



Architecture in Desert Oases

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Abstract

Desert oases are geographical phenomena in the desert that, unlike the desert, have water. Water generates the life of plants and animals, and most often also the life of people. Some oases have been continuously inhabited for thousands of years, and some are uninhabited and have been arranged as natural protected areas. Most oases are located in the Sahara desert where there were rest stops for caravans. Some oases are densely built, where the ruins of thousands of years old architecture, vernacular architecture, and contemporary architecture are present in a wide variety of programs that meet the needs of visitors. The author of this work visited a desert oasis in Saudi Arabia during his participation in The First International Conference on Urban and Architectural Heritage in Islamic Countries (FCUAHIC), Riyadh, Saudi Arabia, 23-28 May 2010, where he presented his work entitled „Vernacular Architecture in Bosnia and Herzegovina“.

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1. Introduction

The Author of this paper visited a desert oasis in Saudi Arabia while participating in The First International Conference on Urban and Architectural Heritage in Islamic Countries (FCUAHIC), Riyadh, Saudi Arabia, 23-28 May 2010, where he presented his work entitled „Vernacular Architecture in Bosnia and Herzegovina“^[1,2] (Fig 1). On that occasion, he had the honor of being a guest at a dinner hosted by His Excellency Prince Sultan bin Salman Al Saud, then President of the Saudi Commission for Tourism and National Heritage (SCTH). Prince Sultan bin Salman Al Saud is the first Arab and the first Muslim to fly into Space, on the American space shuttle mission STS-51-G, from 17 June to 24 June 1985^[3]. The aim of the study trips was to get to know cities on the spot and through their analysis (through 'cabinet work') to contribute to the Author's theory of „Architecturally defined space“^[1,2,3,4,5, 6,7,8,9,10,11, 12,13,14,15,16]. With the same goal, the author visited many cities: in the Balkans^[17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39], in Europe^[40,41,42,43,44,45,46], in the Mediterranean^[47,48,49,50,51,52,53] and in Asia^[54,55,56,57,58,59,60,61,62,63,64,65,66,67,68]. When he was in his second year of studies (1978), the Author came across a book by Kevin Andrew Lynch (1918-1984) entitled “The Image of the City” (1960) and was delighted with its contents. At that time, he also wrote a student paper entitled “Image of the Sarajevo City” which delighted his professor Aleksander Trumic. Since the Author traveled a lot, he always tried to “capture” an image of a city and memorize it.

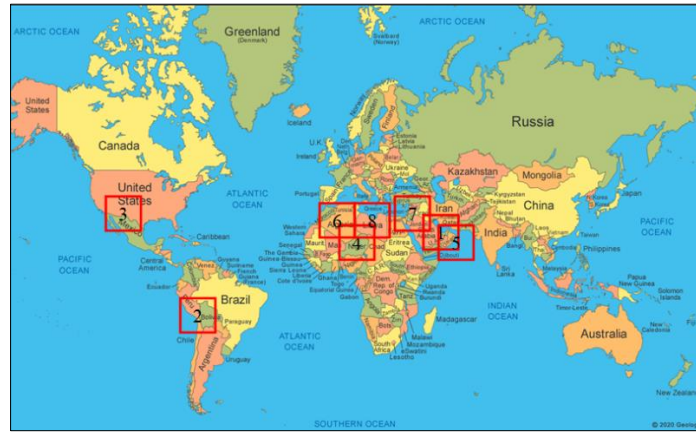


Source: Prof. dr Amir Pasic (May 25, 2010)

Fig 1: The Author at the scientific conference The First International Conference on Urban and Architectural Heritage in Islamic Countries (FCUAHIC), Riyadh, Saudi Arabia, May 23-28, 2010 (together with Prof. Dr. Nader Ardalan, Harvard University)

A desert oasis is a fertile, green area located in an arid desert or semi-desert, formed where groundwater reaches the surface or where groundwater is available, sustaining plant life and providing habitat^[69]. These vital sites are often fed by natural springs or deep wells, acting as key resting places for travelers and supporting localized human, plant and animal populations. They are fed by underground aquifers that rise to the surface, forming natural lakes or springs. They support vegetation, most often date palms, which provide both food and shade. Historically, oases acted as key stops for caravans (e.g. along the Silk Road). Many oases are inhabited, they contain villages and agricultural communities. In an oasis, surface water may be present or water available only from wells or underground canals created by humans. Although they depend on natural conditions, such as the presence of water that can be stored in reservoirs and used for irrigation, most oases as we know them are man-made. The word 'oasis' came into English from the Latin: oasis, from the ancient Greek: ὄασις, óasis, which in turn is a direct loanword from Demotic Egyptian. The word for oasis in the later attested Coptic language (the successor to Demotic Egyptian) is 'wahe' or 'ouahe' meaning 'place of residence'^[70]. Oasis in Arabic is 'wāḥa' (Arabic: واحة). Oases develop in hydrologically favorable locations that have attributes such as high groundwater levels, seasonal lakes or blocked wadis^[71]. Oases are formed when fresh water sources, underground rivers or aquifers, irrigate the surface either naturally or through artificial wells. The presence of water on the surface or underground is necessary, and local or regional management of this essential resource is strategic, but it is not sufficient to create such areas: continuous human work and knowledge (technical and social culture) are essential to maintain such ecosystems. Some of the possible human contributions to oasis maintenance include digging and maintaining wells, digging and maintaining canals, and the continuous removal of opportunistic plants that threaten to overwhelm the water and fertility needed to maintain food supplies for humans and animals. Oases in the Middle East and North Africa cover about 10,000 km², but they provide livelihoods for about 10 million people^[72]. The sharp ratio of oases to desert land in the world means that the oasis ecosystem is "relatively small, rare and precious"^[73]. Part of

their fertility may come from irrigation systems called 'foggare', 'khattare', 'lkhtarts' or various other regional names^[74]. In some oasis systems, there is a "geometric system of raised channels that discharge controlled amounts of water into individual plots, irrigating the soil"^[74]. Oases often trace human history back thousands of years. Archaeological excavations at Ein Gedi in the Dead Sea Valley have found evidence of settlement dating back to 6000 BC. Al-Ahsa in the Arabian Peninsula shows evidence of human occupation dating back to the Neolithic period. The location of oases was crucial to trade and transport routes in desert areas; caravans had to travel through oases to replenish their water and food supplies. Political or military control of an oasis therefore often meant control of trade on a particular route. The oases of Awjila, Ghadames, and Kufra, located in present-day Libya, were at various times key to north-south and east-west trade in the Sahara Desert. The location of oases also influenced the Darb El Arba'in trade route from Sudan to Egypt, as well as the caravan route from the Niger River to Tangier in Morocco. The Silk Road followed its course from watering hole to watering hole, relying on oasis communities such as Turpan in China and Samarkand in Uzbekistan. According to the United Nations, "Oases are at the heart of the overall development of the sub-Saharan countries due to their geographical location and the fact that they are preferred migration routes in times of famine or insecurity in the region"^[75]. The oases in Oman, on the Arabian Peninsula near the Persian Gulf, differ somewhat from the Saharan form. Although still located in an arid or semi-arid region with date palm cover, these oases are usually located below the plateau and are irrigated either by springs or aflays, tunnel systems dug into the ground or carved into the rock to tap underground aquifers. Desert oases are found all over the world. The most famous are: Oasis Al-Ahsa, also known as Oasis Al-Hasa, in Saudi Arabia (the largest oasis in the world), Huacachina in Peru, Oasis Quitobaquito in Arizona, Oasis Kitowok in Mexico, Oasis Bilma in Niger, Oasis Al Ain in the United Arab Emirates, Oasis Taghit in Algeria, Oasis Ein Gedi in Israel, Oasis Rubaksa in Ethiopia, Oasis Ubari in Libya, Oasis in Angola. There are 90 'large oases' within the Sahara (Fig 2).



Source: Author (May 6, 2026.)

