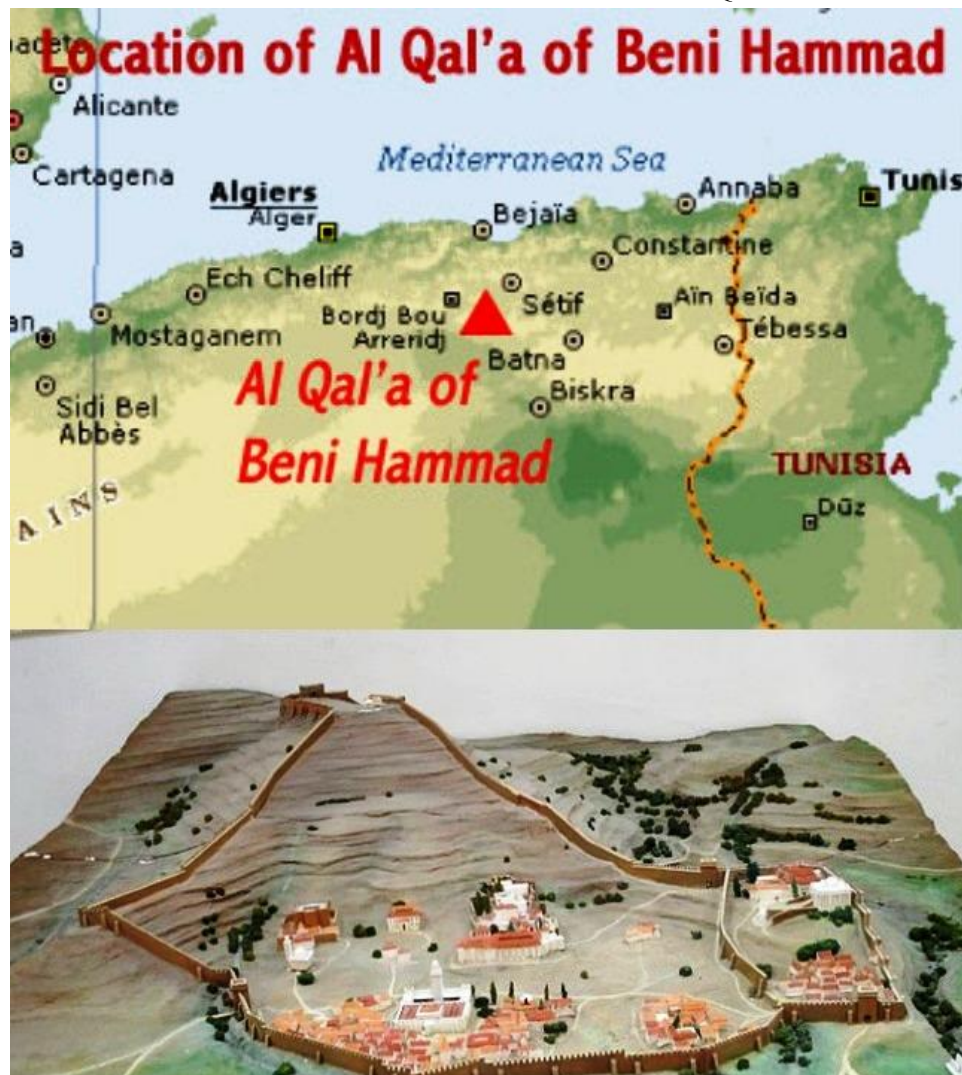
and pilgrims from Iraq, Hejaz, Egypt, Syria, and all parts of the Maghreb, and it serves as the seat of the Sanhaja kingdom..." (Al-Bakri, 58).

The historical significance of Bani Hammad Qalaa lies not only in its military and administrative roles but also in its status as a cultural, economic, and urban hub. The city demonstrates the architectural ingenuity, strategic urban planning, and adaptation to environmental conditions characteristic of early Islamic urbanism, making it an invaluable example of heritage and sustainability in urban development.

Map 1 illustrates the boundaries of the Hammadid state and a virtual reconstruction of Bani Hammad Qalaa at the height of its prosperity.

Map 1

Boundaries of the Hammadid State and the 3D model of Qal'at Beni Hammad.



Source: Prepared by the author, based on Qal'at Beni Hammad, QPedia Encyclopedia.

