

## The Ksour of Ghardaïa: A Model of Sustainable Saharan Architecture in Algeria

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### Abstract

The ksour or kasbahs located in Ghardaïa are perfect examples of new-age, sustainable buildings that have been constructed with an appreciation of the harsh environment of the Saharan Desert. Built by members of the Ibadīt community, ksour are built around a common Mosque and consist of densely populated urban areas made up of densely populated housing arrangements along small and shaded roads, surrounded with the remnants of large fortifications and located near an oasis. The overall layout of ksour provides the necessary conditions to allow people to adapt to the climate, provide social cohesion within their community, and manage their natural resources effectively. The close proximity of agricultural activities to the ksour allows the two spaces to work together effectively and promote efficient water use and sustain agricultural activities. The design characteristics of the ksour; houses built facing inward, courtyards, use of local materials, and compact urban design, all help create buildings and an overall environment that provide thermal comfort and an energy-efficient environment. The ksar of Tafilalt contains these same principal architectural design features, demonstrating that strong cultures inherently develop resilient solutions to urban design issues when guided by their cultural history.

**Keywords:** Ksour of Ghardaïa, Vernacular desert architecture, M'zab Valley, Sustainable urbanism, Climatic adaptation.

## **Introduction:**

The city of Ghardaia, located in the M'zab Valley in southern Algeria, is one of the most important historical cities that reflects human ingenuity in adapting to the desert environment and developing an integrated urban civilization. This city was founded by the Ibadi community, who selected the M'zab Valley as their settlement and constructed a series of compact ksour that are today known as the M'zab Valley Ksour.

These ksour possess a unique architectural character that merges functionality, spirituality, and aesthetic value. They are not merely residential groupings but rather integrated social and economic systems that embody the principles of solidarity and harmony with nature. Furthermore, Mozabite architecture represents a distinguished example of sustainable Islamic architecture due to the innovative environmental solutions it employs to endure the severe desert climate—such as the use of local materials, the organization of urban space to ensure natural ventilation and optimal shading, and the planning of the settlement around the central mosque, which serves as the core of daily life.

Accordingly, this article examines the most important ksour of the M'zab Valley and highlights the extent to which this architectural pattern corresponds to the characteristics of the hot desert environment.

## **1. Urban Patterns in Desert Cities**

Given the vast geographical extent of the desert and the diversity of its characteristics and needs, various forms of urban settlements emerged and developed, differing in both form and function.

### **1.1 In Terms of Form**

Desert architecture can be classified according to form into the following types:

#### **1.1.1 Ksour**

The term ksour is the plural of ksar, which in its general use refers to a luxurious or spacious residence associated with wealthy individuals or figures of authority. However, in desert regions, a ksar denotes a compact and cohesive cluster of dwellings inhabited by groups belonging to different ethnic origins or social backgrounds.

Among the essential characteristics of desert ksour is their location on mountain peaks, slopes, or solid rocky plateaus that facilitate defense and allow for the controlled and precise distribution of water resources. They are also closely tied to agricultural activity, being situated near arable land. For this reason, most desert ksour are surrounded by palm oases, which constitute

the economic base of their inhabitants and provide a suitable environmental buffer against sandstorms.

### **1.1.2 Cities**

A city is a human and geographical concept characterized by its vast spatial extension, high density, and large population. It constitutes an actual urban agglomeration inhabited by numerous tribes, where various crafts and industries flourish—an essential condition for its existence.

In contrast, a ksar is inhabited by a smaller population whose livelihood depends primarily on agriculture. Thus, the ksar represents a rural-agricultural settlement. French researchers often referred to these settlements as villages. Moreover, cities expand and grow over time, whereas ksour, due to their location and physical constraints, lack the space for expansion and remain confined within their walls. When the population increases, residents migrate elsewhere. For this reason, most ksour have not undergone the significant transformations observed in cities; instead, they have preserved their authenticity and traditional character.

### **1.1.3 Isolated Houses**

Throughout desert regions, isolated houses are found outside urban clusters yet remain relatively close to them. Many of these dwellings are used only during specific seasons, depending on need—some are located in ghout (sunken gardens) or oases and used during harvest seasons, whereas others are designated for servants. Some nomadic groups also erect temporary isolated houses near grazing areas. In addition to these forms, a significant portion of the desert population traditionally lived in tents, practicing a nomadic lifestyle with their livestock in search of pasture and water. Although these cannot strictly be classified as architectural structures, they fulfilled their residential purpose for centuries and continue to do so.

