

Proposal from the United Arab Emirates  
For the designation under the GIAHS Program of  
*Al Ain and Liwa Historical Date Palm Oases*

Draft 7 January 2015



## Table of Contents

<b>1 Summary information</b>	<b>3</b>
<b>2 Description of the Agricultural Heritage System</b>	<b>4</b>
2.1 Geographic and socioeconomic context	4
2.1.1 Al Ain	4
2.1.2 Liwa	6
2.2 Food and livelihood security	8
2.2.1 Importance of dates in the economy of UAE	8
2.2.2 Nutritional and culinary value of date palm fruits	9
2.2.3 Medicinal effects of date consumption	9
2.2.4 Secondary traditional uses of date palm	10
2.2.5 Potential for non-traditional uses of date palm seeds	10
2.3 Biodiversity and ecosystem function	11
2.3.1 Date palm genetic resources	11
2.3.2 The diversity of date palm in Al Ain and Liwa	11
2.3.3 Non-date agricultural biodiversity	13
2.3.4 Ecosystem services of date palm plantations	14
2.4 Knowledge systems and adapted technologies	14
2.4.1 Management of the oasis agro-ecosystem	14
2.4.2 Date palm ecological requirements	14
2.4.3 Date palm reproductive system and propagation	15
2.4.4 Date palm cultivation and crop management	16
2.4.5 Date palm harvest and post-harvest knowledge	18
2.5 Cultures, value systems and social organisations	20
2.6 Aflaj irrigation systems in Al Ain	20
<b>3 Historic relevance</b>	<b>22</b>
3.1 History of Al Ain and Liwa	22
3.2 The date palm and oasis livelihoods	23
3.3 History of aflaj irrigation systems	24
3.4 Traditional Arish palm-leaf architecture	25
<b>4 Contemporary relevance</b>	<b>27</b>
4.1 The role and importance of agricultural production in Al Ain and Liwa	27
4.2 Date consumption and dietary significance in UAE	28
4.3 Date palm research and policies	29
<b>5 Threats and challenges</b>	<b>29</b>
5.1 Urban development pressures	29
5.2 Decline of the aflaj irrigation systems in Al Ain	30
5.3 Degradation of date palm plantations	31
5.4 Threats to biodiversity	31

5.4.1 Agricultural biodiversity .....	31
5.5 Loss of indigenous knowledge .....	32
<b>6 Dynamic conservation plan .....</b>	<b>32</b>
6.1 Abu Dhabi Vision 2030 .....	32
6.1.1 Conservation plan for Al Ain oases .....	33
6.1.2 Conservation plan for Liwa (Plan Al Gharbia 2010) .....	36
6.2 Sustainable water management .....	36
6.3 Sustainable tourism .....	37
6.4 UNESCO designations of Al Ain .....	37
6.5 Awareness creation .....	38
6.5.1 Emirates International Date Palm Festival .....	38
6.5.2 Liwa Dates Festival .....	38
<b>7 References .....</b>	<b>39</b>
<b>8 Acronyms .....</b>	<b>41</b>

## 1 Summary information

**Name of the Agricultural Heritage System:** Al Ain and Liwa Historical Date Palm Oases

**Requesting Agency:** Government of the United Arab Emirates

**Country/Location/Site:** United Arab Emirates, Emirate of Abu Dhabi / Al Ain date palm oases (Al Ain, Hili, Al Qattara, Al Jimi, Al Mutaredh, Al Muwaiji, and Al Jahili) and Liwa date palm oasis and their surrounding areas, Al Ain and Al Gharbya Regions

**Accessibility of the site to capital city of major cities:** The sites are situated 100-150 km from Abu Dhabi. Accessibility through modern multilane highways from Abu Dhabi, which enter the oases.

### Abstract

This document proposes to designate Al Ain and Liwa date palm oases as a Globally Important Agricultural Heritage Site (GIAHS) under the respective FAO programme. Al Ain and Liwa constitute globally significant *in situ* repositories of date palm genetic resources, and are home to ancient falaj irrigation systems, which bear testimony to human agricultural and technological ingenuity, with important lessons for future coping strategies and sustainable development in the face of climate change. Located in a country, which has experienced extreme rapid development and undergone dramatic socio-economic change, the oases no longer have their traditional significance in subsistence agriculture. However, their iconic importance to the United Arab Emirates' cultural identity and traditions, and the environmental quality they add to Al Ain and Liwa

City as well as their role in national branding and sustainable tourism, cannot be overstated. A very active and dynamic conservation program, seeking to revitalize the oases through a variety of measures, such as protection against urban encroachment, restoration of aflaj irrigation systems, and re-introduction of traditional agricultural management, is fully supported by state-of-the-art development plans, legislative initiatives, academic research and the highest level of Abu Dhabi's government.

## **2 Description of the Agricultural Heritage System**

### **2.1 Geographic and socioeconomic context**

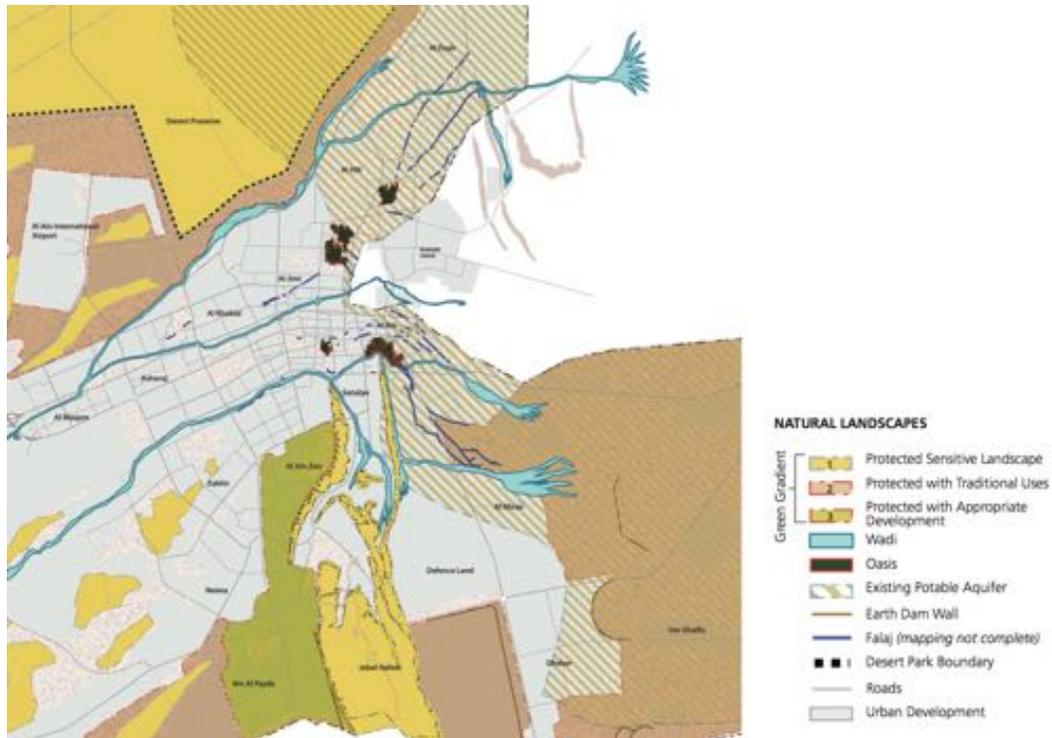
#### **2.1.1 Al Ain**

In the desert enclave of Al Ain, which means “the spring” in Arabic, water underlies all forms of life, from date palms to camels, having been the source of life for more than 3000 years. Located some 160 km East of the city of Abu Dhabi, Al Ain covers a total area of 13,100 square km. Because of its extensive oases, tree-lines avenues and numerous parks, it is often referred to as the “the garden city”. Al Ain is the second largest city in the Emirate of Abu Dhabi in the fourth largest in the United Arab Emirates (UAE), with a population of 400,000. It is also the birthplace of Sheikh Zayed bin Sultan Al Nahyan, the founder and first president of the UAE.

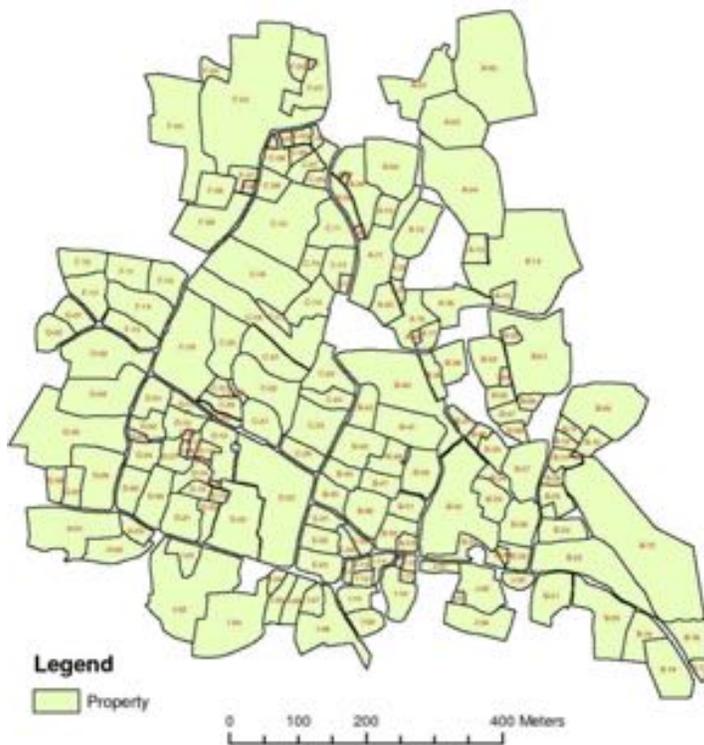
An iconic feature of Al Ain City is its oases known for their date palm groves and falaj underground irrigation systems that bring water to farms and palm trees. Falaj irrigation is an ancient system dating back thousands of years. Al Ain has seven oases covering a total area of 350 ha. The largest is Al Ain Oasis, along with Al Qattara, Al Mutaredh, Al Jimi, Al Muwaiji, Al Hili and Al Jahili.