Retrieved from <https://www.qpedia.org/topics/10512.html?language=french>

Despite the remarkable prosperity that Bani Hammad Qalaa experienced during its peak, this period of urban, cultural, and economic flourishing was unfortunately short-lived. The city's decline was precipitated by a series of violent upheavals that severely undermined its urban structure, social organization, and architectural integrity. Among the most significant events

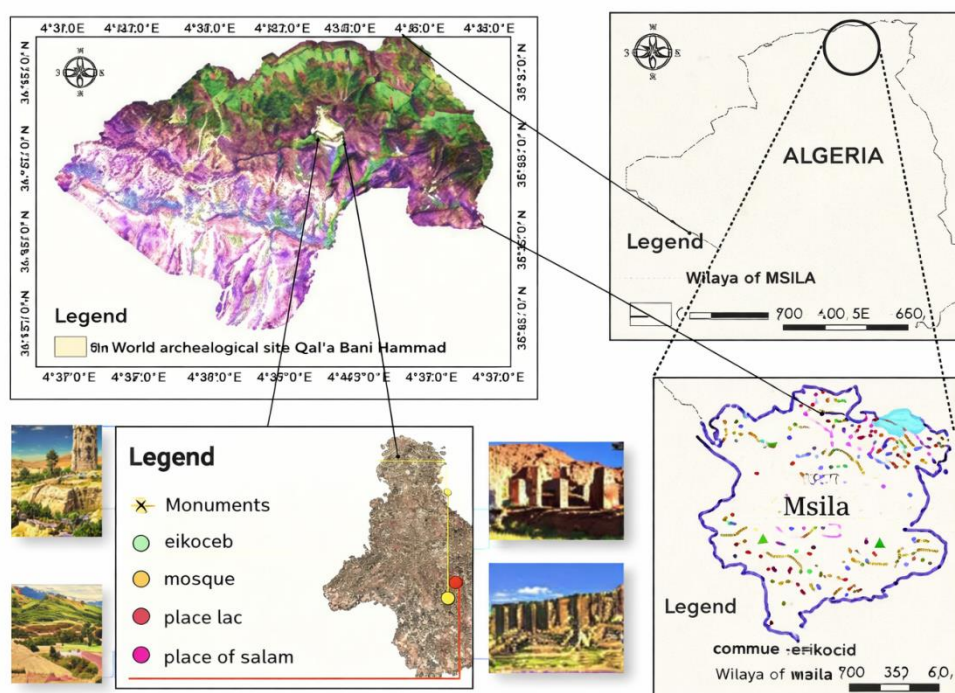
was the Hilali invasion (1050–1052 CE), a military campaign initiated by the Abbasid Caliph al-Muizz against the Hammadid dynasty, following their political allegiance to the Fatimid state. This attack resulted in widespread destruction of residential areas, administrative buildings, and defensive structures, effectively dismantling the urban fabric that had developed over decades (Printing Works Foundation of M'sila Province, 1–18).

The consequences of this devastation were profound. Once a thriving and strategically important capital, Bani Hammad Qalaa quickly lost its political and economic role, deteriorated over time due to natural and human factors, and today only ruins remain, offering a partial view of its past, while many aspects of its planning and architecture are still not fully understood.

Map 2 shows the location and current state of Bani Hammad Qalaa, highlighting its remains and landscape, which reflect the Hammadid dynasty's urban and architectural legacy and its importance for heritage conservation and sustainable planning.

Map 2

Location and archaeological ruins of Qal'at Beni Hammad



Source: PPMVSA chart + Researcher processing by

<https://www.kapwing.com/videos/69cf7e0c2c0cceb94338dac2>

2.5 Sustainability Indicators

Since the 1980s, the concept of sustainability has increasingly emphasized the integration of economic, social, and environmental dimensions. The World Commission on Environment and Development (Brundtland Commission, 1989) defined sustainability as “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (IUCN, p. 10).

Sustainable development encompasses multiple interrelated dimensions. Meaningful progress can be achieved by addressing three critical and interactive aspects (Qanbar, 2010, p. 5):

- **Environmental Sustainability:** Involves reducing waste, minimizing harmful emissions, mitigating negative impacts on human health, promoting the use of renewable raw materials, and responsibly managing toxic substances.
- **Social Sustainability:** Focuses on providing safety and health in workplaces, assessing development impacts on local communities and quality of life, and addressing the needs of vulnerable populations, including the elderly, people with disabilities, and the homeless.
- **Economic Sustainability:** Involves creating new markets and opportunities for sales growth, reducing costs through improved efficiency and lower energy and material consumption, and generating added value to sustain long-term economic growth.