Fig 2: Desert oases in the world (which are presented in this paper). 1. Al-Ahsa Oasis in Saudi Arabia (the largest oasis in the world), 2. Huacachina Oasis in Peru, 3. Quitobaquito Oasis in Arizona, 4. Oasis of Bilma in Niger, 5. Al Ain Oasis in the United Arab Emirates, 6. Taghit Oasis in Algeria, 7. Ein Gedi Oasis in Israel, 8. Ubari Oasis in Libya

2. Al-Ahsa Oasis in Saudi Arabia

Al-Ahsa Oasis is located in the Eastern Province of Saudi Arabia (Geographic coordinates: 25°24'11.33"N, 49°38'00.59"E, Elevation: 143 m). The oasis borders Abqaiq Province to the north, the Gulf of Mexico to the east, the Ad-Dahna Desert to the west, and the Ar-Rub' Al-Khali Desert to the south. It is the largest oasis in the world, with an area of 85.4 km² and over 2.5 million date trees (Fig 3). Since 2018, it has been on the UNESCO World Heritage List. This cultural landscape consists of gardens, canals, springs, wells, an agricultural drainage lake, as well as historical buildings. The landscape of Al-Ahsa in the past and now represents different stages of the evolution of the oasis and the interaction of natural and cultural heritage [76]. The continuity of the oasis' agricultural tradition is represented by an organically developed cultural landscape with an agricultural organization based on the distribution of spring water through a network of open-air canals. The cultural landscape of Al-Ahsa Oasis materializes the vitality and modernity of this specific land-use tradition and demonstrates its continued

relevance at the local and regional levels [76]. This vast cultural landscape consists of different zones covering oasis gardens, mountains, caves, villages, mosques and springs, but also archaeological sites and a small part of the historic center of Al-Hofuf with major monuments that embody the political control of the area and its commercial role during past centuries. The remains of villages, fortresses, mosques, markets and houses, although often in a state of ruin, preserve a complete catalog of architectural elements that make up the urban settlement of Al-Ahsa from the early Islamic period to the Kingdom of Saudi Arabia [76]. The oasis is an outstanding example of a traditional human settlement developed in a desert environment, illustrating the close relationship between the landscape, natural resources, and human efforts to colonize the land. The abundant groundwater near the surface allowed the growth of a large oasis settlement. Water came from surface springs and was pumped from wells that tapped into shallow groundwater. Some of these springs and wells are still visible at the site, a living reminder of traditional agricultural techniques [76].



Source: <https://www.gentletraveller.com/app/uploads/2025/11/S31.jpg>, Accessed: May 6, 2026.

Fig 3: Al-Ahsa Oasis in Saudi Arabia

2.1. Natural resources and sights

The Al-Ahsa Oasis Natural and Cultural Landscape is a property consisting of 12 distinct components, including: irrigation systems (ancient, functional canal systems and artesian springs), Lake Al-Asfar, historic villages such as Al-`Oyun that blend into the agricultural landscape. The site is protected by the Saudi Antiquities Law and demonstrates a unique, continuous interaction between people and their desert environment. Al-Ahsa Oasis has over 2.5 million date palms, more than 280 springs and significant archaeological

sites that demonstrate human settlement from the Neolithic period to the present. Al-Qarah Mountain (Jabal al-Qarah) is known for its natural caves and beautiful viewpoints [77]. Al-Shu'ba Mountain is located east of Al-Shu'ba village near Al-Ahsa and north of Al-Eskan, along the road leading from the eastern villages to the northern villages and to Al-Dammam. It also extends from north to south for a length of 20 km on the eastern edge of the northern oasis, and its width is 4 km (Fig 4).



Source: <https://english.ajel.sa/features/al-ahsa-beauty-of-fascinating-nature-scent-of-ancient-history>, Accessed: May 7, 2026.

Fig 4: Al-Shu'ba Mountain

Al Qarah Mountain, rising from the Al Ahsa landscape, is one of Saudi Arabia's most unique geological and cultural landmarks (Fig 5). Formed over millennia by natural forces, including water erosion, abrasion, and seismic activity, the mountain is best known for its extraordinary network of caves and passages. Stretching over 1.5 kilometers, the mountain has 28 narrow, high caves, each with its own story. Among the most famous are Al Nashab, known for its naturally

regulated temperatures year-round, as well as the caves of Bu Saleh, Al Eid, An Naqa, Al Mua'adhamah, and Al Maheub. These dramatic formations offer a striking contrast to the surrounding desert and provide a pleasant retreat even in summer. Some of the caves house pottery workshops, where visitors can witness the maintenance of traditional crafts by local artisans [76].



Source: <https://whc.unesco.org/en/list/1563/>, Accessed: May 7, 2026.

Source: https://www.istockphoto.com/search/2/image/film?phrase=hofuf&tracked_gsrp_landing=https%3A%2F%2Fwww.istockphoto.com%2Fphotos%2Fhofuf, Accessed: May 7, 2026.

Fig 5: Caves in Mount Al-Qarah (Jabal al-Qarah)

Al-Ahsa Oasis is the largest self-contained oasis in the world, home to more than 2.5 million date trees. Declared a UNESCO World Heritage Site in 2018, this 85.4 km² verdant

landscape is sustained by hundreds of natural underground springs, allowing for year-round agriculture ^[76] (Fig 6).



Source: <https://whc.unesco.org/en/list/1563/>, Accessed: May 7, 2026.

Source: <https://english.ajel.sa/features/al-ahsa-beauty-of-fascinating-nature-scent-of-ancient-history>, Accessed: May 7, 2026.

Fig 6: Dates in Al-Ahsa Oasis

Al-Ahsa has millions of palm trees irrigated by more than sixty artesian springs that provide hot and cold water. The excess water is diverted to Lake Al-Asfar (Yellow Lake) and Lake Al-Uyoun. Lake Al-Asfar is considered the largest body

of water in the region with integrated wildlife. It has a dark color in summer due to increased agricultural drainage, and a lighter dark color in winter due to rainwater ^[76] (Fig 7).



Source: <https://english.ajel.sa/features/al-ahsa-beauty-of-fascinating-nature-scent-of-ancient-history>, Accessed: May 7, 2026.

Source: <https://blog.wasalt.sa/en/al-ahsa-oasis/>, Accessed: May 7, 2026.

Fig 7: Springs and fresh water sources

2.2. Architectural cultural and historical heritage

Al-Ahsa Oasis is protected by the Saudi Law on Antiquities, Museums and Urban Heritage, Royal Decree No. 9/M (dated 01.09.1436 AH, corresponding to 01.11.2014). The Law on Antiquities introduces and details the concept of urban heritage protection, paving the way for the effective protection of historical monuments and neighborhoods within the Oasis. Article 46 of the law defines a coordination mechanism between relevant government bodies regarding the protection and development of urban heritage areas ^[76].

Archaeological sites and protected historical buildings are also protected by the Law of 1 September 1436 AH and are managed by the Saudi Heritage Commission. Urban planning regulations at the local level are defined by the Al-Ahsa Master Plan 2030 and the Report on the Indicative Plan for the Al-Ahsa Metropolitan Area (2014), which synchronize studies, approval plans and regulations issued by the Ministry of Municipalities and Rural Affairs. The plan protects agricultural land located within the urban context. The Ministry of Environment, Water and Agriculture (MEWA)

and its subsidiary Al-Hassa Irrigation and Drainage Company (HIDC) regulate water management for landscape and agricultural land. They operate under the “Regulation on the Protection of Water Sources”, issued by Royal Decree No. M/34 of 1400 AH/1979 [76]. The management plan foresees an important role for civil society and the local community in supporting the sustainable development and conservation of the property. Oasis management should include a specific component of studying, understanding, monitoring and preserving the biodiversity of the oasis as an integral part of

protecting its heritage and sustainability. The monitoring regime, once established, could be improved with more precise periodicity [76]. The Jawatha archaeological site is located near the mosque, showing traces of an early settlement. The Ain Qannas archaeological site contains archaeological evidence dating back to the Neolithic period. Ain Qannas or Ein Ganas is an archaeological site located near the village of Al-Murah in Al-Hasa. It dates back to the late 6th and early 5th millennium BC. The site is related to the Ubaid period, which is the Arabian Neolithic (Fig 8).



Source: [https://en.wikipedia.org/wiki/Ain_Qannas#/media/File:Neolithic_site_of_Ayn_Qannas,_al-Ahsa,_ca._7000_BCE_and_after_\(4\)_50620594986.jpg](https://en.wikipedia.org/wiki/Ain_Qannas#/media/File:Neolithic_site_of_Ayn_Qannas,_al-Ahsa,_ca._7000_BCE_and_after_(4)_50620594986.jpg), Accessed: May 7, 2026.

Fig 8: Ain Qannas archaeological site

The Al-Ahsa Oasis region includes four main settlements: Al Hofuf, Al Oyun, Al Mubarraz and Al Umran, along with numerous smaller villages. Al Ahsa vernacular architecture involved the use of earth, as well as palm trunks and fronds. Other materials included solid stone, which was used in the construction of pillars. Large blocks were used to provide greater height in the spaces within the buildings. In addition to palm wood, tamarisk wood was most often used for the construction of ceilings due to its length and ability to expand and contract in response to temperature changes, making it resistant to cracking. Al Ahsa vernacular architecture also includes various types of arches. Many houses consisted of

one story with a space at the entrance, half of which was covered and the other half left open. The floor of this space was covered with palm fronds and used as a summer seating area [77].

Al-Uqair Port is the first seaport in Saudi Arabia and the oldest in the Arabian Gulf. It is 1,500 years old, but it did not receive its last ship until more than half a century ago. It has witnessed the successive civilizations of Al-Ahsa. It was the center used by King Abdul-Aziz ibn Saud (1876-1953) to meet British delegates and negotiate with the British government (Fig 9).