Fig. 1 provides an overview on the location of Al Ain's oases. They consist of privately-owned plots of densely planted date palm farms, reached via public pathways.

Fig. 2 presents the distribution of land holdings within Al Jimi Oasis, exemplifying the typical size distribution across Al Ain oases.



**Figure 1.** Al Ain City Natural Landscapes, note oases in black (Source: Plan Al Ain 2030, Urban Structure Framework Plan)



**Figure 2.** Distribution of land holdings in Al Jimi Oasis (Source: Nasr Nouredine)

While the fast pace of rapid change brought about by the discovery of oil in the late 1960s was sweeping through coastal settlements such as Abu Dhabi and Dubai, Al Ain has preserved its strong local character and sense of place, largely due to vision of the late Sheikh Zayed Bin Sultan Al Nahyan, founder and first president of the UAE, and the former Ruler's Representative in Al Ain. Through Sheikh Zayed's instructions, the overall structure of the city was largely kept to the human scale, and its oases protected from the urban development occurring around them. Al Ain's traditional green character was reinforced with the creation of parks and gardens, while a strict law restricts building heights to 'G+4 storeys'. Protection of the oases' physical fabric and farming practices was legally guaranteed by decrees issued in 2004 and 2005.

The long-term goals for the development of Al Ain are described in Plan Al Ain 2030, which lays down the foundations for the Al Ain of tomorrow, maintaining a balance between quality of life and 21<sup>st</sup>-century progress as its population grows while at the same time preserving its geographic and socio-cultural uniqueness and standing as the garden city of the UAE. Al Ain's population is forecast to grow by 2015 to have 141,000 Emirati residents and 335,000 expatriates.

The local economy is currently largely based on tourism, construction, services and public administration. Tourism will continue to feature prominently in Al Ain, with the number of annual tourists expected to rise to 474,000. The city offers stunning views of the desert from Jebel Hafeet, the ancient oases, and the local earthen architecture of forts, towers, palaces and mosques. The name of Al Ain, will also be increasingly be associated with its wildlife park and resort, an ambitious expansion of Al Ain Zoo.

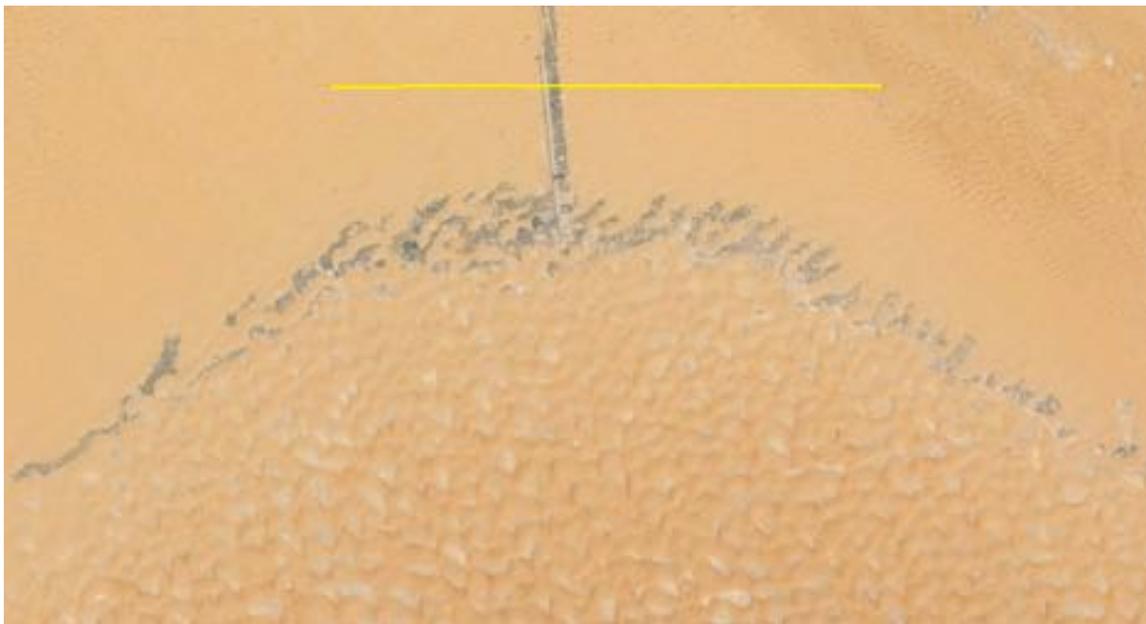
Government authorities see the city shifting towards light manufacturing, software, education and health care in the future. Knowledge industries are already drawing synergies from institutions like the UAE University, Al Ain hospital and a planned aerospace cluster.

### **2.1.2 Liwa**

Liwa, along with Madinat, Zayed, Ghayathi, Ruwais, Mirfa, Sila and Delma Island, is one of the eight townships of Al Gharbia, also known as the western region of Abu Dhabi. Al Gharbia occupies a unique position in Abu Dhabi. With some 83% of the country's land mass, but only 10% of its population, it is home to the UAE's largest hydrocarbon deposits. Oil and gas is the main economic driver in Al Gharbia accounting for 40% of Abu Dhabi's GDP (followed by petrochemicals, construction and public administration). However, Abu Dhabi's Western Region Development Council seeks to stimulate other economic sectors, including agriculture, to account for a growing share of overall GDP. Al Gharbia hopes to retain local talent by investing in education, infrastructure upgrades, by attracting small and medium-sized enterprises, while at the same time maintaining local culture and traditions.

Liwa oasis consists of a series of valleys in Al Gharbia located 230 kilometres from Abu Dhabi City, on the edge of the Rub al Khali desert. The name Liwa derives from the word *jaww*, which denotes the hollows or valleys formed between the south-facing slip faces (*butûn*) of great dune ridges (*qa'âyid*) and the hard backs (*zuhûr*) of the succeeding ridge in the inland sand sea of western Abu Dhabi. These may be deflated down to the level of the hard pan or indurated sands of the desert platform, above which the largest dunes (*zimâm*) may tower some 125m or more. Consequently, the sparse rainfall that is stored in the dunes seeps out at the base and may be adequate for cultivating a few palm trees.<sup>1</sup>

The oases extend in west to east for about 70 km and lie approximately the same distance from the sea (see Fig. 3). As seen in the aerial view in Fig. 3, Liwa oasis forms an arc. The inner side of the arc, the Batâna offers poor grazing, mostly halophytes (harm etc), but the hard packed dunes on the coastal side (Zahâra) has better, albeit sparse potential, and forms part of the region known as the Dhafra (al-Zafra). Liwa forms the core of an economy based on date palm cultivation, livestock herding (essentially camels). Traditionally, Liwa men also pursued basic trade and maritime occupations, such as fishing and pearling.



**Figure 3.** Aerial view of the arc formed by Liwa oases (altitudinal range. Note the large dunes south of the oases, which hold the water that seeps out to irrigate the oasis. Yellow line=50 km (Screen shot from Google Earth, 4 December 2014)

Liwa oasis emerged out of a historic Bedouin encampment. To this day, the area is considered by many to be the spiritual heart of the region. By 2030, the population of

---

<sup>1</sup> Wilkinson 2009

Liwa is expected to grow from today's 20,000 to 65,000. Abu Dhabi's decentralization efforts foresee the oasis to become Al Gharbia's administrative centre. Today, 73% of Liwans are employed in agriculture. Only 8% of the local workforce is currently employed by the oil industry.

An important branch of the local economy is date farming with widespread use of drip irrigation and green houses. The importance of tourism is on the rise and Liwa has several hotels and festivals to service this growing industry.

## **2.2 Food and livelihood security**

The notion of livelihood and small-scale farming as known from most GIAHS sites is not applicable in the UAE, where date palm and other agricultural commodities are produced under harsh climatic conditions with severe limitations on arable land and water sources, and therefore are highly subsidized by the government. Owing to the dramatic economic transition Abu Dhabi has experienced in recent decades, agriculture does not represent more than 0.2 % of GDP in this oil-rich country that imports more than 95% of its food. It is not food security per se that concerns the UAE but rather food autarky.

Yet, as this proposal argues, date palm and oasis agriculture is fundamental to the cultural traditions and dear to the highest sphere of the country. Emiratis recognize the importance of preserving date palm production systems as providers of ecosystem services, and source of traditional knowledge, biodiversity and resilience. The associated heritage is being increasingly used to position Abu Dhabi as an international tourism destination. Both Al Ain and Liwa oases are also important elements in Abu Dhabi's Vision 2030 for urban development as described in section 6.1.

In this proposal, the theme of food and livelihood security will be explored in terms of the high cultural and dietary significance of dates in the UAE, the culinary and medicinal values associated with date consumption, as well as incipient UAE-based research on innovative uses of date palm products.

### **2.2.1 Importance of dates in the economy of UAE**

UAE is the seventh major date producing country in the world, with 6% of the world's total date production. Date palm accounts for 15% of total area of crop cultivation in UAE, with Al Ain and Liwa occupying the central role for national date production. The quality of date palm fruit and processed products is very high, compared with those made in other regions. Al Ain and Liwa oases dates have acquired an excellent reputation in national and international markets, which is also supported by the Royal family's preference for dates from UAE.