## **1.2 In Terms of Function**

Architecture can generally be classified according to function into civil, military, and religious categories. Often, these types coexist within a single settlement. In an urban cluster such as a ksar, civil architecture includes structures used by inhabitants for housing and socio-economic purposes, military architecture is represented by walls and towers intended for defense and security, and religious architecture appears in the form of mosques, zawiyas, and other related buildings (Rabahi, 2018/2019, pp. 16-18).

## **2. Factors Behind the Emergence of Desert Cities**

**a– The commercial factor**

This played a pivotal role in the establishment of cities through commercial exchange among nomadic groups in areas where trade caravans intersected.

**b– The water factor**

This is represented mainly by temporary valleys (seasonal streams) that supply the cities, such as Oued Mzab and Oued Miah, as well as wells, which serve as sources for extracting groundwater.

**c– The defensive factor**

The planning of desert cities and ksour in general is linked to security considerations, including the construction of walls and gates.

**d– The religious factor**

The mosque and the zawiyas are sacred elements that occupy the central position within the ksar (Jelloul & Abdelrazak, p. 509).

**e– The ecological role of the ksar:** From a bioclimatic perspective, environmental architecture within the ksar provides thermal and psychological comfort and allows life to be lived in a traditional manner without reliance on other technological means. (Jelloul & Abdelrazak, p. 509)

### **3. The Most Important Ksour of the M'zab Valle**

#### **3.1. Malika Ksar (Malika)**

It is located 4 km from Ghardaia Ksar on the left bank of the valley and is inhabited by approximately 2,400 residents. This ksar was established in 1053 AD. Adjacent to it lies the cemetery of Sidi Issa Abu Mahdi. Malika Ksar shares the same urban characteristics found in Ghardaia Ksar, including the market, the mosque, the houses, and the cemetery.

#### **3.2. Ben Isguen Ksar (Ben Isguen)**

It is situated southeast of Malika Ksar on the right side of Oued Netissa and is inhabited by about 6,500 residents. This ksar was established in 1367 AD. It is also surrounded by a wall, within which lies the town of Ben Isguen, and along this wall stand several watchtowers. These towers serve to monitor external dangers and to observe floodwaters and prepare for them. The ksar is also distinguished by the presence of water reservoirs along its edges.

#### **3.3. Bounoura Ksar (Bounoura)**

Bounoura Ksar is located south of Ghardaia Ksar on a rocky plateau. It is considered the least populated of the ksour, with about 1,400 inhabitants, and is regarded as one of the more recent ksour. It contains two gates: a northern gate and an eastern gate (Boulahdid, 2008, pp. 8-10).

This ksar dates back to the 11th century AD, and at its center stands the mosque, which still exists today. The ksar is surrounded by a defensive wall reinforced with six defensive towers, some of which have collapsed, leaving only three remaining: the Qibli Tower (southern), the Eastern Tower, and the Khoukha Tower. The average height of the wall is approximately three meters, with a thickness ranging from 70 to 150 cm (Nouibat, 2014).

### **3.4. El Ateuf Ksar (El Ateuf)**

It is considered the last ksar of the M'zab Valley and is located 4 km east of Bounoura Ksar. It is inhabited by about 2,800 residents and is one of the oldest ksour, having been established in 1013 AD. It represents the first area where newcomers from Ouargla and Oued Souf settled. However, the ksar suffers from pollution, as the wastewater drainage channels of Ghardaia city and the various ksour empty into it due to topographical conditions.

### **3.5. Ghardaia Ksar**

Ghardaia Ksar was founded in 1048 AD. It consists of approximately 2,180 houses and is surrounded by a wall containing several gates, including Bab Salmou Issa, Bab Hawasha, Bab al-Ra'i, Bab Sghir, Bab al-Haddad, and Bab al-Souq (M'zab, 2024).

Ghardaia Ksar reflects the social values and cultural characteristics introduced by Islam. The ksar forms a cohesive and unified entity. At its core lies the mosque, which represents its beating heart and plays a central role in unifying the components of the ksar, as well as in directing, shaping, and organizing movement within it. In addition to this center, there are the quarters, which constitute the parts from which the center draws its vitality, the necessity of its existence, and its essential meaning. Ghardaia Ksar is also distinguished by its paths and alleyways, which function as arteries through which movement occurs and which connect the various parts of the ksar to one another (Mariem, 2011, p. 323).



**Figure 1.** Plan of Ghardaia Ksar

Source: photographed by the researcher.