Source: <https://english.ajel.sa/features/al-ahsa-beauty-of-fascinating-nature-scent-of-ancient-history>, Accessed: May 7, 2026.

Fig 9: Al-Uqair Port

The traditional city was divided into socio-urban clusters called 'fareej' (similar to a neighborhood). A fareej generally includes a group of residential buildings, a mosque, and a school. Typically, each of these clusters would be owned by a single family. In the Al Ahsa urban pattern, buildings are dense and compact to protect themselves from the sun by casting shadows on the streets and buildings. The walkways of the urban fabric are oriented east-west, with buildings directly on their edges. The walkways in this area are narrow,

completely shaded during the day. In addition, a larger open space is created when the walkways intersect, helping the movement of air along the walkways. The street space in front of the property was used as an extension of the residential building and was locally called 'fina' (front patio). Another physical element aimed at extending the property was the sabat (roof structure with the street below), which is a room built as a bridge between two buildings above the street^[77] (Fig 10).

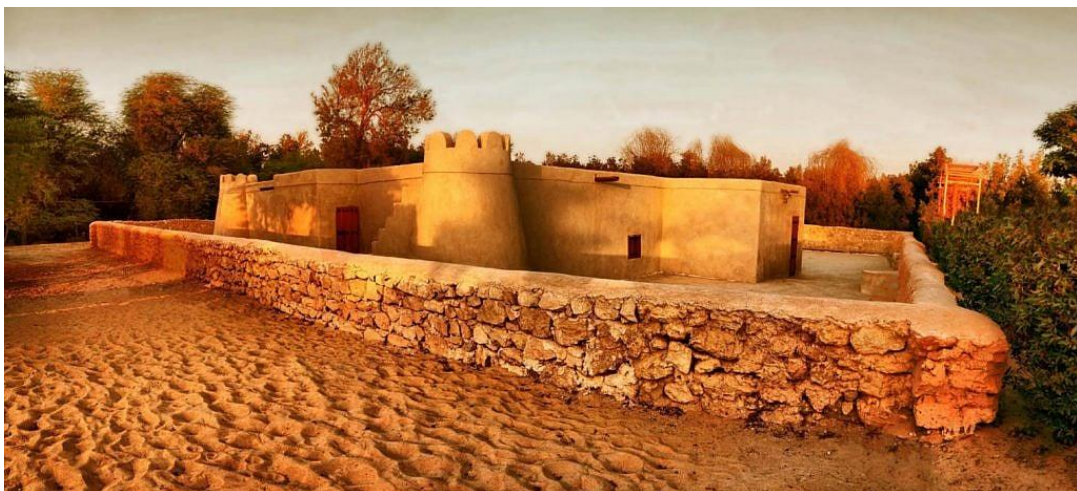


Source: https://www.istockphoto.com/search/2/image-film?phrase=hofuf&tracked_gsrp_landing=https%3A%2F%2Fwww.istockphoto.com%2Fphotos%2Fhofuf, Accessed: May 7, 2026.

Fig 10: The village of Al-Qarah

The buildings, with their lotus-flowered, arched tops, blend well with the natural surroundings. There is no clear architectural vernacular style for the region; the mix of many styles reflects the vibrant synthesis of the many cultures brought to Al Ahsa throughout history due to its regional role in trade. Landmarks such as the Al Qaysariya market stand as a testament not only to the region's historical continuity, but

also to its social and cultural vibrancy. Jawatha Mosque is one of the earliest mosques in Islam, built in 7 AH, 628 AD in Al Ahsa. It is the second mosque in Islam to host Friday prayers, after the Prophet's Mosque. It was restored by the Saudi General Commission for Tourism and National Heritage^[76] (Fig 11).



Source: <https://english.ajel.sa/features/al-ahsa-beauty-of-fascinating-nature-scent-of-ancient-history>, Accessed: May 7, 2026.

Fig 11: Jawatha mosque

Al-Battaliyah-Al-Hassan Mosque was built in the 10th century during the Ottoman period in the Islamic style with seven aisles on each side of a central gate opening onto a large

square courtyard surrounded by a wall. It is considered not only one of the oldest mosques in the Al-Ahsa Oasis, but also one of the most important historical buildings ^[76] (Fig 12).



Source: <https://sandalsand.net/world-heritage-1563-al-ahsa-oasis/>, Accessed: May 7, 2026.

Fig 12: Al-Battaliyah-Al-Hassan mosque

Suq Al-Qaysariyah is a historic market that can still compete with the modern markets in Al-Ahsa. It is considered the oldest market in the Arabian Gulf, dating back six centuries and having a prominent social and economic importance. It is an ancient forum for traditional handicrafts such as textiles,

Saudi robes, swords, daggers, wooden and leather souvenirs, ceramics, handmade clothing made of camel hair or wool, in addition to dates, herbs and folk medicines. The market buildings have an architectural style that combines originality and diversity ^[76] (Fig 13).



Source: <https://english.ajel.sa/features/al-ahsa-beauty-of-fascinating-nature-scent-of-ancient-history>, Accessed: May 7, 2026.

Fig 13: Suq Al-Qaysariyah

Ibrahim Palace is a large Ottoman-era fortress that represents historical military architecture and administration. It was built in 1556 by Ali Ibn Ahmed Ibn Lawand Al-Burayki, the Ottoman governor at the time. A palace of historical importance, it was formerly known as Al Kut. It was the headquarters of the Ottoman army during their rule over Al-Ahsa, and the palace was attributed to the governor Ibrahim

bin Afaisan, Prince of Al-Ahsa during the reign of Imam Saud. Its area is approximately 5,600 m². The palace is located in the center of the old Kut district of Hofuf. It was once part of the northern city wall, which was built by the Ottoman Empire between 956 and 1091 AH (1549-1680). The area around the palace was developed and became the administrative center of the regional government ^[76] (Fig 14).



Source: <https://visaliv.com/bangladesh-to-saudi-arabia/saudi-arabia-tourist-places/ibrahim-palace-al-ahsa>, Accessed: May 7, 2026.

Fig 14: Ibrahim Palace

There are three remaining palaces in Al-Ahsa Oasis; the Sahood Palace, built during Ottoman rule with a cannon in it to protect the city from the Bedouins, the Khuzam Palace, built in 1932 in a typical rectangular shape surrounded by a

deep moat (Fig 15), and the Al-Fakhriya Palace, built at the turn of the twentieth century with an authentic local architectural style ^[76].



Source: <https://www.arabnews.com/node/1926626/%7B%7B>, Accessed: May 7, 2026.

Fig 15: Palace Khuzam

There are three remaining palaces in Al-Ahsa Oasis; the Sahood Palace, built during Ottoman rule with a cannon in it to protect the city from the Bedouins, the Khuzam Palace, built in 1932 in a typical rectangular shape surrounded by a

deep moat (Fig 15), and the Al-Fakhriya Palace, built at the turn of the twentieth century with an authentic local architectural style.



Source: <https://www.arabnews.com/node/1524891/saudi-arabia>, Accessed: May 7, 2026.

Fig 16: Princes' School

3. Huacachina Oasis in Peru

Huacachina Oasis in Peru is a popular natural oasis and small town surrounded by large sand dunes in the Peruvian desert (Geographic coordinates: 14°05'16.26"N, 75°45'51.33"W, Elevation: 400 m). Huacachina is just over 300 km south of Lima and a few minutes from Ica, Peru; attracts visitors for dune buggy rides, sandboarding on the Huacachina sand dunes, boating on the lagoon and sunsets in the golden sand desert. The name comes from the Quechua language: wakachina, literally 'to guard, hide', possibly shortened from wakachina qucha literally 'hidden lagoon' (Fig 17). The origin

stories of this oasis say that a beautiful Inca princess known as Huacca China spent her days in this peaceful place. This woman had the gift of making everyone in her path fall in love with the special sound of her beautiful voice. Once, while the princess was walking, a man watched her and was dazzled by her beauty, so he decided to approach her. The princess ran away from him. Along the way, the lady's dress began to tear through the bushes until it finally fell off and turned into a sheet of sand. The mirror she always carried with her also fell, and when it broke, it turned into a lagoon in which she plunged and became a mermaid [78].



Source: <https://thursd.com/articles/huacachina-peru-natural-desert-oasis>. Accessed: May 7, 2026.

Source: <https://trexperienceperu.com/blog/huacachina-oasis>, Accessed: May 7, 2026.