UAE is also a major player in the international trade of dates, with 40 percent of the world's dates traded through UAE. In the pre-oil era, dates trade had contributed to the livelihood of local communities for a long period. However its contribution to the livelihood in the communities is relatively diminishing due to wealth based on oil revenues. Still, dates and other agricultural products are the main source of food and nutrition in the communities.

### 2.2.2 Nutritional and culinary value of date palm fruits

As described in section 4.2, dates represent an important element in the diet of the population in Abu Dhabi in general, and in Liwa and Al Ain in particular. Moreover, dates contribute significantly to the nutritional quality of the national and local diets. Depending on their maturation and dehydration state, dates contain a high percentage of carbohydrate (total sugars, 44-88%), protein (2.3-5.6%), fat (0.2-9.3%), essential salts and minerals, vitamins and an elevated proportion of dietary fiber (6.4-11.5%). They also contain oil in the flesh (0.2-0.5%) and the seed (7.7-9.7%). The seed represents 5.6-14.2% of the entire fruit weight.

Dates are particularly rich in carbohydrates. Sugars, especially fructose, glucose, mannose, maltose, and other non-reducing sugars such as sucrose, represent over 80% of the dry matter. The glucose-to-fructose ratio varies between 1 and 2 depending on the cultivar and ripening stage. A small amount of the carbohydrates in dates is accounted for by polysaccharides such as cellulose and starch. Usually, the sugar content is lower in the kimri and khalal stages as compared to commercial dates at their full ripeness stage of tamar. Fully mature dried dates contain such high average dietary fiber content (three quarters consisting of insoluble fibers) so that six to seven dates (approximately 100 g) consumed daily by an adult would provide 50-100% of the recommended daily intake.

Dates are also rich in vitamins, especially  $\beta$ -carotene (vitamin A), thiamine (B), riboflavin (B), niacin, ascorbic acid (C) and folic acid. The contents of carotenoids vary with the cultivar and stage of ripeness, with the total content of carotenoids decreasing towards the final ripening stages and in storage.

Dates also contain significant amounts of at least 15 essential minerals, including phosphorus, potassium, sodium, zinc, manganese, magnesium, copper, iron, fluorine and selenium, with individual minerals varying in content from 0.1 to 1000 mg per 100 g dry matter.

In conclusion, a diet based on dates, when complemented with protein-rich food items such as milk products and fish, is uniquely simple but perfectly sustaining. Apart from being a good substitute for refined sugar, and a rich source of natural fibers, dates have been identified as having antioxidant and anti-mutagenic properties, and were also found to reduce heart disease (see below).<sup>2</sup>

### 2.2.3 Medicinal effects of date consumption

A number of medicinal effects are directly or indirectly ascribed to the consumption of dates. The fruit is rich in tannins, making it a good astringent remedy for intestinal troubles. Formulations based on dates such as infusions, decoctions, syrups and pastes are often administered against colds, sore throat and cough.

---

<sup>2</sup> Section based on El-Hadramy & Al-Khayri 2012

Phenolic compounds in dates are known to have *anti-viral, -bacterial and -fungal properties*, potentially explaining their reputed use as remedy for certain diseases and prevention of chronic inflammations. The fruit and its by-products are rich in dietary fibers, selenium, carotenoids, ascorbate and other antioxidants, which may prevent oxidative damages.

Studies have demonstrated the *anti-carcinogenic properties* of phenolics, several of which are abundantly present in dates. Phenolics are believed to interfere with the development of malignant tumors at various stages. Phenolics such as caffeic and ferulic acids, present in dates in relatively high concentrations, are known to inhibit skin tumors.

Dates being rich in both phenolics and dietary fibers can play a role in the *modulation of the immune system and prevention of cardiovascular diseases*. Lower incidences of cardiovascular disorders have been observed in populations relying on a regular intake of dates. This is believed to occur through the inhibition of the oxidation of low-density lipoprotein and through the prevention of platelet aggregation. Phenolics contained in dates may also be able to reduce blood pressure and have anti-thrombotic and anti-inflammatory effects as shown for other fruits.

#### **2.2.4 Secondary traditional uses of date palm**

Several secondary (non-fruit) products of the date palm result from annual pruning and have essential uses for the cultivator. They include frond bases, midrib, leaflets, spikelets, fruit stalks, spathes, all of which are used as ruminant feed.

Leaves are very often used to construct fences providing wind protection for horticultural crops, or to make mats, screens, baskets and crates. They also represent a source of fuel and raw material for making fishing implements and objects such as walking sticks and brooms.

The trunks of date palms are providing construction material for different purposes, notably for traditional Arish houses, the authentic Emirati architecture with a 7,000-year history of human habitation in the Arabian Peninsula dealt with in more detail in section 3.4.

#### **2.2.5 Potential for non-traditional uses of date palm seeds**

Date seeds have other nutritional property relevant for value-adding. They contain over 60% carbohydrates, up to 10% fat and 5% protein and a substantial amount of dietary fiber (6-12%). They also represent a source of sterols, oestrone and some alkali-soluble polysaccharide. The seeds yield a yellow-green, moisturizing oil rich in oleic, lauric, myristic and palmitic fatty acids, which has been suggested for use in cosmetic, pharmaceutical and related specialty products.

Date seeds can also be chemically processed to produce up to 65% oxalic acid or burned to produce charcoal for silversmiths. The seeds are also often strung into necklaces.

Researchers at UAE University in Al Ain are testing the use of date pits to replace the antibiotics administered to chickens. Research findings suggest that date pits, have significant ability to protect poultry against common ailments. Pits are inexpensive, since the UAE's date industry generates 50,000 t of pits annually as byproducts of processing. For chicken producers, date pits make an attractive alternative to yellow corn, a costly ingredient in animal feed. The UAE University researchers calculate that pits could be used to replace up to a fifth of the corn in chicken feed. That would cut both costs and the use of growth-enhancing drugs. Since antibiotics in animal feed can encourage the growth of resistant strains of bacteria, getting antibiotics out of the food chain would be highly welcome.

## 2.3 Biodiversity and ecosystem function

### 2.3.1 Date palm genetic resources

Genetic diversity studies on date palm have demonstrated that there is a clear association between population characteristics and the environments (i.e., oases) in which they grow. However, plasticity has apparently been sufficient to allow genetically similar date palm cultivars to grow and produce in widely differing oasis environments. Ecotypic differentiation in date palm affects many plant traits such as the relative rates of development in this slow-growing tree, resistances to biotic and abiotic stresses, responses to soil fertility, and adaptation to different management practices (e.g., cultivation, irrigation and harvesting methods) as well as differences in fruit quality.

Local date palm cultivars with outstanding adaptation to climatic, edaphic, and management factors, are the products of centuries of interaction between farmers, the genetic and breeding systems of the date palm, and the environment. The breeding system of date palm as well as several ecological pressures affect the distribution of intra-population variability and determine the genetic composition of cultivars within oases. In addition, selection for ecological adaptation may have resulted in differences in originally identical clones grown in oases with different environmental and management factors.

Partitioning of genetic diversity within and between oases, populations, and date palm cultivars is an important factor to be considered in biodiversity studies and genetic resources conservation efforts of date palm. The data on the extent, structure and distribution of date palm genetic diversity is necessary in managing both *in situ* and *ex situ* conserved genetic resources. So far, deliberate *in situ* conservation of cultivated date palm and its wild relatives have been rather limited.<sup>3</sup>

### 2.3.2 The diversity of date palm in Al Ain and Liwa

The Arabian Peninsula is both a center of origin for the date palm and also historically the most important production zone for date palm, with the highest sophistication and diversity of date consumption. It is then no surprise that the UAE harbour great date

---

<sup>3</sup> Jaradat 2011

palm diversity. According to recent estimates, there are at least 200 cultivars of date palms in the UAE, of which some 70 are economically salient.<sup>4</sup>

Date palm cultivars are differentiated principally by two criteria. For consumers, fruit characters are relevant, in particular the degree of sweetness and dryness (soft, semi-dry, and dry) in accordance with fruit water content, sugar and dry matter content as well as textural properties (depending on their water and type of sugar content at harvest when fully-ripe). Producers, on the other hand classify date palms by their period of maturation. The selection and maintenance of date palms ready for harvest at different times allows producers and markets to extend the supply over longer periods.<sup>5</sup>

In Liwa and Al Ain, four maturation groups of date palm are recognised:

- 1) Very early maturing (May 15-25), e.g. Battah, Hbisha and Khatri cultivars.
- 2) Early maturing (May 25 until end of July), e.g. Meznaj, Nghal, Hallawi, Ghoura, Hiri, Shahla, Jech Khassra, Khadri, Khnizi, Nmishi, Chichi, and Khadraoui cultivars.
- 3) Middle season maturation (1 - 21 July ), e.g. Ayacha, Jech Ramli, Abu Maan, Dabbas, Khlass, Zamli, Sukkari, Sakie, Medjhouli, Chebib, Barhi, Sultana, Rziz, Lulu, Anbara, Jabri, Nabtat Saif, and Maktoumi cultivars.
- 4) Late & Very Late maturing varieties (end of July until early January ), e.g. Fard Assfar, Fard Shmar, Nghal Hilali, Hilali and Khissab cultivars.

Within each maturation group there are a few varieties that account for most of the production, particularly in modern and market-oriented plantations. These varieties include Khlass, Barhi, Medjhouli, Sukari, Abu Maan, Sultana, Nabtat Saif and Fard. All other cultivars are grown at very small scale and mostly handled in a traditional way of cultivation and consumption.