## **4. Components of the Ksar**

### **4.1. The Ibadī Mosque**

The Ibadī mosque is a distinctive religious structure characterized by two pyramidal minarets. The first minaret is tall, with a height of approximately 22 meters, and is crowned by four crenellations. Inside it are 114 steps, symbolizing the number of surahs in the Qur'an. Adjacent to this minaret stands a smaller one. The mosque is distinguished by its narrow windows, which prevent direct penetration of sunlight.

The Ibadī mosque includes a prayer hall and another hall designated for ablution. Regarding construction materials, they are local and bear a brown coloration. Ghardaia Ksar also contains within it a Maliki mosque, a synagogue, and a church. Thus, the urban landscape of Ghardaia Ksar makes it possible to distinguish between the residential quarters of the Ibadīs, the Malikīs, the Christians, and the Jews.

### **4.2. The Ibadī House**

The Ibadī dwelling is considered an architectural heritage in its own right and serves as strong evidence that the Ibadī community possesses a distinct architectural identity. Ibadī houses share the same general form: each consists of two floors—one lower and one upper—and is characterized by narrow windows to maintain a moderate indoor temperature. The houses also have approximately the same height, ranging between 6 and 7.5 meters, and a neighbor is not

permitted to build higher than the adjacent dwelling.

If an owner wishes to increase the height of his house, he must leave an additional distance between his house and his neighbor's so that sunlight can still reach the neighboring dwelling. The floor area of the houses is also similar, generally not exceeding 120 m<sup>2</sup>. The houses are coated in a brown color leaning toward yellow, which creates visual harmony between the buildings and the characteristics of the local environment.

Ibadi houses are distinguished by a particular internal organization. They consist of two floors: the ground floor includes an inner courtyard surrounded by rooms and is most widely used in summer, whereas the upper floor is primarily used in winter (Bellal & Tacherifte, 2003).

The inward-oriented construction style (the use of the internal courtyard) is one of the architectural elements that has successfully addressed climatic environmental challenges, as well as environmental considerations more broadly. Designing the dwelling around an inner courtyard is regarded as one of the most effective methods for confronting climatic difficulties, especially in desert regions, because the courtyard functions as a regulator of indoor temperatures both day and night. The courtyard also facilitates ventilation and protects dwellings from hot winds by orienting or shaping its walls in a manner that ensures this. In addition, the internal courtyard allows for the planting of vegetation, which plays an important role in purifying and cleaning the air by reducing dust, smoke, and suspended particles in the atmosphere (Fathy, 1985).

A study indicated that the use of inward-oriented construction featuring internal courtyards allows for effective internal air circulation, whereas outward-oriented buildings exhibit higher temperatures by an average exceeding 50%. Since air movement decreases significantly at night compared to daytime, cold air settles in the courtyard during the night and gradually seeps into the rooms, and this cooling effect continues until late in the day. Thus, the courtyard functions as a temperature regulator. At the same time, the hot air passing above the house during the day does not enter the courtyard.

At night, the temperature within the courtyard rises while the temperature of the outside air decreases, causing the warm air inside the courtyard to ascend and be replaced by cooler air from above. This cool air accumulates in layers within the courtyard and then enters the surrounding rooms, cooling them.

The compact form of the buildings was also adopted, where houses were constructed closely adjacent to one another to reduce the exposure of their façades to sunlight and winds that increase

indoor temperature. This system in Islamic architecture was known as the “one cohesive fabric” system. The considerable height of the exterior walls of the houses provides shade to large sections of the roofs. To mitigate the impact of the hot climate, the mass of the buildings in the horizontal plan was made larger than the area of exposed open spaces, whether streets or internal courtyards, ensuring the greatest possible amount of shade (Hakim, 2013).

As for the building material, it consists mainly of toub. The word toub is an Arabic term meaning unfired or raw bricks, used to distinguish it from modern types such as cement bricks. It is referred to as toub in French, adobe in English, and ottob in Spanish. The meaning of this term varies among Arab countries. Yaqut al-Hamawi mentioned that ajurr is known among Egyptians as toub and among the people of al-Sham as qarmid. A third term used in Iraq is tabouq.

The process of making toub varies from one region to another depending on the quality of the raw materials, the additives used, and the method of molding—whether molds are used or not, the shape of the molds, and other related factors. The raw material used in making toub is a mixture of clay, sand, and various additives that improve the structural properties of the brick. These additives act as stabilizers. Its production requires several stages, including the procurement of raw materials, preparation of the mixture, shaping, and drying (Kada, pp. 63-64). Toub is an excellent insulating material for heat, which contributes to cooling the interior of the ksar. Local stones are also sometimes used in construction (Rezig, 2021, p. 164).