Fig 17: Huacachina Oasis in Peru

3.1. Natural resources and sights

The Huacachina Oasis is known for its emerald green lagoon, surrounded by palm trees, huarangos (carob trees), and massive sand dunes. The oasis was formed by the natural seepage of underground aquifers. Due to overexploitation of local aquifers and increased tourism, the water level began to drop in the early 2000s, requiring artificial pumping to maintain water levels since 2015. The oasis contains endemic palm, eucalyptus, and huarango trees, which serve as a refuge for local birds. The area is surrounded by some of the largest sand dunes in South America, reaching heights of up to 200 meters. They are used for recreational activities such as dune buggy riding and sandboarding. The oasis supports a variety of migratory birds that stop in the lagoon and feed on the vegetation, as well as several species of reptiles and insects. The Huacachina Lagoon and the surrounding desert are

protected as a regional conservation area. Studies show that water losses through evaporation and infiltration are significant, with infiltration exceeding evaporation by more than 1.7 times. To ensure the sustainability of this natural resource, efforts are underway to restore the lagoon and address water depletion caused by tourism and local economic growth. The Huacachina Oasis, a natural desert oasis near Ica, Peru, supports a specialized, small ecosystem surrounded by massive sand dunes. Although known for its tourist activities, its fauna consists primarily of migratory birds, small lagoon fish, and desert reptiles, with a richer coastal wildlife (penguins, sea lions) found nearby in Paracas. The oasis serves as a refuge for migratory birds and local species, including the coastal miner (*Geositta peruviana*), the Amazonian hummingbird (*Amazilia amazilia*), the Pacific dove (*Zenaidura macroura*), and occasionally a species of heron.

The surrounding sand dunes are home to reptiles adapted to arid climates, such as the coastal leaf gecko (*Phyllodactylus angustidigitatus*) and various lizards (*Microlophus* species). The lagoon itself contains small, specialized species of fish and microalgae. The oasis' vegetation consists of huarango trees (*Prosopis pallida*), palms and eucalyptus, which provide vital shade and nesting sites. Ballestas Islands (approximately

1 hour away): Visitors often combine a trip to Huacachina with a boat trip to these islands to see Humboldt penguins, sea lions, fur seals and birds such as the blue-footed booby. The coastal desert reserve is often visited for sightings of Andean condors and migratory flamingos, especially during their migration periods (Fig 18).



Source: <https://www.auriperu.com/huacachina-peru/>, Accessed: May 7, 2026.

Source: <https://www.instagram.com/p/C5OZw3MOWar/>, Accessed: May 7, 2026.

Source: <https://pixabay.com/photos/bird-huacachina-peru-oasis-4018342/>, Accessed: May 7, 2026.

Source: https://www.reddit.com/r/whatsthisbird/comments/lv7ms6/spotted_in_huacachina_peru_a_small_lake_in_an/ Accessed: May 7, 2026.

Source: <https://www.nomadicmoments.com/guides/exploring-the-huacachina-oasis-a-magical-journey-in-peru/>, Accessed: May 7, 2026.

Fig 18: Flora and fauna in Huacachina Oasis in Chile

3.2. Architectural cultural and historical heritage

Huacachina has a charming, if rustic, mix of 20th-century resort architecture and modern tourist infrastructure set right around a natural lagoon. The village is defined by colonial-style hotels and restaurants, lush palm trees, and colorful, sand-hued buildings designed for visitors, creating a stark contrast to the massive surrounding dunes. Many of the buildings reflect the classic Peruvian style with whitewashed walls, terracotta roofs, and wooden balconies, reminiscent of

the 1960s, when the village was a hotbed for the wealthy. The Huacachina settlement is densely packed, surrounding a small, central emerald-green lagoon that is surrounded by a malecon (boardwalk). The architecture is heavily influenced by the tourist industry, with numerous hotels, hostels, and cafes with swimming pools and outdoor seating. While the atmosphere is charming, some areas look rustic or in need of maintenance, mixed in with more modern accommodations like eco-camping tents ^[79] (Fig 19).



Source: <https://www.istockphoto.com/photo/huacachina-desert-gm1245278055-363072580?searchscope=image%2Cfilm>
Accessed: May 7, 2026.

Fig 19: Huacachina Village

4. Quitobaquito Oasis in Arizona (Quitobaquito Springs)

Quitobaquito Oasis is a spring-fed wetland located in Organ Pipe Cactus National Monument near the Arizona-Mexico border (Geographic coordinates: 31°56'33.70"N, 113°01'14.40"W, Elevation: 326 m). Located about 200 meters north of the Mexican border, it is a key water source in the arid Sonoran Desert. The site was a prehistoric trade route ("Old Salt Road") and a historic residence for local families until it was taken over by the National Park Service

in the 1950s. The area features an artificial pond, streams, and cottonwood trees, providing a stark contrast to the surrounding desert [79]. It can be reached via Puerto Blanco Drive in the national monument, which is often visited on ranger-led tours. It is popular for birdwatching, photography, and exploring the cultural history of the area. The site is strictly managed to protect its fragile ecosystem from drought and, more recently, the potential impacts of border infrastructure development (Fig 20).



Source: <https://www.nps.gov/orpi/learn/historyculture/quitobaquito-springs.htm>, Accessed: May 7, 2026.

Fig 20: Quitobaquito Oasis in Arizona (Quitobaquito Springs)

4.1. Natural resources and sights

This ecological hotspot supports endangered species, including the Quitobaquito pupfish and the Sonoyta mud turtle, and serves as a vital cultural site for the Tohono

O'odham and Hia C-ed O'odham peoples. Quitobaquito Oasis is home to endemic species found nowhere else in the U.S., including the Quitobaquito pupfish, the Sonoyta mud turtle, and the Quitobaquito spring snail [80] (Fig 21).





Source: <https://blog.matthewgove.com/2018/03/08/a-natural-desert-oasis/>, Accessed: May 7, 2026.

Source: <https://blog.desertmuseum.org/2020/12/07/new-challenges-and-new-hope-for-the-sonoyta-mud-turtle/>, Accessed: May 7, 2026.

Source: <https://www.inaturalist.org/taxa/114639-Tryonia-quitobaquita>, Accessed: May 7, 2026.

Fig 21: Flora and fauna of Quitobaquito Oasis in Arizona (Quitobaquito Springs)

4.2. Architectural cultural and historical heritage

Nestled between a sprawling saguaro grove and a busy highway in Mexico, Quitobaquito is a small oasis. Wildlife and indigenous communities have long relied on this rare spring system for fresh water in the middle of the Sonoran Desert. The spring flows into a pond just steps from the U.S.-Mexico border at Organ Pipe Cactus National Monument in southern Arizona. The Hia C-ed O'odham and members of the Tohono O'odham tribe lived and passed through here long before the monument or the border existed^[81]. Quitobaquito Springs in Organ Pipe Cactus National Monument is a historic cultural landscape with an artificial pond, earthen dams, and irrigation canals, in place of traditional buildings. It served as an oasis for 16,000 years, with historic houses (Fig 22), agricultural sites, and a 1960s National Park pond, now marked by the adjacent U.S.-Mexico border wall. In the 1860s, Andrew Dorsey built a dam, and by 1947, more than

4,000 feet of irrigation ditches had been installed to support fig and pomegranate trees. The house, which was home to a Hia C-ed O'odham family, was present until 1961, when the National Park Service (NPS) removed all structures and expanded the pond to promote a "wild" landscape. The current pond is a man-made clay-lined structure that requires regular maintenance and was expanded by the NPS in the 1960s. A parking lot and visitor trails were built in the 1960s. A 30-foot-high U.S.-Mexico border wall was built in 2020 near the southern edge of the site (Fig 23). Jefferson Davis Milton established a post in the area in 1887. Current Status The area is managed as a "cultural landscape" to protect its historic and ecological features, although it is not formally listed on the National Register of Historic Places. The site was restored and the pond was relined in 2022 to protect the endangered Quitobaquito fish.



Source: <https://www.nps.gov/orpi/learn/historyculture/quitobaquito-springs.htm>, Accessed: May 7, 2026.

Fig 22: Native American pithouse at Quitobaquito (circa 1920s)



Source: <https://cronkitenews.azpbs.org/2020/08/10/border-wall-construction-quitobaquito-springs-desert/>, Accessed: May 7, 2026.

Source: <https://www.instagram.com/p/DWml3YWEiZ1/>, Accessed: May 7, 2026.