The global importance of date palm diversity in Al Ain and Liwa is further corroborated by research findings (Jaradat & Zaid 2004) suggesting that the UAE has higher genetic diversity of fruit quality traits than any of the other countries of the Arabian Peninsula included in the sample (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia). The high level of polymorphism displayed by germplasm from UAE was associated with relatively high values of standard deviations. This suggests that user preferences for specific fruit characters as listed in Table 1, which vary from place to place, and the possibility of propagating date palm both sexually and clonally have resulted in the highly diverse germplasm in its center of origin.

---

<sup>4</sup> Jaradat & Zaid 2004

<sup>5</sup> Kader & Hussein 2009

Table 1. Date fruit quality traits relevant to assess consumer preferences and diversity assessments (adapted from Jaradat & Zaid 2004)

Fruit quality trait	Description and character states
Economic value	Commercial, semi-commercial, non-commercial
Fruit color	Yellow, red, light red, dark red, yellowish red, reddish yellow, light yellow, yellow orange
Fruit shape	Ovate, obovate, ovate elongated, obovate elongated, cylindrical, spherical, global
Fruit ripening	Early, medium, late
Fruit size	Small, medium, big, very big
Fruit softness	Dry, semi-dry, soft
Fruit eating quality	Low, medium, good, excellent
Consumption stage	Bisr, tamr, rutab, tamr & rutab

### 2.3.3 Non-date agricultural biodiversity

Besides date palm, Al Ain and Liwa oases also harbour a range of fruit species such as lemon, orange, mango, banana, grapes, figs and pomegranate. Also, field crops such as alfalfa, wheat, and barley are cultivated as well as vegetables including eggplant, onion, tomatoes, carrots etc. However, vegetables accounted in 2012 for a mere 2% of the total arable area (see Fig. 4). Onions, tomatoes, cabbage and cucumber accounted for 75% of all vegetables. Timber trees and windbreaks occupied another 3.4% of the total arable land. Since agricultural labour is becoming scarce, about a third of the agricultural land in Al Ain and Liwa is lying fallow (34.8% in 2012).

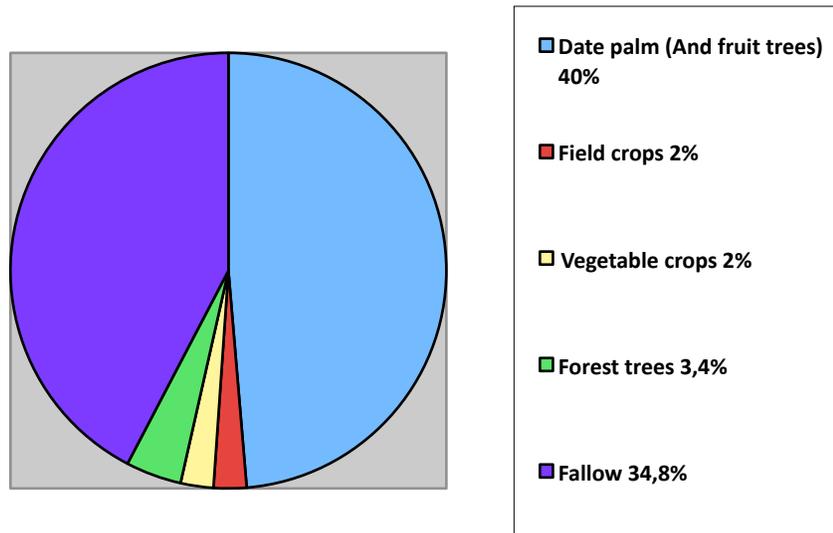


Figure 4. Planting Structures in Al Ain and Liwa historical oases in 2012

### **2.3.4 Ecosystem services of date palm plantations**

Date palm trees are the dominant element of Al Ain and Liwa oases, but most date plantations are intercropped with vegetables, cereals or fodder crops in the first few years and subsequently with low growing fruit trees and grapevines. The tremendous advantage of the date palm tree is its resilience, its long term productivity, and its multipurpose attributes. Cultivars derive their importance from their local adaptation to climatic, edaphic and from socio-economic conditions and preferences for specific qualities of the date fruit.

The tree is a spectacular palm for landscaping large areas. It provides shade and protection from wind. It also prevents soil degradation and desertification, thus protecting the environment.

## **2.4 Knowledge systems and adapted technologies**

### **2.4.1 Management of the oasis agro-ecosystem**

"Oasis" is a Greek word for watered green fertile land in the desert where the "oasis effect" is manifested as cooling caused by vegetation. Under the harsh desert environment, farmers use their adaptive ingenuity, which has developed over millennia to create sustainable palm-based agricultural systems. These systems are usually managed through local resource management institutions that enable farmers to make judicious decisions for sustainable resource use and to maintain stable and productive oasis agro-ecosystems.

The oasis agro-ecosystem was patiently developed and evolved over millennia into a very complex ecological, social, and economic infrastructure. It is the final optimization of the interaction between culture, engineering constraints, economic limitations, and climatic diversity of an environment equally hostile to human, animal and plant life. Although oasis agro-ecosystems cover a relatively small land area, they can support large numbers of people living at high population densities.

The oasis agro-ecosystem is a standard model for a spatially heterogeneous, three-story inter-cropping system of date palms, fruit trees and annual crops. The composition and configuration of the three-story system creates different profiles of horizontal wind speed, relative air temperature and relative air humidity. Date palms, fruit trees, and annual crops approximately intercept various proportions of daily net radiation.

Date palm can withstand strong, hot and dusty summer wind and consequently protects associated crops by breaking the force of the wind and sheltering more susceptible vegetation.

### **2.4.2 Date palm ecological requirements**

Dates can grow in very hot and dry climates, and are relatively tolerant of salty and alkaline soils. However, they thrive in deep soils, preferably sand 1-2 meters deep. Date palms require a long, intensely hot summer with little rain and very low humidity during the period from pollination to harvest, but with abundant underground water near the

surface or irrigation. One old saying describes the date palm as growing with “its feet in the water and its head in the fire.” Such conditions are found in the oases and wadis of the date palm's center of origin in the Middle East.

Date palms can grow from 13 to 28 °C average temperature, withstanding up to 50 °C and sustaining short periods of frost at temperatures as low as –5 °C. The ideal temperature for the growth of the date palm, during the period from pollination to fruit ripening, ranges from 21 to 27°C average temperature.

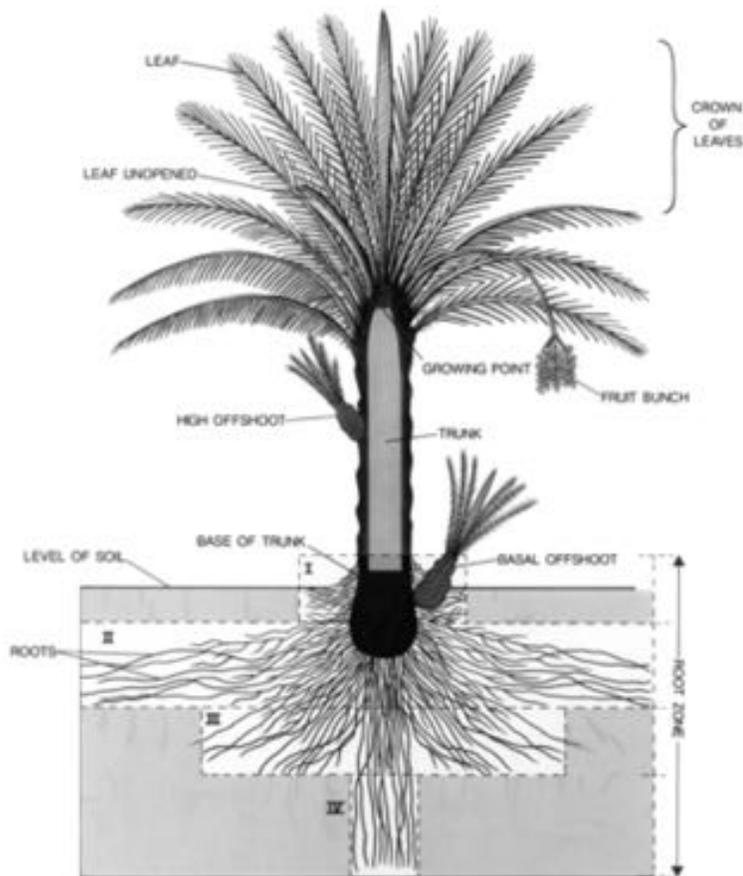
### 2.4.3 Date palm reproductive system and propagation

Date palm is a diploid perennial and monocotyledonous plant belonging to the Arecaceae (palm family). The scientific name of date palm, *Phoenix dactylifera*, refers to its fruit; the Greek word *phoenix* means purple or red, and *dactylifera* refers to the finger-like appearance of the fruit bunch. A distinguishing feature of date palm, with important implications for the production of dates, is that it has separate female and male trees. It is of course only the female trees, which bear fruit.

New date palm cultivars are the result of a continuous selection process carried out by farmers in their orchards following sexual reproduction. Seeds germinate easily and are available in large numbers. Occasionally, seeds germinate under their mother trees and this leads to large levels of genetic diversity within populations, especially with natural pollination. Although the use of palm seedlings is the easiest method of propagation, it may take up to 10 years before trees begin to flower and produce fruit, which is a serious disadvantage.

The long time span for a date palm to reach sexual maturity and reveal its sexual identity have led to the predominance of clonal propagation (offshoots) of females from elite date palm cultivars. This is today the most common method of propagation. It relies on the transplanting of offshoots exchanged or traded between growers and groves. A well-maintained palm can produce up to three offshoots per year with a maximum of up to 40 during its lifetime. However, transplanted offshoots develop slowly, and typically begin to bear fruit within 5-8 years.