3.5 LEED-ND: Leadership in Energy and Environmental Design – Neighborhood Development

The LEED-ND system is an American tool developed to establish internationally standardized criteria for green building development, integrating the three dimensions of sustainability: environmental, social, and economic (LEED, 2009). Its main objectives include:

- Controlling urban sprawl and promoting compact development.
- Preserving endangered or sensitive areas.
- Planning and developing new green neighborhoods.
- Enhancing the aesthetic and functional quality of residential areas and increasing occupancy rates.
- Strengthening the sense of place through walkable streets and integration with historic buildings.
- Providing social benefits to communities by creating employment opportunities and reducing health risks.
- Supporting the redevelopment of industrial project sites by integrating them with surrounding neighborhoods.

The tool is designed to assess sites ranging from small plots to entire towns, based on principles of smart growth, urban development, and green buildings. The assessment is structured around the following axes (Hamdan, 2012, p. 23):

- **Sustainable Site:** Focuses on site selection and design strategies.
- **Water Efficiency:** Promotes responsible water use and conservation.
- **Energy and Atmosphere:** Ensures optimized energy performance across the entire building.
- **Materials and Resources:** Encourages the use of materials with low environmental impact throughout their life cycle.
- **Indoor Environmental Quality:** Focuses on reducing pollutants and improving internal environmental conditions.
- **Innovation:** Promotes creativity in design and the development of new environmental strategies.

Using a point-based scoring system, the LEED-ND framework determines the sustainability rating of buildings and urban fabrics, providing guidance for both design and planning decisions (Abdullah & Al-Ajili, 2012, p. 23). As shown in Table 3, the table illustrates the evaluation levels for urban and architectural sustainability within the LEED program,

highlighting the criteria and scoring methodology used to assess performance across environmental, social, and economic dimensions.

Table 1
Rating Levels of Urbanism and Architecture in the LEED Program

No.	Classification Levels	Points Range	Certification Type
01	Platinum Level	52 – 69	Platinum
02	Gold Level	39 – 51	Gold
03	Silver Level	33 – 38	Silver
04	Certified Level	26 – 32	Certified
05	No Rating	25 or Less	Not Rated

Source: Citizen's Guide LEED-ND

6. Analysis and Discussion

This section aligns the LEED-ND criteria with the urban sustainability of the heritage city Bani Hammad Qalaa, analyzing the planning and urban design implemented during its period of prosperity to determine its corresponding sustainability rating under the system.

6.1 Site Sustainability of the Archaeological City “Bani Hammad Qalaa”

These criteria are intended to assess the strategy behind geographic site selection and the compatibility of urban and architectural design with the local environment.

- **Regional Priority:** Bani Hammad Qalaa served as the first capital of the Hammadid State, which experienced significant territorial expansion, particularly during the reigns of Balkan ibn Muhammad and al-Nasir ibn Alnas, encompassing numerous cities across Algeria, including M'sila, Ténès, Zab, Achir, Tahert, Merssa Dajaj, Zawawa, M'Qara, D'kama, Balzma, Souq Hamza, and Fez. Eventually, the capital was relocated to the city of Bejaia during the reign of al-Nasir ibn Alnas (General l' de Beylie, p. 1).

As illustrated in Map 3, the map depicts the location and historical boundaries of the Hammadid State, highlighting the strategic geographic position of Bani Hammad Qalaa, which reflects both its historical importance and the planning considerations that contributed to its sustainability in terms of defense, access to resources, and urban cohesion.

Map 3

Showing Bani Hammad Qalaa and Surrounding Archaeological Sites, Algeria.



source: Author's illustration based on historical and archaeological references.