Fig 23: A section of the border wall was erected a few kilometers east of Quitobaquito Springs on July 18, 2020. Approximately 48 kilometers of the park will eventually be enclosed by the wall

5. Bilma Oasis in Niger

Bilma is a remote oasis town in the northeast of Niger, located in the Agadez region, which serves as an important agricultural and commercial center in the Sahara desert (Geographic coordinates: 18°41'33.28"N, 12°55'06.57"E, Elevation: 354 m). Known for extensive salt and natron production, date cultivation and as a historic destination for the azalea caravan route from Agadez, the city is protected by the Kaouar cliffs. Located below the Kaouar cliffs in the Ténéré desert, it is the largest settlement along the steep Kaouar slope. Historically and currently, Bilma is known for

its salt mines. Salt and natron are produced in evaporation ponds and transported by camel caravans across the Sahara. The oasis enables the cultivation of dates and vegetables. Bilma has a hot desert climate (type BWh according to the Köppen-Geiger climate classification). Temperatures often exceed 40°C between March and October. The maximum temperature of 48.2°C was recorded in 2010. According to the 2012 census, the population was 4,016, many of whom belong to the Bilma Kanuri subgroup. Bilma Oasis serves as a key stop and source of trade on the traditional trans-Saharan trade route (Fig 24).



Source: <https://www.britannica.com/science/oasis-geological-feature>, Accessed: May 7, 2026.

Fig 24: Bilma Oasis in Niger

5.1. Natural resources and sights

Bilma Oasis in Niger is a key, green hub in the central Sahara Desert, known for its extensive date groves, gardens, and surrounding desert vegetation. Date trees (*Phoenix dactylifera*) form the core flora, while local agriculture includes vegetable cultivation, and the surrounding arid landscape contains specialized, drought-tolerant desert plants. Key elements of the flora and agriculture of Bilma Oasis include: Date trees (*Phoenix dactylifera*). They dominate the oasis landscape, providing shade, food, and supporting the local agricultural way of life. The oasis is known for its small-scale cultivation, including vegetables,

which are grown to feed the local population. Recent efforts have included the addition of citrus trees within the oasis, highlighting the intensification of agricultural land use in recent decades. Around the irrigated, green hub of the oasis, the area has a typical, rare Saharan flora adapted to the extremely arid conditions. Efforts to expand green spaces and increase the number of fruit trees have added, for example, 12,000 citrus trees, supporting, to some extent, a thriving, small community despite the hostile environment, and, for example, according to research, 12,000 citrus trees have been added to the agricultural land of the area, for example, in addition to the existing 12,000 citrus trees, to support, albeit

limited, the community within an overall challenging ecological environment (). The fauna of the Bilma Oasis in Niger consists mainly of domestic animals used in the historic salt trade, including camels, goats, and donkeys, along with birds attracted by the water sources and agriculture in the oasis. Camels are vital to the Bilma region, used in massive salt caravans (Azalai) to transport salt from local brine ponds. Other domestic animals supported by the oasis environment include goats and cows. Birds are often heard and seen around the oasis' permanent water sources, which spring from

underground aquifers ^[82]. The vast Sahara surrounding Bilme is home to a highly resilient fauna, such as the critically endangered addax antelope, dama gazelle, and Saharan cheetah. These animals are rare and are found throughout the wider Tenere Desert. Agricultural plots and gardens, which produce dates and vegetables, can support small rodents and insects adapted to the desert environment. The oasis serves as a viable stopover for both wildlife and humans traveling through the otherwise uninhabitable surrounding Erg Bilme ^[83] (Figs 25,26).



Source: https://www.mfaucher.com/files/Niger06/LRTG18/CRW_3735-single.html, Accessed: May 8, 2026.
 Source: <https://www.britannica.com/place/Bilma>, Accessed: May 8, 2026.

Fig 25: Bilma Oasis in Niger





Source: <https://birdwatchinghq.com/birds-of-niger/>, Accessed: May 8, 2026.

Source: <https://study.com/academy/lesson/video/the-niger-river-ecosystems-trade-routes-in-africa-12th-16th-centuries.html>

Accessed: May 8, 2026.

Source: <https://www.worldatlas.com/articles/the-native-birds-of-niger.html>, Accessed: May 8, 2026.

Source: <https://a-z-animals.com/animals/xerus/>, Accessed: May 8, 2026.

Fig 26: Fauna in Bilma Oasis in Niger

5.2. Architectural cultural and historical heritage

Bilma Oasis in Niger features traditional Saharan rectangular mudbrick and stone architecture designed for desert survival, characterized by dense, flat-roofed structures, thick walls for cooling, and narrow, shaded walkways. A key, heavily fortified, and historically significant salt trade oasis along the Kaouar Cliffs, it includes date gardens, date buildings, and large, shallow evaporation ponds for salt and natron production. Mudbrick is predominantly used, often mixed with stone for reinforcement, designed to provide thermal mass against extreme heat. Dense, clustered, rectangular

houses designed to create shade and protection. Historically protected by fortified walls, with similar nearby settlements (such as Fachi) featuring large communal granaries and high defensive walls, sometimes reaching 8 meters in height. Narrow passages are used to navigate the dense settlement, offering relief from the sun. The architecture integrates with the surrounding Kaouar escarpment and massive salt pans/evaporation basins, which are crucial to the local economy and the traditional trans-Saharan camel caravans (Azalai), (Figs 27,28).



Source: <https://en.wikipedia.org/wiki/Bilma#/media/File:Bilma-Saline-85.jpg>, Accessed: May 7, 2026.

Fig 27: The saline pans at Bilma



Source: <https://wikimapia.org/4919818/Bilma#/photo/7422413>, Accessed: May 8, 2026.

Source: <https://kamelitravel.com/en/the-remote-oases-of-niger-and-the-air-mountains/>, Accessed: May 8, 2026.

Fig 28: Architecture in Bilma

6. Al Ain Oasis in the United Arab Emirates

Al Ain Oasis (Arabic: **وَاةَ الْعَيْنِ** = "Oasis of the Springs") is the largest oasis in the city of Al Ain, within the Eastern Region of the Emirate of Abu Dhabi, United Arab Emirates. It is located in the Al-Mutawa'a District of central Al Ain and east of the Al-Jahili District. The border between the city of Al Ain and the Omani city of Al Buraimi is to the northwest (Geographic coordinates: 24°13'00.77"N, 55°46'12.97"E, Elevation: 293 m). Al Ain Oasis is the largest oasis in the city, more than 4,000 years old. The oasis covers more than 1,200 hectares and contains more than 147,000 date trees producing 100 varieties of dates. The oasis is bordered by the Al Ain National Museum and the Sultan Bin Zayed Fort to the east, and the Al Ain Palace Museum to the west. To the south is the Al Ain Sports Club and Jabal Al-Naqfah, the ridge of Jebel Hafeet. To the southwest are the Al Ain Etisalat Building and Oasis Hospital. Al Ain Oasis is also known as Al-Jahily Falaj. It was built by Sheikh Zayed bin Khalifa Al Nahyan, also known as Zayed the Great (1835-1909)^[84]. The

Al Ain Oasis has been a UNESCO World Heritage Site since 2011, but it's only now, with the construction of an educational eco-centre and an extensive system of shaded paths winding through some 147,000 date palms, that it's opened to the public. And that's a far cry from the giant shopping malls, extravagant (see: underwater) hotels and stunning engineering feats for which the country is famous^[85]. The Al Ain Cultural Sites (Hafit, Hili, Bidaa Bint Saud and Oases areas) represent a series of sites that testify to the sedentary human occupation of the desert region since the Neolithic period, with traces of many prehistoric cultures. Notable remains on the site include circular stone tombs (c. 2500 BC), wells and a wide range of adobe structures: residential buildings, towers, palaces and administrative buildings. Hili also stands out as one of the oldest examples of a sophisticated aflaj irrigation system dating back to the Iron Age. The site provides important evidence of the transition of cultures in the region from hunting and gathering to sedentary lifestyles^[85] (Fig 29).



Source: <https://www.lovethatdesign.com/news/aedas-reimagines-al-ain-oasis-hub-an-immersive-landscape/>, Accessed: May 8, 2026.

Fig 29: Al Ain Oasis in the United Arab Emirates

6.1. Natural resources and sights

Al-Ain Oasis is famous for its underground irrigation system (falaj or qanāt), which brings water from wells to irrigated

farms and palm trees. The falaj irrigation system is an ancient system that dates back thousands of years and is widely used in Oman, the UAE, India, Iran, and other countries (Fig 30).





Source: <https://www.lovethatdesign.com/news/aedas-reimagines-al-ain-oasis-hub-an-immersive-landscape/>, Accessed: May 8, 2026.

Source: <https://www.cntraveler.com/story/al-ain-oasis-the-uaes-first-unesco-world-heritage-site-is-now-open>, Accessed: May 8, 2026.

Source: <https://whc.unesco.org/en/list/1343/>, Accessed: May 8, 2026.

Source: <https://monkboughtlunch.com/wp-content/uploads/2011/01/DSC06938-2.jpg>, Accessed: May 8, 2026.

Source: <https://conferences.uaeu.ac.ae/icrega18/en/attractions.shtml>, Accessed: May 8, 2026.

Source: <https://www.timeoutdubai.com/things-to-do/things-to-do-news/70647-al-ain-safari-opens-at-al-ain-zoo-video>
Accessed: May 8, 2026.