Elite or endangered cultivars cannot be propagated through off-shoots quickly enough and distributed en mass to farmers. During the last few decades, much effort has therefore been given to the development of micro-propagation methods that are fast and reliable in generating large numbers of genetically identical plants (clones). This relies on the use of various tissue culture methods, which speed up the multiplication of individual trees with desirable characteristics of growth and fruit quality. Phytosanitary reasons are a further advantage of micro-propagation (avoiding the spread of pests and diseases through off-shoots).



**Figure 5.** Schematic representation of date palm structure, showing attachment of offshoot to mother palm, among other morphological features (Source: USDA)

Although clonal propagation is the method of choice for commercial date production, it promotes genetic uniformity, and accelerates the process of genetic erosion, and enhances the vulnerability of those elite cultivars to biotic and abiotic stresses.

#### 2.4.4 Date palm cultivation and crop management

Female plants start producing dates at 4 to 6 years of age and reach full production within 15 to 20 years. Production often shows a decline after 100 years of cultivation, depending on the soil, microclimate and cultural practices. The average date palm produces 40 kg fruit annually, with yields of more than 100 kg possible with intensive management. When farmed with low levels of inputs and management, dates may produce 20 kg fruit or less annually.

There are a few date palms that are probably several hundred years old. Because of the biology of the date palm, its cultivation has a number of unusual features that are not common in other perennial crops. Several cultural practices, such as pollination, bunch tie-down, covering, harvesting, and pruning require access to the crown of the tree, and in old trees reaching tens of meters in height, this can be challenging and sometimes

dangerous. The practice of climbing the trees for access to the crown is still found in Al Ain and Liwa, but the use of mechanical lifts is increasing.



**Figure 6.** Date tree in full fruit production (Source: Dr Zaid)

Although date trees are wind- and insect-pollinated, farmers in Al Ain and Liwa practice artificial pollination in order to secure fruit set. Some male trees are grown in date gardens, and pollen is collected for the artificial pollination that is critical for the success of production. Cultivars differ greatly in their fruit set percentage. It is also part of traditional knowledge that different pollen sources can influence the size of fruits, known to science as the “metaxenia” effect (by influencing the tissue outside the embryo and endosperm).

After pollination, bunches are often tied to the leaf stalks to support the weight of the fruit. Fruit thinning is sometimes practiced, since it increases fruit size, improves fruit quality, advances fruit ripening, and facilitates bunch management. Fruit thinning can be carried out in three ways: removal of entire bunches, reduction in the number of strands per bunch, and reduction in the number of fruit per strand.

Although dates palms can withstand long periods of drought under high temperatures, large amounts of water are required for vigorous growth and high-quality fruit. Flood irrigation is the oldest form of irrigation and is still used in Al Ain and Liwa. Sprinkler, and drip irrigation are often used in newer plantations.

As seen in Table 2, date planting densities in Al Ain vary considerably (27-598 trees per ha)

Table 2. Date palm numbers and densities in Al Ain oases

Oasis	Al Ain	Hili	Al Qatarra	Al Jimi	Al Mutaredh	Al Muwaiji	Al Jahili
Total area (ha)	118.64	60.81	38.57	61.57	28.26	41.48	20.94
Number of date palms	70,896	18,409	15,147	13,864	9,271	5351	573
Date palm planting density (trees/ha)	598	303	393	225	328	129	27
Area per date palm (m <sup>2</sup> /tree)	17	33	25	44	30	78	365
Number of land holdings	554	252	216	185	141	9	5
Average size of holding (ha)	0.21	0.24	0.18	0.33	0.20	4.61	4.19
Average no of trees per holding	128	73	70	75	66	595	115

Source: Al Ain City Municipality (2011)

Date palms are usually fertilized, although responses to fertilization are inconsistent particularly when applying nitrogen. Manure has traditionally been used in date production, but increasingly inorganic fertilizers are used. Cover and pasture crops are also often used in date production. In Liwa and Al Ain date palms provide shade for fruits and vegetables intercropped with dates.

#### 2.4.5 Date palm harvest and post-harvest knowledge

Unlike most other fruits, dates can be consumed at the four distinct ripening stages described below, with obvious implications regarding their utilization, marketability, nutritional value and processing. These four stages are usually referred to by the Arabic terms “Kimri,” “Khalal” (or “Bisr”), “Rutab,” and “Tamar” to represent the immature green, the mature full colored, the soft brown, and the hard raisin-like stages, respectively.

During the Kimri stage, the fruit increase in size and weight rapidly until in the Khalal stage they reach full size and weight (Fig. 7). The fruit color changes from green during Kimri to a color characteristic of the cultivar during Khalal. They remain turgid and astringent and due to a substantial amount of water-soluble tannins have adstringent taste. Fruits during the Rutab stage are characterized by a darkening of the skin to amber, brown, or nearly black, accompanied by softening, decreasing astringency.

Elite or endangered cultivars cannot be propagated through off-shoots quickly enough and distributed en mass to farmers. During the last few decades, much effort has therefore been given to the development of micro-propagation methods that are fast and reliable in generating large numbers of genetically identical plants (clones). This relies on the use of various tissue culture methods, which speed up the multiplication of individual trees with desirable characteristics of growth and fruit quality. Phytosanitary reasons are a further advantage of micro-propagation (avoiding the spread of pests and diseases through off-shoots).



**Figure 7.** Date fruits at the Khalal stage, when reaching full size and weight (Photo: Dr. Zaid)



**Figure 8.** Shrivelling of date fruits due to water loss at the Tamar stage (Photo: Dr. Zaid)

## 2.5 Cultures, value systems and social organisations

Like no other religion, Islam holds dates and the date palm in great esteem. The Holy Koran mentions dates and the date palm in many suras (chapters) and verses. Prophet Muhammad, *Peace be upon Him*, is reported to have said that the best property is the date palm, that dates cure many disorders, and he urged Muslims to eat dates and tend the date palm.

Daily fasting during Ramadan is broken every evening with the fruit. In the hadiths, the sayings of the Prophet Muhammad, he often mentions the benefit of eating dates. He is quoted as saying: "The family who has dates will not go hungry," implying that if a person has dates in his home, he is satisfied.

## 2.6 Aflaj irrigation systems in Al Ain

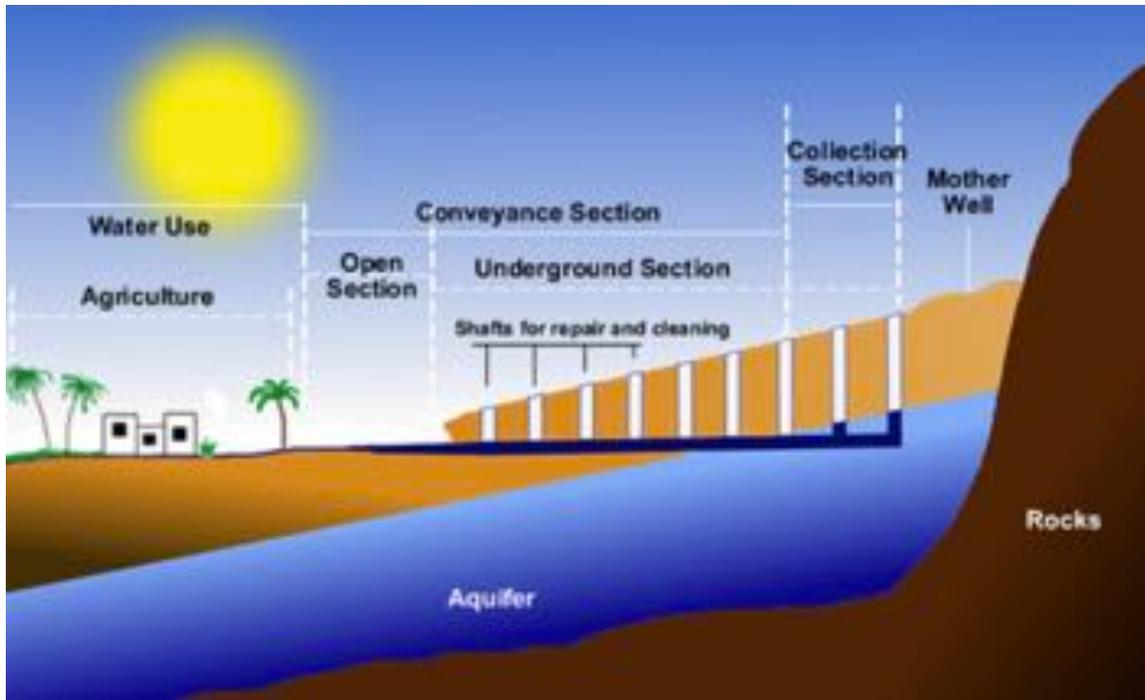
Aflaj (singular: Falaj) are traditional man made channels, found both above and below ground, used to collect groundwater, spring water and surface water and transport it, by gravity, to a demand area. Historically, they provided the main source of drinking and irrigation water to the seven Al Ain oases.

Three types of aflaj are known, namely:

- *Aini aflaj* water sources are invariably springs, which develop due to impervious bedrock exposures, and are perennial in nature;
- *Dawoodi* or *Daoudi aflaj* are subterranean and are constructed channels, which are accessed via vertical shafts. Their source is a mother well, which feeds the main channel by gravity. The aflaj in Al Ain are mostly of the Dawoodi type as schematically represented in Fig. 9;
- *Ghaili aflaj* consist of channels, which is fed by bunding and diversion of a surface water flow, most often an active wadi bed or a spring.

However, none of the Al Ain Aflaj are currently working fully under natural flow conditions, rather they are now largely supplemented from pumped groundwater from 96 groundwater support wells and piped desalinated water, at a rate of 1,6 million imperial gallons per day from the relatively new Qidfa desalination plant in Al Fujairah.