- **Site Selection:** The geographic location of Bani Hammad Qalaa was chosen primarily as a military strategy. Its rugged mountainous terrain, including Jebel Taghrabest (1,418 m) and Jebel Ghourine (1,190 m), formed a natural barrier, while to the south, the only access road to the fortress followed the winding path of Wadi Farj, making the site highly secure against enemy attacks at the time.
- **Preventing Environmental Degradation from Construction:** The city's walls defined its urban limits, leading to intensive land use through closely built structures and narrow side streets while prohibiting construction outside the walls. This strategy preserved natural resources and constrained urban sprawl. Excavations conducted by the Polish-Algerian Restoration Mission between 1987–1988 (1408–1409 AH) revealed the city wall extending approximately 7 km westward along the ridge of Jebel Ghourine, sloping down to the Wadi Farj plain. The walls' width ranged between 1.6 m and 7.2 m, which further complicated access and reinforced security.
- **Density of Development and Community Integration:** From the outset, the founder of the Hammadid State, Hammad ibn Bulkin, recognized that controlling territory alone did not secure power; organizing social relations was essential to maintain security and protect the land. Tribal solidarity among the Sanhaja facilitated the state's independence from the Zirid dynasty in 1004 CE (395 AH). Following political stabilization, the Hammadids cultivated a culture of inclusivity, integrating newcomers into urban life, particularly after the Hilalian invasions, which brought traders, artisans, scholars, and students to the city. This influx contributed to the city's prosperity and cultural prominence from 1050 CE (440 AH), rivaling other Maghreb centers such as Mahdia (Ibn Khaldun, n.d.).
- **Urban Redevelopment:** Historical sources indicate that the site had previously served as a refuge for Abu Yazid Bahlid ibn Kidar after his defeat by the Fatimid Caliph Abu Tahir Ismail al-Mansur, when it was known as Qalaa Abu Tuwil (Mazali, 2013, p. 13). Hammad ibn Bulkin later rebuilt and redeveloped the site, establishing it as a fortified urban center.
- **Accessibility to Public Spaces:** Maintaining access routes, particularly trade roads for gold and slaves from Sudan to Ifriqiya, was a key priority for Bulkin ibn Menad and his son Hammad. They constructed cities and forts, including Achir, Miliana, Algiers, and Médéa, ensuring a secure road network extending to the Atlantic coast, which facilitated commerce throughout the Islamic Maghreb. Al-Bakri described the city as "a destination for merchants, visited by travelers from Iraq, the Hijaz, Egypt, Syria, and across the Maghreb".
- **Open Spaces and Parking Areas:** Courtyards and empty squares around palaces and the Great Mosque were left undeveloped to provide public gathering spaces and horse stables.
- **Climate and Outdoor Activity:** The site benefits from fertile agricultural land, abundant forests, flowing freshwater sources, and a Mediterranean climate—mild in summer and snowy in winter—creating favorable conditions for human activities in open, unroofed public spaces.

Figure 1 illustrates the natural features and environmental context of Bani Hammad Qalaa, highlighting how these elements contributed to the urban planning and sustainable use of the site during its peak.

Figure 1

Integrated Natural Features of Bani Hammad Qalaa

Natural Features of Bani Hammad Qalaa



Source: Photographed and processed by the author

- **Thermal Impact and Roof Design:** The planners of Bani Hammad Qalaa drew heavily from their mountainous environment when designing the urban fabric. Buildings were constructed using stone materials with high thermal mass, resilient like the surrounding mountains, providing insulation against the cold winter climate. Roofs were sloped to prevent snow accumulation, thereby avoiding structural cracks caused by excessive weight on columns. Additionally, small window openings were strategically placed along streets to maintain moderate indoor temperatures, optimizing natural thermal comfort within the built environment.

Figure 2 illustrates examples of traditional residential structures at the archaeological site of Bani Hammad Qalaa, reflecting the integration of environmental adaptation, local materials, and sustainable architectural practices in the design of the city.

Figure 2

Traditional Dwellings at the Archaeological Site of Bani Hammad Qalaa



Source: Author's own elaboration based on Google (n.d.), Gemini outputs.

2.6 Resource Efficiency and Materials

This criterion aims to promote the efficient use and conservation of resources, particularly water and construction materials, within the urban and architectural planning of the Bani Hammad Qalaa.

- **Reduction of potable and irrigation water usage:** Archaeological investigations by De Beylie (1908), assisted by Marcais, uncovered remnants of the city's water management system, including tanks, cisterns, and wells, which supplied and stored water for the inhabitants.
- **Aesthetic and functional water use:** Excavations conducted by Golvin highlighted the Hammadids' attention to water as an urban design element. A notable example is the artificial lake associated with the Palace of the Lake, fed by nearby streams. The lake measured 64 m in length, 45 m in width, and 1.6 m in depth. De Beylie also identified a small fountain in the lake's eastern corner (0.4 m × 0.3 m), illustrating an integration of functionality and ornamentation.