Fig 30: Flora and fauna in Al Ain Oasis in the United Arab Emirates

6.2. Architectural cultural and historical heritage

The architecture of Al Ain Oasis is defined by 7,000 years of sustainable, earthen construction - including mudbrick forts, residential towers and the ancient aflaj irrigation system. Declared a UNESCO World Heritage Site, the architecture emphasizes climate-sensitive design with thick walls, internal courtyards and shaded alleys that reflect the traditional Emirati way of life and oasis agriculture. Natural, locally sourced materials dominate, primarily mudbrick (adobe), palm trunks for roofs and palm mats for floors. Traditional buildings, such as the 19th-century houses in Hila Oasis, feature fortified tower houses, inward-facing courtyards and blank external walls that provide privacy and cooling. The high density of low-rise buildings is linked by narrow shaded paths known as 'sikke', which encourage pedestrian movement and natural shading. An extensive

3,000-year-old underground irrigation network, known as the 'aflaj' (or 'falaj'), is central to the landscape architecture, providing sustainable access to water. Iconic structures and examples A prime example of mudbrick, residential and defensive architecture is seen at the Sultan Fort (1910). It features a 35-meter corridor with 19 shops built with traditional, thick mud walls for natural insulation. The Hili Oasis features buildings with square corner towers, demonstrating a mix of residential and defensive needs, according to Abu Dhabi Culture. Ongoing conservation efforts (e.g. the restoration of the Al Ain Museum) are aimed at preserving the authentic mudbrick architecture and correcting early 20th-century errors. Modern planning, such as the "Green Fingers" initiative, aims to connect these historic, green areas across Al Ain city using sustainable design, as outlined in the Al Ain Plan 2030 (Fig 31).



Source: <https://whc.unesco.org/en/list/1343/>, Accessed: May 8, 2026.

Fig 31: Architecture in Al Ain Oasis in the United Arab Emirates

7. Taghit Oasis in Algeria

Taghit, known as the 'Pearl of the Sahara', is a beautiful desert oasis town in western Algeria, located 60 miles south of Béchar near the Grand Erg Occidental (Geographic coordinates: 30°55'27.53"N, 2°01'50.16"W, Elevation: 281 m). Known for its massive, golden sand dunes, 700-year-old mud-brick ksar (old town), and lush palm groves, it offers a dramatic contrast between desert and greenery. The high

dunes are ideal for sunrises/sunsets and photography. Ancient petroglyphs (rock paintings) depicting animals are found near the oasis. A large, green, 20 km long oasis that offers shade and water. The Maousseem Festival in late October celebrates the date harvest with music and culture (Fig 32). Taghit is popular with local and international tourists who come to enjoy the area's historical sites and unwind in its natural surroundings.



Source: <https://www.lookphotos.com/en/images/70375832-Algeria-Sahara-Grand-Erg-Occidental-Taghit>, Accessed: May 8, 2026.

Fig 32: Taghit Oasis in Algeria

7.1. Natural resources and sights

The region relies on a combination of ancestral knowledge and specific natural resources to sustain its palm groves and inhabitants. The oasis is sustained by underground aquifers and the Oued Zousfana, a temporary river that provides the necessary water despite being largely dry on the surface. The area relies on traditional water harvesting techniques, including 'foggars' (underground water channels). Taghit is

known for its dense palm groves that provide shade and support crops such as dates, fruits and vegetables, creating a functional oasis ecosystem. The natural landscape is a major resource, with high, smooth golden sand dunes, the palm oasis and the surrounding arid rocky terrain, which serve as the foundation for local tourism^[86]. The area is rich in ancient petroglyphs (rock carvings) dating back thousands of years and the historic architecture of the mud-brick 'ksar' (fortified

city), which are considered part of its unique, inherent cultural assets. The oasis faces significant threats from overexploitation of groundwater and salinization of water and soil, which affect traditional, mostly small-scale, agricultural plots. The local economy is mainly agricultural, relying on palm plantation agriculture and livestock farming, which is slowly modernizing but often faces sustainability issues. The Taghit Oasis in Algeria is a vibrant Saharan ecosystem home to desert-adapted animals such as gazelles, fennec foxes, desert rodents (jerboas, gerbils) and various snakes. The area, with its dramatic dunes (Grand Erg Occidental) and the Zousfana River, is known for its camel herds, migratory birds and rich rock art depicting ancient fauna such as giraffes and elephants. The surrounding desert is home to gazelles,

fennecs, striped hyenas, desert hedgehogs, and small rodents such as jerboas. Snakes, especially horned snakes or side snakes, are found in the sandy areas. The oasis supports camels, sheep, goats, and donkeys, which are vital to local agricultural livelihoods and tourist camel rides. The region is a resting place for migratory birds, including starlings and storks. Neolithic carvings around Taghit indicate that the area was once home to giraffes, elephants, ostriches, and antelopes. Palm groves provide a refuge for fauna within the harsh Sahara Desert. Natural Park Initiative: There are efforts to conserve local fauna through the development of Taghit National Park. Fauna Distribution: The area is known for its “sand oceans,” which are popular for camel trekking, a key activity for visitors to the region (Fig 33).



Source: <https://www.explo.com/produits/a098-algerie-les-oasis-du-grand-erg-occidental>, Accessed: May 8, 2026.

Source: https://x.com/Discover_DZ/status/1030166647804514304/photo/1, Accessed: May 8, 2026.

Source: <https://www.shutterstock.com/video/clip-3682216071-taghit-bechar-province-algeria---november-14>, Accessed: May 8, 2026.

Source: <https://a-z-animals.com/animals/elephant-shrew/>, Accessed: May 8, 2026.

Source: <https://a-z-animals.com/animals/house-sparrow/>, Accessed: May 8, 2026.

Fig 33: Natural resources and sights in Taghit Oasis in Algeria

7.2. Architectural cultural and historical heritage

A short drive outside the city, petroglyphs of cows and antelope are scattered across a rocky hillside. Visitors can climb directly among the ancient drawings, scrambling up the rocks to get a view of the entire basin. From there, the oasis's diverse terrain is more visible. Low bushes are scattered around the basin, and groves of palm trees are closer to the villages. Winter rains often flood some of the lowland areas, later leaving large deposits of hard, cracked mud when the rainy season subsides and the water evaporates. The ruins of an ancient city from the eleventh century, now partially

restored by the government, lie on the edge of the city. A tall arch leads into a maze of narrow alleys that wind down the hillside. Carved wooden doors adorn mud-brick passages, revealing a small number of shops and guesthouses opened by local entrepreneurs. One vendor sells colorful paintings and a large selection of drums, guitars, and Arabic ouds—all handmade. The town's covered alleys and ventilation shafts once served as a primitive air conditioning system, circulating fresh air during the summer months and also retaining heat during the winter. A traditional mud-roofed village with 120 houses overlooking palm groves^[87] (Fig 34).



Source:

<https://www.facebook.com/photo/?fbid=10210059343413990&set=a.10201850639881532>,
Accessed: May 8, 2026.

Source: <https://www.unusualtraveler.com/taghit-a-sahara-desert-oasis-in-algeria/>, Accessed:
May 8, 2026.

Fig 34: Architectural cultural and historical heritage in Taghit Oasis in Algeria

8. Ein Gedi Oasis in Israel

Ein Gedi Oasis in Israel is a beautiful desert oasis and nature reserve on the western shore of the Dead Sea, with year-round freshwater springs, waterfalls, and lush vegetation (including tropical plants). It serves as a popular hiking destination and a vital, lush contrast to the surrounding barren Judean Desert (Geographic coordinates: 31°27'08.23"N, 35°22'56.53"E,

Elevation: -278 m). Two main streams, which provide hiking trails with waterfalls and pools suitable for swimming. It contains over nine different trails, from easy family walks (such as the lower Wadi David) to more challenging, day-long hikes (such as the Arugot Stream). Ein Gedi Oasis is known for its population of Nubian ibex and hyenas, which are easily spotted along the cliffs. Ein Gedi Oasis is known

as the place where David hid from Saul and is mentioned in the Song of Songs. It contains the ruins of a Chalcolithic

temple from the 4th millennium BC and a Roman-era synagogue with a mosaic floor^[88] (Fig 35).



Source: Google Earth, Accessed: May 8, 2026.