Artificial recharge has also occurred in and around Al Ain City as a result of substantial leakage from piped distributions systems, resulting in a general rise in groundwater levels over the last 4-5 years, specifically from 3 m to 10 m. On the other hand, groundwater levels in the source area and original mother well locations have declined significantly, thus causing the original source mother wells to become dry and the aflaj to no longer operate with natural discharge.



**Figure 9.** Longitudinal cross-section of a dawoodi falaj  
 (Source: [www.flickr.com/photos/suonnoch/3434372154/in/photostream/](http://www.flickr.com/photos/suonnoch/3434372154/in/photostream/))

The current situation of the Al Ain aflaj is as follows<sup>6</sup>:

- Al Dawoodi falaj, which supports Al Ain Oasis, is now fed by 24 groundwater wells. It receives some natural flow but also desalinated water from Qidfa. The mother wells of the Dawoodi aflaj range in depth from 6.5 to 30m and are located some 7km away. It is estimated that one third of the total flow is still natural groundwater discharge.
- Falaj Al Mutaredh went dry in 1982 and has no natural flow. It is supplied by nine boreholes (approximately yielding 800m<sup>3</sup>/d) and treated sewage effluent.
- Falaj Al Qattara was reported as being dry as early as 1979. Between 1964-1969, it averaged a flow of 31 l/s. Today, it is the only falaj, which is supplied by only pumped groundwater (25 wells supply Qattara and Al Jimi Falaj).
- Falaj Al Jimi went dry in 1979. Today, it shares a 25-well supply with Falaj Al Qattara, but is also receives treated sewage effluent.
- Falaj Al Muwaijei also went dry in 1979, prior to which it had a discharge of around 20l/s.
- Flaj Al Jahili has only a trace of natural flow. The mother well is located in the vicinity of the Inter-continental hotel, Zaroub. The falaj shafts and channel have been re-furbished.

<sup>6</sup> Brook & Al Houqani 2006



**Figure 10.** Al Ain Falaj (Source: Abu Dhabi Tourism & Culture Authority)

## **3 Historic relevance**

### **3.1 History of Al Ain and Liwa**

The Al Ain area appears to have been permanent settlement since the Neolithic period. Extensive scatters of flint tools have been found in the nearby desert. From the Bronze Age, there are the Jebel Hafit tombs, the Hili Tomb, the Qattarah grave and Iron Age villages at Rumailah and Qarn Bint Saud. Early Omani chronicles suggest that the area was important at the beginning of the Islamic era, and archaeological remains testify to a substantial township in the early Abbasid period.

Until the late 1960s, Al Ain was an isolated date palm oasis with a small resident population controlled by semi-nomadic bedouin of the Beni Yas confederation. The leaders of the tribes had gained control of the oasis by steadily purchasing date palm gardens. The Beni Yas had their main seat of power in the coastal settlements at Abu Dhabi, west of Al Ain and were the most important tribe in a group of oases in the Liwa area to the south west of Al Ain. The journey of 160 km from Al Ain to Abu Dhabi took a

minimum of three days by camel and could take as long as 2 weeks for a caravan of goods.<sup>7</sup>

In contrast to the early history of Al Ain, evidence of human occupation is much more patchy in Liwa. It was occupied during the Neolithic period (around 6000 BP), when there was much more rainfall than there is today, and dunes would have been lush with vegetation. But during the following Bronze Age there was a sharp reduction of rainfall, and there is no evidence of human occupation until the Late Islamic period (16th or 17th Centuries). It is not yet known why there appears to have been no occupation in Liwa until a few hundred years ago. By around the 16th century, Liwa has been occupied again, by the Manasir, who also migrated northwards to the eastern coastline of Saudi Arabia, and elements of the Bani Yas confederation, according to historical sources.<sup>8</sup>

Practically the only vegetation in Liwa were the gardens of date palm, which are able to survive due to the deep root systems. There are a few wells but the water tended to be brackish and did not support subsidiary agriculture. In contrast the plantations of the Al Ain area have the benefit of continuous running water from several ancient falaj, underground water collection channels, which tap the ground water flows from the adjacent Hajar Mountain range. This really explains the attraction of the Al Ain date gardens. Not only was the date yield approximately doubled but substantial planting could be undertaken in the shade of big palms to provide fresh vegetables and fodder to help support sheep and goat herds.<sup>9</sup>

As a true sand desert oasis, Liwa oasis was the first economic power base of the Beni Yas, which augmented their nomadic camel herding. Liwa settlements have been variously estimated as between 38 and 48 according to their degree of occupancy, which traditionally was in the summer months only. A 1968 survey gave a figure of 301 families living in 37 valleys: six were used by between 20 and 32, and another ten between 10 and 20. Eight were only used by a single family.

### 3.2 The date palm and oasis livelihoods

Dates have been a staple food of the Middle East for thousands of years. They are believed to have originated around Iraq, and have been cultivated since ancient times from Mesopotamia to prehistoric Egypt. There is archaeological evidence of date cultivation in eastern Arabia in 8000 BP.

The early Neolithic settlers of the Gulf were already aware of the use of dates. Some of the earliest evidence for date consumption found within the Middle East is the archaeological discovery of carbonized date stones on Dalma Island, which is located in the Persian Gulf approximately 42 kilometres off the coast of Abu Dhabi. Dated to the late 6th to early 5th millennium BP, it is clear that they were consumed at that time, although it cannot be determined whether they represent wild or cultivated dates. They

---

<sup>7</sup> Iddison 1998

<sup>8</sup> Hellyer 2012

<sup>9</sup> Iddison 1998

may have been harvested locally on Dalma but they could also have been brought onto the island through trade.<sup>10</sup>

Along with the camel, the date palm was responsible for opening the vast desert territories for human activity and the development of oasis agro-ecosystems. The oasis essentially represents the climax of rigorous management of scarce water and land resources in alliance with the date palm, the only indigenous desert plant definitely domesticated in its native harsh environment.

Date cultivation has had a very important influence on the history of the UAE. Without dates, no large human population could have been supported in the desert regions. The caravan routes existed for centuries mainly for the transportation of dates. Early on, date cultivation became a sacred symbol of fecundity and fertility, and had great spiritual and cultural significance.

### 3.3 History of aflaj irrigation systems

The water resources development within Abu Dhabi can be traced right back to the stone age (7,000-6,000 BP), through the iron age (3000 BP) and Islamic period to the present day. Shallow hand dug wells (only a few meters deep) and aflaj systems provided permanent water sources for sustainable agriculture and drinking water. Many Islamic period aflaj irrigation systems, which account for most sites, continued in use until pre-modern times and were regularly cleaned. The Iron Age aflaj have, however, long since fallen out of use and are now covered and blocked.<sup>11</sup>

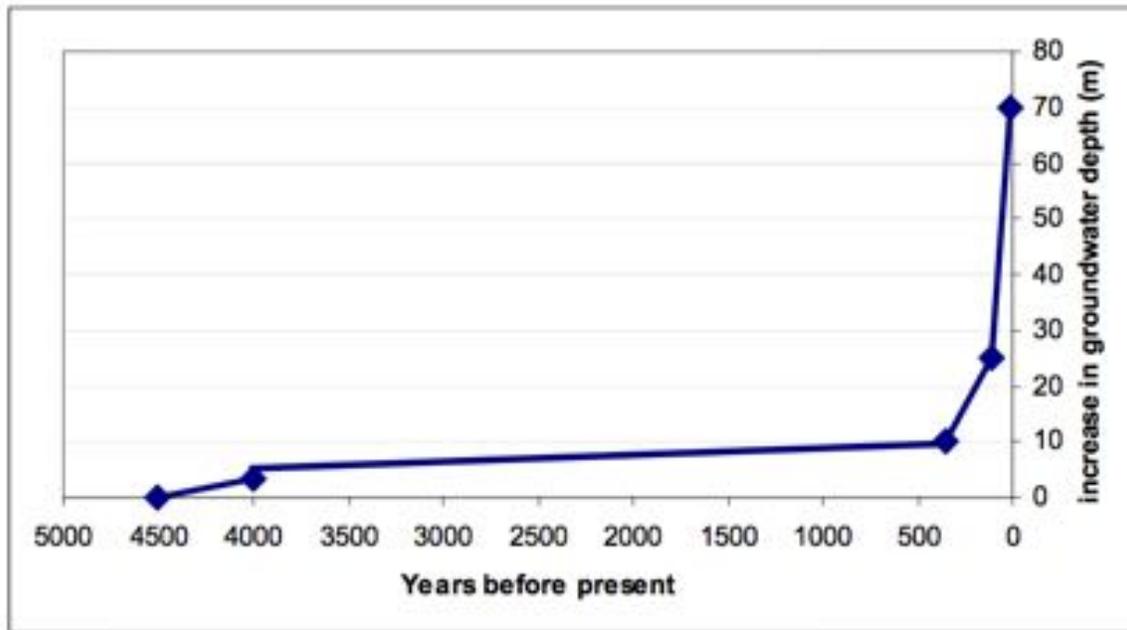
Hydrologic and archaeological studies of climate change in Al Ain have shown that trends of increased well depths and declining water levels for the past 4,500 years correlate with an increase in aridity of climate (see Fig. 11). Water tables declined slowly from 4,500 BP 400 BP, but since the decline has been accentuated with a very rapid, largely anthropogenic, drop in the last 120 years.

The increase in aridity experienced in Abu Dhabi represents a trend, which existed over all or most of the Middle East, the eastern Mediterranean and northern Africa, which had an immense impact on civilizations. In the Al Ain area, non-irrigation farming could not successfully be sustained at the end of the Bronze Age. This hindered economic development until the aflaj system was introduced in the Iron Age.