### **3.4. Cemeteries**

Cemeteries are among the structural elements of the urban landscape in Ghardaia Ksar. They are located at the edge of the ksar, and each ksar in Ghardaia has its own cemetery. The cemetery in Ghardaia Ksar is characterized by several elements: it contains a designated prayer space and an area for preaching, in addition to the widespread presence of pottery vessels placed on graves. Each cemetery surrounding the ksar is named after the clan to which it belongs, such as Sidi Ibrahim Cemetery, Aami Saïd Cemetery, and others.

### **4.4. Roads**

The most distinctive feature of the roads in Ghardaia Ksar is that they follow circular paths whose diameter increases as one moves away from the center of the ksar. The circular configuration of the roads prevents the infiltration of hot air masses into the ksar. In some areas, these roads are covered, facilitating movement during periods of intense heat with relative ease. Roads within the ksar are also characterized by their narrowness, allowing only for the passage of a donkey load;

various modern means of transport cannot navigate the interior. These circular roads are connected to one another by radial roads to ensure continuous and uninterrupted connectivity.

These roads are further distinguished by their narrow width and winding paths, which reduce the exposure of façades to direct sunlight. They create continuous shaded zones and accelerate localized air currents that enhance natural ventilation. The relative height of the buildings contributes additional shading between floors (Bianca, 2000).



**Figure 2.** Circular roads in Ghardaia Ksar

Source: photographed by the researcher.

#### **4.5 The Wall**

Each ksar is surrounded by a wall supported by towers, with entrances that close using large wooden gates. The wall surrounding Ghardaia Ksar contains numerous gates, such as Bab Salmou Issa, Bab Hawasha, Bab al-Ra'i, Bab Sghir, Bab al-Haddad, and Bab al-Souq (Hakim, 2013).

#### **4.6 Neighborhoods**

Neighborhoods are distributed according to tribal affiliation and are sometimes enclosed by walls with gates that are closed in the event of conflicts between tribes. Each neighborhood contains a designated prayer space. Ghardaia Ksar also includes a market for commercial exchange.

#### **4.7 The Market**

The market is considered one of the most important structuring elements of Ghardaia Ksar. It is located in the center of the ksar. In addition to its commercial role, the market functions as a

gathering place for individuals and as a site for resolving complex issues. In the market of Ghardaia Ksar, there is an area containing a group of stones numbering 22, representing the number of clan leaders. The elders meet in a council known as the “Aami Saïd Council” to resolve disputes among individuals.



**Figure 3.** The traditional market in Ghardaia

**Source:** Author 2026

## **5. The Ghardaia Oasis**

The ksar is closely linked to the agricultural domain because it represents the agricultural hinterland of the settlement (Côte, 1988). The Ghardaia Oasis is located 1,500 meters northeast of Ghardaia Ksar and contains approximately 60,000 palm trees. These palms are irrigated through groundwater fed by the floodwaters of Oued Mzab and Oued Touzouz. Numerous dwellings are scattered throughout the oasis, as most inhabitants of Ghardaia Ksar have two residences: one in the city and another in the oasis.

Discussing the Ghardaia Oasis leads to an examination of the water distribution system. It is important to note that the region relies on two primary water sources: the first consists of wells, and the second consists of the floodwaters of the valley. Regarding the Ghardaia Oasis specifically, it is irrigated primarily by floodwater brought by Oued Mzab through what is known as “Saqqiyat Bouchen.” This is a dam that retains the floodwater carried by Oued Mzab. The barrier contains openings, each leading to either the eastern or western section of the oasis. Each group of gardens has its own canal that supplies it, and the size of each opening varies according to the gardens it serves; water flows through these openings toward the orchards.

Between the orchards lies a corridor with openings that allow water to reach the palm trees. The size of each opening corresponds to the size of the grove: the larger the grove, the larger the opening. When the palm trees become saturated with water, the opening is closed so that the next grove may receive the required amount of irrigation. When there is an excess of water, the canal is closed and the water is diverted to a small dam near the main barrier to prevent flooding, similar to the situation that occurred in 1994 when Ghardaia experienced a destructive flood (Remini, 2018).



**Figure 4.** Bouchen Saqqiya Barrier

Source: photographed by the researcher.

## 6. The Tafilalt Ksar

To preserve the traditional urban pattern of the M'zab Valley, the ksar model was adopted in planning the new urban centers, such as the Tafilalt Ksar. It is considered a global example of sustainable planning. This ksar distinguishes itself from other new residential settlements in the province of Ghardaia and from other regions of the country due to its unique characteristics, which adhere to environmental and social standards as well as traditional architectural and urban criteria, enriched with a refined civilizational touch in line with the dimensions of sustainable development.