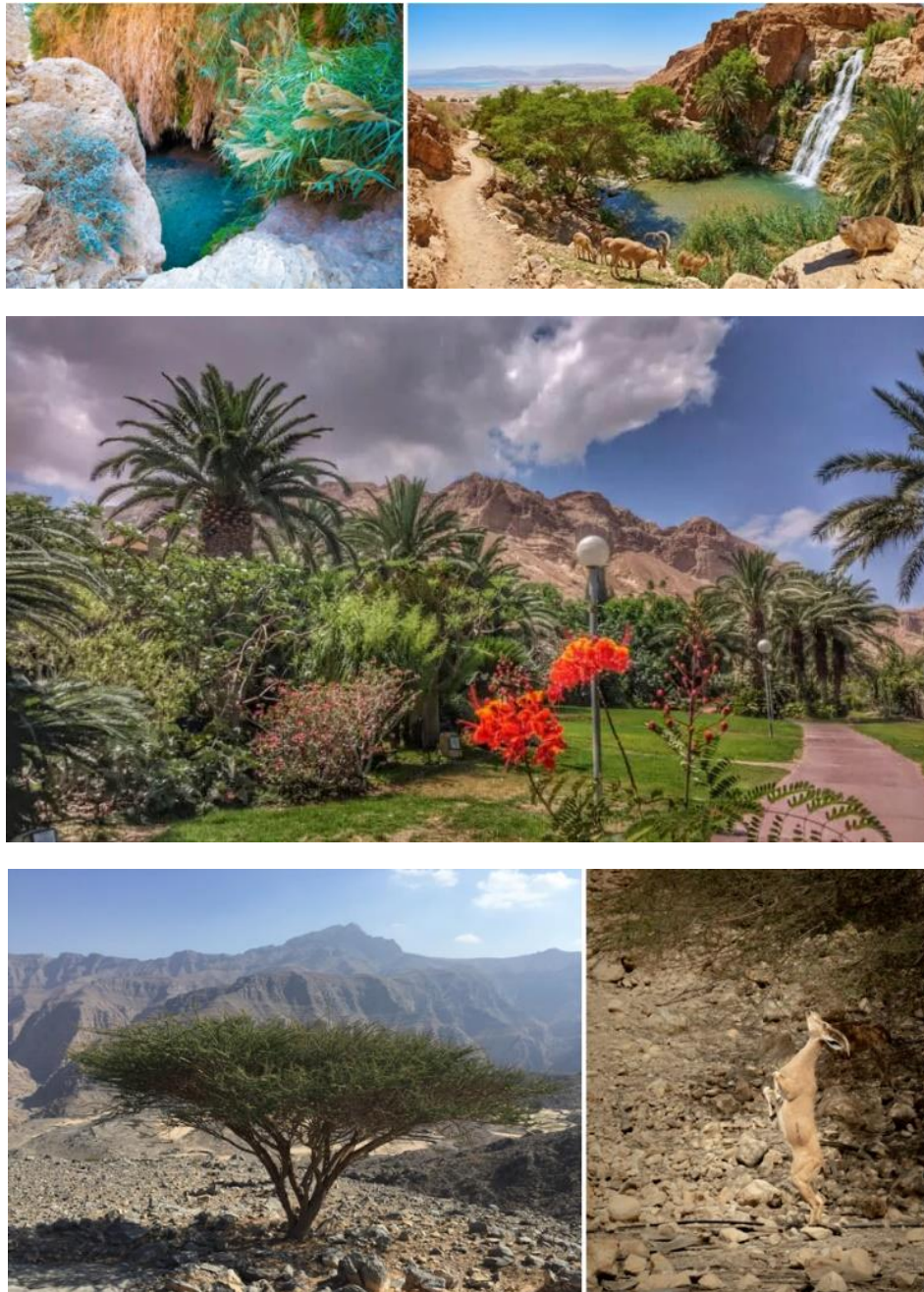
Fig 35: Ein Gedi Oasis in Israel

8.1. Natural resources and sights

Ein Gedi is a popular tourist attraction and in 2016 was included in the list of the most popular natural sites in Israel^[89]. The site attracts about a million visitors a year. Adjacent to the reserve is the Ein Gedi Archaeological Park, which contains the remains of a nearby Jewish settlement from the Roman and Byzantine periods. Immediately to the south is modern Ein Gedi, a kibbutz (collective community) founded in 1954. The Ein Gedi Oasis is a lush, water-rich oasis on the Dead Sea that, despite its desert setting, is home to a high density of tropical and rare plants. Characteristic plants include the Christ's thorn (*Ziziphus spina-christi*), acacias, balsam Arabic, and reeds, while a neighboring kibbutz maintains an internationally recognized botanical garden. Ein Gedi has the highest density of tropical plants in Israel, often considered the northernmost point of their distribution. The Christ's thorn (*Ziziphus spina-christi*) is a tree whose thorns were traditionally used for Jesus' crown of thorns. *Acacia raddiana* (single trunk) and *Acacia tortilis* (umbrella) are common. The Jericho balsam (*Balanites aegyptiaca*) is known for its thorns and date-like fruit. *Salvadora persica* (toothbrush tree) is a small tree whose twigs are traditionally used for dental hygiene. *Maerua crassifolia* is a very rare tree species, with only a few remaining in the area. Common reed

(*Arundo donax*), rush (*Phragmites australis*), and bulrush (*Typha domingensis*) grow in Wadi David and Wadi Arugot. The adjacent kibbutz is a populated botanical garden with over 900 plant species from around the world, including a large cactus garden^[90]. In ancient times, the oasis was known for growing balsam, which was used in high-quality perfumes. The flora has declined slightly compared to earlier times due to intensive use of water for agriculture, but it is intensively protected by the nature and park administration. The Ein Gedi Oasis is a lush, picturesque nature reserve with beautiful waterfalls - especially David's Falls (Nahal David) - that flow year-round. Known as the biblical refuge where David hid from King Saul, this desert sanctuary offers popular hiking trails, swimming pools, and frequent sightings of ibex and hyenas. David's Falls is a picturesque 36-meter-high waterfall with a refreshing pool at the base. Located within the Ein Gedi Nature Reserve near the Dead Sea and Masada, it is accessible from the main tourist entrance. The Wadi David Trail is an easy, short, and family-friendly hike that takes 1-2 hours to explore the lower pools and waterfall. The area includes several smaller waterfalls, lush vegetation, and hidden caves. The location is mentioned frequently in the Bible, most notably as the place where David hid from King Saul in caves, as described in 1 Samuel 24 (Fig 36).





Source: <https://en.parks.org.il/new/en-gedi-nature-reserve/>, Accessed: May 8, 2026.

Source: <https://www.gawaterfalls.com/davids-falls.html>, Accessed: May 8, 2026.

Source: https://www.magnific.com/premium-photo/oasis-desert-ein-gedi-nature-reserve-israel_24973141.htm, Accessed: May 8, 2026.

Source: <https://deadsea.com/articles-tips/ein-gedi-waterfall-israel-guide/>, Accessed: May 8, 2026.

Source: <https://www.wikiloc.com/hiking-trails/donkey-path-21875447/photo-13793483>, Accessed: May 8, 2026.

Source: <https://dannythedigger.com/ein-gedi/>, Accessed: May 8, 2026.

Source: <https://www.walkmyworld.com/posts/ein-gedi>, Accessed: May 8, 2026.

Fig 36: Natural resources and sights in Ein Gedi Oasis

8.2. Architectural cultural and historical heritage

The Ein Gedi Oasis in Israel is a key historical, cultural, and ecological site where freshwater springs support lush vegetation in the arid Judean Desert. Inhabited from the Chalcolithic to the Byzantine era, the site is known for its ancient agricultural technology, sacred architecture, and strategic importance as a source of valuable perfume ingredients. Known in the Bible as the "spring of the kid" (Ein Gedi), it is known as the place where David hid from King Saul. It is also mentioned as Hazazon Tamar in 2 Chronicles 2 and as a paradise in the Song of Songs. The Chalcolithic

Temple of Ein Gedi (4th Millennium BCE) was discovered on a hill above the spring, serving as a cult center for nomadic tribes. During the Roman and Byzantine periods (2nd–6th centuries CE), Ein Gedi was a wealthy settlement known for the production of a unique perfume from the balsam plant. A mosaic inscription in the ancient synagogue contains a curse against anyone who discovers the secret of perfume production in the city. The ruins of the Great Synagogue (3rd–6th century AD) with its well-preserved mosaic floor are the main archaeological attraction, showing a unique entrance facing west and devoid of human Figs. Excavations

have revealed terraces, irrigation systems, and a Roman garrison, suggesting that it was an important imperial estate. The oasis was maintained by advanced, sophisticated irrigation, using spring water to irrigate terraced agriculture, which was essential for the cultivation of dates and balsam. Remains include stone dwellings, industrial zones for oil and perfume production, and a synagogue with a 6th-century mosaic floor featuring botanical patterns. A 7th-century BC Jewish outpost or fortress was located on a platform near the main spring. Established in 1971, it covers two main streams,

Nahal David and Nahal Arugot, with waterfalls, and lush greenery, which attracts great popularity as a tourist attraction. The area is known for its herds of ibex and rock hyrax, which are often found near the springs and waterfalls. Kibbutz Ein Gedi was founded in 1953, a nearby modern settlement operates a botanical garden, grows dates and other crops^[91]. The key archaeological sites to visit in the Ein Gedi National Antiquities Park are the synagogue and the surrounding excavated village, which are managed by the Israel Nature and Parks Authority (Figs 37,38,39).