---

<sup>10</sup> Beech & Shepherd 2001

<sup>11</sup> Al Tikriti 2002



**Figure 11.** Changes in groundwater levels at Al Ain over the last 4,500 years.  
(Source: Jorgensen & Al Tikriti (2002))

### 3.4 Traditional Arish palm-leaf architecture

Date palms were cultivated in Liwa and Al Ain for centuries not only to produce food, but equally important, to provide material for the ingenious construction of houses known as Arish, traditional summer dwellings (Fig. 12). Dry palm leaves, palm trunks and rope (made from palm trunk fibres) are the only materials used to build these simple and yet highly sophisticated enclosures, illustrating the traditional dependence on one single species of tree in the desert environment.

Carbon-14 archaeological studies have found that the first settlements in UAE using the Arish technique date back as far as 7,000 years. Arish has thus been fundamental to the Arab housing culture since the dawn of civilization. It is extremely interesting to note that the tradition still endures notwithstanding its great risk of extinction.

In 1908 the population of Liwa Oasis would have required around 800 of these homes, which were typically built by women while the men followed a summer migration to the coast in search of income. As recently as the 1970s, when the oil industry introduced sudden wealth and Western building techniques to the Arabian peninsula, Arish buildings accounted for 80 per cent of domestic dwellings in the Emirati region.



**Figure 12.** Arish palm-leaf houses in Liwa, 1948 (Photograph of Wilfred Thesiger, source: <http://www.architectural-review.com>)



**Figure 13.** Fastening the roof of a date palm leaf house to the cross beams and external palm panels, using rope made of palm hair derived from the top of the date palm's trunk (Source: Rhawker's Blog <https://rhawker.files.wordpress.com/2011/06/p1010949.jpg>)

Beautiful and versatile, and varying in style and weaving patterns, the Arish palm-leaf architecture is based on a locally available, carbon-neutral and biodegradable resource. It epitomizes the kind of heritage techniques that many contemporary architects are turning to in response to the need for fresh thinking regarding urban expansion and its impact on climate change. Together with layouts that optimize available shade and wind towers that channel wind into living areas, traditional building principles such as Arish offer valuable lessons to architects and planners as to how the challenging climatic conditions of the UAE can be tamed using sustainable methods. With contemporary Western architecture now being much used in the Gulf region, Arish building techniques are being lost. However, it is believed that the Arish legacy can be safeguarded during the next two decades before this tradition fades away forever along with those who preserve it.

Recognizing the date palm's pivotal role in the UAE's traditional architecture, and with the patronage of the Abu Dhabi Tourism and Culture Authority, a recent exhibition in London celebrated the unique Arish building and craft tradition. It provided a comprehensive overview of palm-leaf architecture, its history and traditions, including historical photographs, the description of architectural and stylistic details and their regional variations, contemporary applications of palm-leaf architecture, and an introduction to the making of Arish houses, from raw material to built form.

The exhibition and the associated publication of a book in 2012 is an attempt to safeguard Arish heritage and to bring it from the past to the contemporary urban landscapes of Al Ain and Liwa<sup>12</sup>. It is also an example of the integration of locally available natural resources with wisdom that has accumulated over millennia of experimentation. The Tourism and Culture Authority recognizes the need to capture the imagination of a new generation of architects and engineers to develop Arish technologies in ways that are commercially viable, such as the possible contemporary use of palm-leaf construction using classic manual techniques — basically, arched structures made of fascia that compensate for the material's lack of mechanical strength — as well as the prefabrication of lightweight hybrid palm-leaf and metal-jointed structures.

## 4 Contemporary relevance

### 4.1 The role and importance of agricultural production in Al Ain and Liwa

The world date palm cultivation is concentrated mostly in the Near East and North Africa, favoured by the suitable dry sub-tropical and high temperature climate prevailing in these regions. According FAOSTAT (2009) about 75% of the world production of dates is in Arab countries for 2008; half of this is in the Gulf area (including Iraq and Yemen).

---

<sup>12</sup> Piesik 2012

El Juhany (2010): The UAE has the largest number of date palms for any single country in the world. It was reported to have 40 million date palm trees. In 2006, the UAE had 16,342,190 productive date palms producing 757,600 tones of dates (AOAD, 2008). Recently, The UAE has been officially recognized as the world's leading cultivator of date palms with 42 million trees, as was announced on 15 March 2009. Abboudi (2000) reported that the UAE has become 100% self-sufficient in its date consumption.

## 4.2 Date consumption and dietary significance in UAE

Date fruits are tremendously appreciated in the UAE for their food and feed uses. Dry and soft dates are often eaten out-of-hand. They may also be press-packed, sliced or prepared in many ways to generate other products consumed locally and elsewhere. These include their use in pudding, bread, cakes, cookies, ice cream, candy bars and cereals.

An entirely new industry has also been developed in recent years around date palm and dates. For example, factories with more or less sophisticated means of pitting, piercing, crushing and sieving dates provide a significant number of local jobs. Surplus production not consumed fresh often is transformed locally into paste, spread, powder (used locally as a sugar), jam, jelly, juice, syrup, vinegar and alcohol. Unused dates do not go to waste. They are often dehydrated, crushed and mixed with grains and straw to become a valuable feed for domestic animals.<sup>13</sup>

The most often consumed dates and date products in UAE are rutab, tamr, seh (pitted tamr pressed into dough), debbs (date syrup), batheeth (tamr dough mixed with flour and ghee) and madlouj (tamr dough mixed with ghee). In one consumer survey, a majority of the UAE population reported consuming rutab daily, mostly in the summer, coinciding with its season of harvest and availability, but a sizable percentage of the population consumes rutab throughout the year because of the common practice of freezing it in bulk, thus making it available all year round. Different consumption habits were found for tamr. Small, medium, and large portion sizes are almost equally eaten by consumers. Similar to rutab, and because of its continuous availability, tamr is consumed daily by a majority of the respondents, throughout the year. In general, surveyed people consume small portions of seh year-round, and the percentage of people that rarely consume seh was high compared to rutab and tamr.

Debbs, batheeth, and madlouj are of minor importance to today's population in Abu Dhabi. They are rarely consumed and, if so, mostly in small portions.

On average, the daily consumption of dates per capita in UAE was found to be 114 g (41.6 kg per year). While date fruit consumption in terms of frequency and portion size appears to be independent on gender, there is a marked difference in consumption between generations, with younger Emirati (18-30 years) consuming much fewer dates at lesser frequencies than their older fellow citizens (30-60 years), of which two-thirds still consume dates on a daily basis. It is not clear, though, whether this generational

---

<sup>13</sup> El-Hadramy & Al-Khayri 2012

discrepancy is due to younger people moving away from traditional dietary habits, or whether it reflects a tendency for people to consume more dates as they grow older, a phenomenon observed in some cultures.<sup>14</sup>

### 4.3 Date palm research and policies

There are several national institutions working on the date palm cultivation and related subjects such as Aflaj irrigation systems. These institutions include the University of Al Ain, Ministry of Environment and Water, several Municipalities, Abu Dhabi Food Control Authority, Abu Dhabi Tourism & Heritage, etc.

Date palm is considered as the skeleton of the UAE agricultural system. A range of national policies concern or impact on date palm genetic diversity, and most national planning strategies include such components.<sup>15</sup>

## 5 Threats and challenges

### 5.1 Urban development pressures

Urban development has been very present in the immediate vicinity of Al Ain oases since the early 1960s. This refers in particular to urban development around the periphery of Al Ain oasis such as the establishment of an industrial zone south of Al Ain, the construction of motorways and express roads bordering the oases, construction of hotel complexes, at times very visible within the landscape.

Traditional agricultural production in the oases, of dates in particular, is tending to become much less profitable than in the past, within an otherwise prosperous economy. Two trends have arisen: the temptation to improve crops using non-traditional methods or the replacement of crops and farming with more profitable activities.

Nevertheless, the private owners of the oases have maintained a basic level of cultivation, supported by the Municipality's Aflaj Directorate, which manages irrigation by way of pumping water into the traditional falaj network. The oases have also been left largely untouched by the city's development, which encircles them.

Various factors do continue to affect the oases' integrity and authenticity. These include: (1) a certain degree of urban encroachment along the oasis fringes; (2) unsympathetic developments affecting their visual setting; (3) littering within their boundaries; (4) wind and water erosion acting on the fragile earthen materials of the historic buildings and walls in the oases in combination with deficient repairs and maintenance; (5) increased use and visitation potentially exceeding their carrying capacity.

Further factors are related to the effects of deeper social and economic changes. These include physical interventions necessitated by the new model of subsidized agriculture,

---

<sup>14</sup> Ismail *et al.* 2006

<sup>15</sup> Personal communication, Dr. Zaid, December 2014

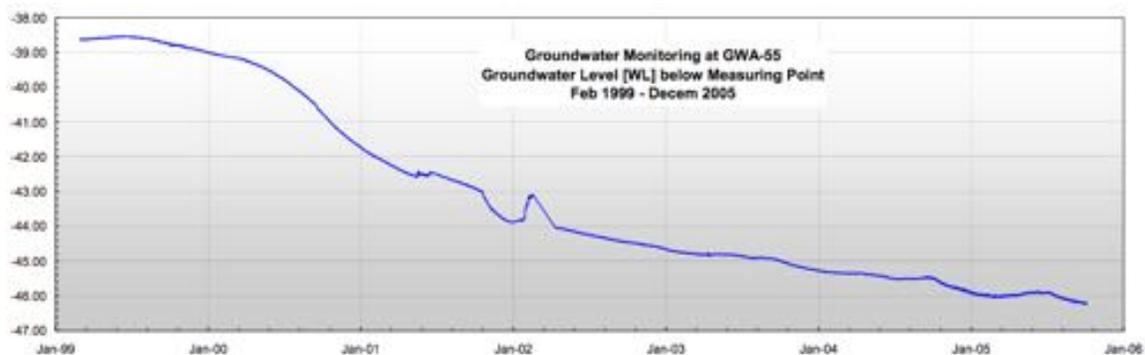
such as widening of oasis pathways, and replacing their original mudbrick surface and boundary walls with concrete. Moreover, traditional knowledge of oasis management is being lost to the younger generation of Emiratis, as they prefer to employ Asian expatriate workers to manage their gardens.