This has drawn the attention of experts and international bodies, resulting in visits from academic delegations from various universities, institutes, and urban planning research centers, in addition to tourist delegations from inside and outside the country. The project has received several international awards in the fields of urbanism and environmental preservation. Its construction relied on:

### 6.1 Planning and implementation according to sustainable development dimensions

Tafilalt Ksar was equipped with social and educational facilities integrated into the overall framework of the ksar. These include a school for Qur'anic education, a primary school, a middle school, a multi-service clinic, a hall for various sports, a football field, a green library, a museum of desert archaeological and traditional landmarks, a goat-breeding enclosure, a small zoo, and commercial shops. Most of these facilities are located along a single main street and share the same architectural pattern of the ksar to avoid distorting its general appearance.

The ksar does not encounter transportation issues since the farthest two points within it do not exceed 15 minutes on foot. The ksar is surrounded by green belts and play spaces that offer residents an atmosphere of joy. It was planned with green spaces in mind: for every 1,050 houses, 10 palm trees are planted along with an equal number of fruit trees suitable for the region, such as fig and pomegranate, in addition to some flowering plants such as jasmine.

The location of this residential landmark at the top of a plateau allows fresh air to flow smoothly through its alleys, enhancing the tranquility that characterizes its atmosphere.

Among the innovative initiatives in building this ksar was the construction of traditional external structures of wells so that the younger generation could appreciate the considerable efforts their ancestors exerted in digging wells in rocky terrain to obtain drinking water.

## **6.2 The social dimension**

Equality among community members was achieved since all houses share the same architectural pattern, and construction costs were made accessible to the poor and middle class, thus eliminating class divisions and social disparities. The urban pattern of Tafilalt Ksar contributed to the reproduction of traditional local social relationships among its residents.

In this social aspect as well, one can observe the strength of the social structure within Tafilalt Ksar through various social practices such as visits, volunteer campaigns, and other behaviors that reflect the strong social bonds that this urban pattern succeeded in recreating and reinforcing.

The housing system in Tafilalt also enabled families to express their individuality, character, and culture since this housing reflects their values, customs, and beliefs. The direct participation of beneficiaries in the construction of their homes allowed them to incorporate their personal features and characteristics within their dwellings, enabling them to feel comfortable and secure.

## **6.3 The economic dimension**

Construction costs were reduced to their lowest possible level by using local building materials and relying on cooperation and participation among all parties involved in building the ksar in order to minimize expenses and costs.

#### **6.4 The environmental dimension**

This dimension was achieved through the use of locally produced building materials such as stone, gravel, and lime—materials that are environmentally friendly—and through the recovery of household waste for recycling via selective sorting that allows the optimal reuse of various materials, especially plastics and metals. Goat waste is also collected weekly for use by agricultural fertilizer manufacturing units. Residents received specialized training to master this process. As a result, the ksar has become one of the cleanest residential communities in Algeria. Its builders also created a biological wastewater treatment system using aquatic plants, along with a solar-powered public lighting system that operates automatically, qualifying the ksar to be classified among the so-called smart cities (Battesti, 2005).



**Figure 5.** Tafilalt Ksar

Source: Author 2026

#### **Conclusion**

The ksour of Ghardaia are not merely ancient architectural landmarks; they are living testimony to the ingenuity of the Mozabite people in adapting to their harsh desert environment and creating an integrated urban system that combines simplicity, functionality, and beauty. The

nature and cohesion of Mozabite society are reflected in its compact and unified architectural pattern (“one cohesive fabric”), which enabled the community to face various challenges, foremost among them the severe climatic characteristics of the desert environment. These ksour also highlight the importance of water as a geographical element, for without it, these social, urban, and economic structures would not have emerged.

Through these ksour, the local community succeeded in establishing a unique model of the sustainable Islamic city, where the physical structure integrates with religious and social values to form a coherent civilizational fabric that extends across centuries. It becomes clear that the distinctive urban character of these ksour was not accidental but the result of meticulous planning that responds to the requirements of security, privacy, environmental adaptation, and social organization.

Based on this, the need arises to preserve this tangible and intangible heritage through effective policies for restoring the ksour and safeguarding their authentic character, while strengthening local awareness of their historical and cultural significance. The sustainability of the Ghardaia ksour is not solely a local responsibility; it is a collective global duty aimed at protecting a shared human memory that reflects humanity’s capacity for creativity in confronting the challenges of nature and time.

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