Source: <https://en.parks.org.il/new/en-gedi-nature-reserve/>, Accessed: May 8, 2026.

Fig 37: Manu Grinspan



Source: <https://en.parks.org.il/article/masada-museum/>, Accessed: May 8, 2026.

Fig 38: The Masada Museum in Memory of Yigael Yadin



Source: <https://hotels-of-israel.com/kibbutz/kibbutzhotels/eingedi.htm>, Accessed: May 8, 2026.

Source: <https://www.touristisrael.com/hotels/ein-gedi-kibbutz-hotel/>, Accessed: May 8, 2026.

Fig 39: Kibuc Ein Gedi

9. Ubari Oasis in Libya

Ubari or Awbari (Arabic: اوباري, Romanized: 'Awbārī) is an oasis town and the capital of the Wadi al Hayaa District, in the Fezzan region of southwestern Libya. It is located in Idehan Ubari, the Libyan part of the Sahara desert. It was the capital of the former baladiyah (district) called Awbari, in the southwest of the country (Geographic coordinates: 26°42'35.70"N, 13°20'03.23"E, Elevation: 460 m). Ubari is located in the Targa Valley, between the Messak Sattafat plateau and the sand dunes and lakes of the Idhan Ubari erg. Native plants include marsh grasses on the shores of natural spring-fed lakes and native Saharan date palm (*Phoenix dactylifera*). Ubari is located in one of the sunniest and driest areas in the world. It has a hot desert climate (type BWh, according to the Köppen-Geiger climate classification) with short, very warm winters but long, extremely hot summers. The average annual rainfall is one of the lowest on Earth at only 8 mm and many decades can easily pass without any precipitation. Ubari has constant, unrestricted sunshine and clear skies throughout the year and in all seasons. Clouds are extremely rare over this dry land. Average high temperatures

exceed 40 °C from June to September. The Ubari Sand Sea is a vast area of high sand dunes in the Fezzan region of southwestern Libya. 200,000 years ago this was a humid and fertile area with abundant rainfall and flowing rivers. These rivers fed a vast lake, the size of the Czech Republic, in the Fezzan basin, called Lake Megafezzan. During wet periods the lake reached a maximum size of 120,000 km². Climate change caused the region, part of the Sahara, to gradually dry out, and 3,000 to 5,000 years ago the lake evaporated into thin air. Traces of this great lake still exist today in the form of micro-lakes scattered among the high dunes like wet patches in the desert. Currently, there are about 20 lakes in the Ubari Sand Sea - beautiful oases lined with palm trees that look like anomalies in the harsh desert environment ^[92]. The Ubari Lakes are very salty. This is due to the fact that these lakes are continuously evaporating and have no rivers to replenish them (Libya has no permanent rivers that flow all year round). As a result, the dissolved minerals in the lake waters have become concentrated. Some of these lakes are almost five times saltier than seawater. Some take on a blood-red hue due to the presence of salt-tolerant algae (Figs 40,41).



Source: <https://www.amusingplanet.com/2015/04/the-lakes-of-ubari-sand-sea.html>, Accessed: May 8, 2026.

Fig 40: The Lakes of Ubari Sand Sea



Source: <https://www.wildmanlife.com/the-ubari-lakes-libya-desert-oases/>, Accessed: May 8, 2026.

Fig 41: Ubari Oasis in Libya (Jezera Ubari)

9.1. Natural resources and sights

Nestled in the heart of the Sahara Desert in southwestern Libya, the Ubari Lakes, also known as the Awbari Lakes, are a remarkable testament to the beauty and resilience of Libya's nature. These pristine lakes are a mesmerizing sight amidst the arid landscape, providing a haven for a diverse range of flora and fauna. With their turquoise waters shimmering under the desert sun, the Ubari Lakes have long been revered as a hidden gem, attracting adventurers, scientists and nature lovers from around the world^[93] (Fig 42). The formation of Lake Megafezzan during the Miocene epoch is attributed to increased volcanic activity in northeastern Libya, which led to the diversion of the Wadi Nashu River, a major watercourse flowing into the Mediterranean Sea. The first four lakes are usually favored by locals for their accessibility: Mandara, Umm al-Maa, Mavo (or Mahfu), and Gaberoun. Access to the remaining lakes requires crossing high ridges of steep dunes, which requires additional time and the use of more capable vehicles within the group. As volcanic activity obstructed the flow of the river, water began to accumulate within the Fezzan Basin, forming the proto-Lake Megafezzan

during wet climatic periods. This prehistoric lake, about 200,000 years old, which once dominated the landscape of the Fezzan Basin, played a key role in shaping the region's ecosystem and supporting a diverse flora and fauna (). The lakes of the Ubari Oasis in Libya (particularly in the Ubari/Ramlat al-Dauada Sand Sea) support unique salt-tolerant life within the hyperarid environment, including red shrimp and algae. The surrounding ecosystem of the oasis attracts wildlife such as fennec foxes, gazelles, African wildcats, and migratory birds such as flamingos. The highly saline lakes are inhabited by tiny red shrimp (*Artemia*), which have been a historical source of local livelihood. The lakes serve as a resting place for migratory birds, including flamingos, herons, and ducks. Other birds seen in the surrounding palm groves include kingfishers, herons, and shrike. The region is home to desert-adapted species such as fennec foxes, Ruppell's foxes, striped hyenas, jackals, African wildcats, and gerbils. A variety of reptiles and rodents, including the desert agama, are common in the surrounding desert dunes. Mosquito swarms are common in the summer (Fig 42).





Source: <https://www.amusingplanet.com/2015/04/the-lakes-of-ubari-sand-sea.html>, Accessed: May 8, 2026.

Source: <https://www.wildmanlife.com/the-ubari-lakes-libya-desert-oases/>, Accessed: May 8, 2026.

Fig 42: Ubari Oasis in Libya (Ubari Lakes)

9.2. Architectural cultural and historical heritage

The Ubari oasis in Libya's Fezzan region features traditional, sustainable architecture adapted to the Sahara, including palm thatched dwellings and mud brick earthen structures often designed by the local Tuareg^[94] (Figs 43,44,45). The architecture blends into the landscape of high sand dunes and saltwater lakes, such as Gaberoun and Umm al-Maa, using local materials for natural insulation. The area is dotted with simple, traditional dwellings that serve the nomadic and semi-nomadic lifestyle of the local population, often with mud brick construction. The buildings typically use earth,

mud, and palm materials to provide thermal comfort, keeping the interior cool from the high desert temperatures. The oasis is known for its picturesque landscape, with the ruins of an abandoned, traditional earthen village directly on the edge of a large, saltwater lake. The architecture here is defined by its sparse, functional nature, designed to coexist with scarce water sources and dense palm groves. The architecture exists alongside the natural, salt-covered shores of lakes, such as Umm al-Maa (Mother of Waters), creating a stark contrast to the surrounding sand dunes.



Source: <https://www.wildmanlife.com/the-ubari-lakes-libya-desert-oases/>, Accessed: May 8, 2026.

Fig 43: Traditional family house in the ancient caravan town of Ghadames



Source: <https://www.wildmanlife.com/the-ubari-lakes-libya-desert-oases/>, Accessed: May 8, 2026.

Fig 44: Traditional reed house



Source: <https://tourslibya.com/fezzan/ubari-lakes/>, Accessed: May 8, 2026.

Fig 45: Vernacular architecture in Ubara Oasis in Libya

Recently, tourist camps have been built in the Ubari Oasis in Libya, near the Ubari Lake. These are tents with an oval floor plan with a construction made of steel pipes and a mantle

made of strong canvas. In their appearance, they resemble the 'yurt' of nomads from Central Asia (Fig 46).



Source: <https://www.facebook.com/photo.php?fbid=202745165599196&set=a.179724067901306&id=100075911420924>
Accessed: May 8, 2026.

Fig 46: Tourist camps in Ubari Oasis in Libya

Conclusion

Desert oases are exceptional geographical places where water has made a great contrast to the waterless desert environment. This water is a true symbol of life since it generates a unique flora and fauna and human life. Architecture as a framework for people's lives in a desert oasis has accompanied people's lives for thousands of years. Architecture is, for the most part, vernacular, organized according to the general principles of bioclimatic architecture. However, architecture, with its appearance, design and materialization, follows social changes: once it was the framework for the lives of only the inhabitants living in the oasis, and today it is also the framework for the lives of people who come to deserts and oases for fun and relaxation in exceptional natural environments. Over time, 'oasis' has acquired a much broader meaning in people's everyday lives - as a 'peaceful and comfortable refuge'.

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