3.6 Minimum Energy Performance

- **Energy and Environment:** Buildings represent one of the largest sources of environmental impact due to energy consumption for heating and cooling, as well as high energy requirements in construction materials (Sykes, 2010, p. 30). Planners of Bani Hammad Qalaa used locally sourced stone and timber from surrounding forests to construct durable, energy-efficient structures.

4.6 Materials and Resources

- **Collection and storage of reusable materials:** During the peak of economic prosperity under rulers like Al-Nasir ibn Alnas and his son Al-Mansur, the city achieved remarkable material abundance. Al-Idrisi describes it as "one of the largest and richest lands, with extensive wealth, fertile lands, and abundant fruits" (Al-Idrisi, trans. 1154).
- **Use of local materials in construction:** Archaeological excavations of the Palace of the Lake reveal extensive use of limestone mortar and rubble masonry, demonstrating sustainable material practices (De Beylie, 1908).

- **Locally sourced raw materials:** Local wool, leather, and metals (gold, silver) supported vibrant textile, tanning, and metalworking industries, reinforcing the city's economic resilience.

5.6 Indoor Environmental Quality

- **Low-use of paints and coatings:** Residences of the Hammadids featured minimal external decoration, with ornamentation concentrated in palaces and religious buildings using natural materials reflecting regional identity and Islamic teachings.
- **Thermal comfort management:** Walls, stone facades, small window openings, and strategic orientation minimized solar gain and maintained moderate indoor temperatures. Courtyards provided natural light and ventilation, covering over one-third of the interior space and connecting rooms through corridors.

6.6 Design Innovation

The Palace of the Lake represents a remarkable innovation, functioning as a recreational water facility in a city without direct access to open waterways. Fed by surrounding streams, the rectangular pool measured 64 m × 45 m × 1.6 m, featuring a northern slide and a three-sided arcade supported by columns, likely roofed. The southern section contained 18 square chambers used for boat races (Golvin, 1987).

The Grand Mosque, the oldest and largest structure at the site, occupies a rectangular area of 63.3 m × 53.2 m, with a central courtyard, surrounding arcades, a prayer hall with multiple rows of arches, and a mihrab. Its unique minaret rises 24.7 m high, with a square base of 6.5 m per side and 127 internal steps, influencing later Maghreb minaret designs in Seville and Rabat

LEED-ND Assessment Results

By applying the LEED-ND criteria to Bani Hammad Qalaa at its peak, using a point-based scoring system for each sustainability indicator, the results (Table 2) provide a comprehensive evaluation of the city's performance across site sustainability, water efficiency, energy and environment, materials, indoor environmental quality, and design innovation, demonstrating an early historical example of environmentally adapted, socially integrated, and resource-efficient urban planning.

Table 2

Evaluation Results of the Heritage City "Bani Hammad Qalaa" Using LEED-ND

Indicator	Criterion	Description	Score	Total
Site Sustainability	Regional Priority	First capital of the Hammadid state	4	12
	Site Selection	Military strategy	1	
	Pollution Prevention during Construction	Defining the urban domain and preventing expansion beyond the walls	1	
	Development Density and Community Integration	Providing security and stability; acceptance and integration of others after African Hilalian invasion	1	
	Redevelopment of the	Reclaiming the site by	1	

Indicator	Criterion	Description	Score	Total
	Area	rebuilding the Qalaa city after the decline of Abi Tuwail's city		
	Access to Public Places	Securing trade routes with watchtowers	1	
	Parking Capacity	Leaving squares/open spaces around public areas for horse stables	1	
	Heat Impact (Without Roof)	Suitable natural conditions (moderate climate, forest cover, fertile lands)	1	
	Heat Impact (With Roof)	Use of architectural designs and local building materials insulating against heat	1	
Water Use Efficiency	Reduce Drinking and Irrigation Water Use	Building irrigation systems and water tanks to supply the city	2.5	4
	Efficiency in Water-based Landscaping	Use of water basins and fountains to enhance urban aesthetics	1.5	
Minimum Energy Performance	Minimum Energy Performance	Use of eco-friendly building materials resistant to climate factors	2	4
	Energy Performance Improvement	Architectural design ensuring natural ventilation and lighting	2	
Materials and Resources	Collecting and Storing Recyclable Materials	Abundant local material production	0.75	11.8
	Use and Conservation of Local Building Materials (Walls, Floors, Roofs)	Using local materials in construction	9.75	
	Locally Extracted, Processed, and Manufactured Materials	Making local material manufacturing the second pillar of the economy	1.3	
Indoor Environmental Quality	Minimum Indoor Air Quality Performance (Increased Ventilation)	To maintain thermal comfort, exterior openings minimized or eliminated	0.75	12.65
	Low Emissions of Materials, Paints, and Coatings	Use of simple façade without paints/decorations	0.75	

Indicator	Criterion	Description	Score	Total
	Daylight and Views in Spaces	Internal open courtyard created for natural ventilation and lighting	11.25	
Design and Innovation (	Innovation		2.5	2.5
Overall Total			46.95	

Source: Prepared by the author, based on the evaluation of the heritage city “Bani Hammad Qalaa” using the LEED-ND program

7. Conclusion

Based on the analytical study of the planning and urban heritage components of the global archaeological site “Qal’at Beni Hammad” in the municipality of El-Maâdjid, and by adopting the Leadership in Energy and Environmental Design – Neighborhood Development (LEED-ND) system to assess its planning, urban, and architectural dimensions, the evaluation results indicate that the heritage city qualifies for a Gold rating, achieving a total score of 46.95 points according to the LEED-ND point system. This classification reflects compliance with the minimum requirements for urban performance efficiency and demonstrates the planning and engineering efforts undertaken at that time with a perspective aligned with modern sustainable development standards.

This also reflects the alignment between the objectives of preserving the urban heritage of the fortress and current urban development goals in the municipality of El-Maâdjid (including comfort, safety, welfare, and creativity), despite differences in planning methods. Traditional societies relied on accumulated field knowledge and practical techniques, continuously adapted through daily practices and in harmony with their environmental and cultural context, while modern urban planning relies on specialized scientific theories and advanced technological tools.

From this, the following conclusions can be drawn:

1.7 Environmental-Urban Indicator

This axis reflects the interaction between the natural environment and the urban environment, and the extent to which the depletion of non-renewable natural resources is controlled. Results for the heritage city “Qal’at Beni Hammad” revealed:

- **Urban adaptation to the natural environment:** The city’s layout optimally utilized the mountainous terrain, supported by a well-integrated hydrographic network, resulting in a cohesive urban fabric aligned with the surrounding topography.
- **Control over spatial utilization:** The city walls defined the urban boundaries while promoting dense internal development to protect external areas.
- **Optimal use of natural resources:** Leveraging high mountains, extensive forests, and diverse climatic conditions (cold and snowy in winter, mild in spring, hot and sunny in summer), the city planners minimized energy consumption by using local environmentally friendly materials and climate-adapted architectural designs.

2.7 Socio-Cultural Indicator

This axis highlights the influence of social and cultural composition on urban form:

- **Urbanization factor:** Openness to external regions and migration contributed to the city becoming a major urban center, rivaling the capitals of its time.
- **Social equity (accessibility to public facilities and comfort):** The Great Mosque served as a central public facility, strategically located to facilitate access across the city.
- **Social interaction:** The openness of the Hammadid society to incoming cultures fostered knowledge transfer and enhanced artistic and architectural creativity.
- **Valuing local identity:** Despite external influences, the city maintained its Islamic-Tamazight cultural identity through distinctive architectural and decorative styles, which continued in urban settlements in the municipality of El-Maâdjid, despite the current physical degradation of the site.

3.7 Economic Axis

- **Regional significance:** The city served as the developmental capital of the Hammadid state, enabling it to play a political and economic role throughout the central Maghreb, leveraging local resources and trade exchanges.
- **Economic activity diversity:** Agriculture and industry were the pillars of the Hammadid economy, supported by optimal exploitation of local raw materials and the creation of growth-enhancing factors.

Recommendations and Suggestions

Based on the study findings, it is recommended to:

- Understand the dynamics of the physical environment and prepare the archaeological site for integration within the local urban ecosystem, considering sustainability indicators that qualified it for global heritage classification.
- Address the site using both quantitative and qualitative approaches in urban and architectural planning, and assess the urban area through a socio-cultural lens to ensure community continuity in preserving heritage as a planning unit that maintains the spiritual and ethical values of society.

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