## 5.2 Decline of the aflaj irrigation systems in Al Ain

The last 50 years have seen incredible economic development in Abu Dhabi and massive growth in the use of water, largely sourced from groundwater aquifers. Technical innovation such as the introduction of the electric submersible pump in the early 1980's has further accelerated groundwater productivity, but at the expense of aquifer sustainability. Groundwater abstractions have continued unregulated with severe consequences of declining groundwater levels and substantial increases in groundwater salinity in some areas and also widespread groundwater pollution associated with agricultural practices.

Today, the aflaj continue to be used for irrigation of the Al Ain oases, which occupy an area of 350 ha, or about 5% of the total green area of the city. However, only two of the seven operating aflaj have natural flow and all aflaj are supported by varying mixtures of pumped groundwater from wells, imported desalinated water from Qidfa desalination plant, and, more recently, from treated sewage. Augmentation of the significantly reduced natural discharge with groundwater pumped from on-site wells commenced in 1983.

The irony of the water situation is that, while groundwater decline in the area of mother wells has continued in recent years as shown in Fig. 14, water levels in the immediate vicinity of the aflaj, have risen for the last 5–10 years as both desalinated water and treated effluent has been used for irrigation of the green areas of Al Ain city and has recharged the shallow groundwater table.



**Figure 14.** Groundwater decline as revealed by observation wells in the vicinity of Al Ain Aflaj mother wells (Vertical axis indicates water level in meters below ground level) (Source: Brook & Al Houqani 2006)

For the time being the drying of mother wells is being offset by the massive injection of additional water into the old aflaj system from groundwater and desalination, and

wastewater treatment. The main risk from climate change is the further drop in the aquifers.

### 5.3 Degradation of date palm plantations

Date palm production faces serious problems such as low yields as well as marketing constraints. Over the last decade, productivity of date palm trees has declined in the traditional growing areas. As much as 30% of production can potentially be lost as a result of pests and disease. In the Gulf countries and Egypt, the Red Palm Weevil has recently become one of the major date palm pests.

Rehabilitation of date palm trees is crucial and needs collaborative efforts and a dedicated budget. Recommendations for stopping the degradation in date palm sector and strengthening this industry particularly for cultivation, harvesting, date processing and marketing in the Arab countries have been proposed.

In a review article on the decline of date palm plantation in Arabic countries<sup>16</sup>, identifies the following issues as affecting detrimentally date palm production in UAE: (1) shortage of qualified and trained farm workers, (2) lack of adequate pest and disease research, (3) a shortage of good quality varieties, (4) poor harvesting, processing and packing techniques, and (5) poor water management resulting in the overuse of limited groundwater.

The Red Palm Weevil (*Rhynchophorus ferrugineus*) is considered a major pest of the date palm in UAE. Capable of killing date palms fast, it has been a big menace in the recent past causing considerable harvest losses and requiring considerable resources for the control of this pest. The Red Palm Weevil was discovered in UAE in 1985. In the five years to 1995, trees infected with the Red Palm Weevil in the UAE increased from 1,300 to 44,000 date palms

### 5.4 Threats to biodiversity

#### 5.4.1 Agricultural biodiversity

At the current time, there seems to be no real threat to the extant date palm diversity in Al Ain and Liwa. Most orchard owners in the oases are not solely guided by commercial considerations in the selection and maintenance of the varietal composition of date palms. Indeed, many owners are rather well off through income from non-agricultural sources. They insist on having a large spectrum of date varieties, including commercial and rare varieties. Their preference for diversity rather than market demand-driven predominance of a small number of varieties, and the resultant narrowing of the genetic base is in large measure because of the extended period of maturation period of fruits as explained above, which make freshly harvested date fruits of a preferred quality available for their own consumption for a long period, lasting from early May until early January (about nine months per year!).

---

<sup>16</sup> El-Juhany 2010

Each oasis, or indeed many of the individual small and medium-scale holdings within an oasis, could be considered as an *in situ* conservation site for date palm genetic diversity owing to the large number of cultivars – frequently exceeding 20 - maintained per holding.<sup>17</sup>

## 5.5 Loss of indigenous knowledge

Elderly people with traditional knowledge on the ecology and management of the date palm oases are becoming increasingly rare. Eventually they will pass away without handing over their age-old wisdom to younger generations. Moreover, young people with the career choices available in a high-income country such as the UAE, lack incentives to carry on with the hard work of their forebears. The globalization and increasing uniformity of cultural and dietary preferences further exacerbates the abandonment of customs and etiquette. It has also been suggested that more emphasis needs to be given to the teaching of traditional knowledge and values in schools.

Loss of traditional knowledge, unless preserved in written accounts that document ancient practices, can jeopardize the conservation of Al Ain and Liwa date palm oases, or lead to changes in the management of crop husbandry and the irrigation. The regulatory and provisioning ecosystems services provided by the oases, is substantially undervalued.

## 6 Dynamic conservation plan

### 6.1 Abu Dhabi Vision 2030

Al Ain has in recent years been the fastest changing city in the Arabian Peninsula. It has gone from a desert oasis to a thriving modern city in just over 30 years<sup>18</sup>. The conservation of the oases, which are embedded in the urban area, therefore has to be seen in the overall development context of the city. While many cities around the world are being developed at the cost of agricultural areas, remarkably, Al Ain's development has been based on conservation of agricultural areas and the reclamation of the desert.

Key to the understanding of Al Ain and Liwa oases perspectives is the "Abu Dhabi Vision 2030", a strategic framework plan undertaken by the Abu Dhabi Urban Planning Council (UPC). Guided by the environmental, economic, social and cultural Estidama<sup>19</sup> principles, the plan sets out a pathway to a sustainable Abu Dhabi that protects resources for current and future generations. It aims to achieve this by (1) supporting and enabling economic diversification and growth; (2) raising the standard of living across Abu Dhabi; and (3) enhancing and promoting Arab and Emirati culture and tradition.

---

<sup>17</sup> Based on correspondence with Dr. Aabelouahhab Z. Zaid

<sup>18</sup> Yagoub 2004

<sup>19</sup> Arabic for « sustainability »

Flowing from the overarching principles is a set of key directions that underpin the realisation of Vision 2030 and form the basis for all plans. The first framework plan – ‘Plan Capital 2030’ – was launched in 2007 and was ground-breaking in both scale and approach. Since then, the UPC has gone on to prepare other regional framework plans – Plan Al Ain 2030 and Plan Al Gharbia 2030.

### **6.1.1 Conservation plan for Al Ain oases**

Vision 2030 calls for Al Ain to become “a contemporary expression of a healthy desert oasis city that builds on traditions of water management and agriculture while expanding the role of the oasis in the urban setting.” And further: “Al Ain will embody its role as the founding source of the Abu Dhabi through protecting its historic assets, its delicate cultural landscapes, and its noble heritage.” This will be supported by an economic development towards competitive manufacturing, service trades, higher education and healthcare as well as expanded cultural and ecological tourism.

Vision 2030 further calls for the bio-diverse habitats of Jebel Hafeet, adjacent to the city, the oases, the desert, and the wadis to be respected and conserved. Oases, wadis and farm edges will be designed sensitively where they integrate with the city. A substantial protected desert and mountain belt around the city of Al Ain will be established as a National Park.

Al Ain is famous for its character as a ‘Garden in the Desert’ and Vision 2030 seeks to preserve and enhance this desirable quality. Al Ain’s oases are more than just palm plantations. They are cultural landscapes and marvels of ancient hydrology. They are the heart of the community and its most iconic aspect. They are living museums, providing insight into the past and guidance for the future. As the city’s heart and soul, they will reassume their place as a vital part of the city’s public realm.

Unfortunately, the oases of Al Ain are not in an ecologically healthy condition. They are beset by a variety of challenges, including the loss of traditional agricultural practices, contamination with pesticides and fertilizers, encroachment by development, and the recent addition of non-traditional concrete walls. The Plan seeks to address these issues and restore the oases to health and prominence.

The first achievement in this regard was the designation of Al Ain as a UNESCO World Heritage Site, which has been accomplished in 2011 (see section 6.4). This designation has brought about additional protection the oases warrant, in the face of neglect and development pressures.

The Al Ain Oasis located in the downtown, in particular, is the city’s foremost feature and amenity. Several measures are proposed to reintegrate the oasis into the life of the city. View corridors will be established ensuring the oasis is visible down prominent axes. Precincts are established around the edge of the oasis to define its edge and prevent encroachment from inappropriate development. The programming of the oasis edge precincts focuses on culture and tourism, building on the key strengths of Al Ain’s brand. As seen in Fig 15, planted pedestrian byways will emanate out from the oasis, carrying its theme through the city. They link parks, courtyards and public outdoor spaces into a

continuous network of shaded pedestrian paths through the city, enhancing Al Ain's garden city character.

The edges of the oasis are currently ambiguously defined, allowing development to encroach upon it. The scheme proposes a series of well-defined precincts ringing the oasis to robustly define its edge and prevent encroachment. The northern edge is the main interface with the downtown, and this is envisioned as a continuous shaded mixed-use Souk District, with cafes that provide views onto the oasis.

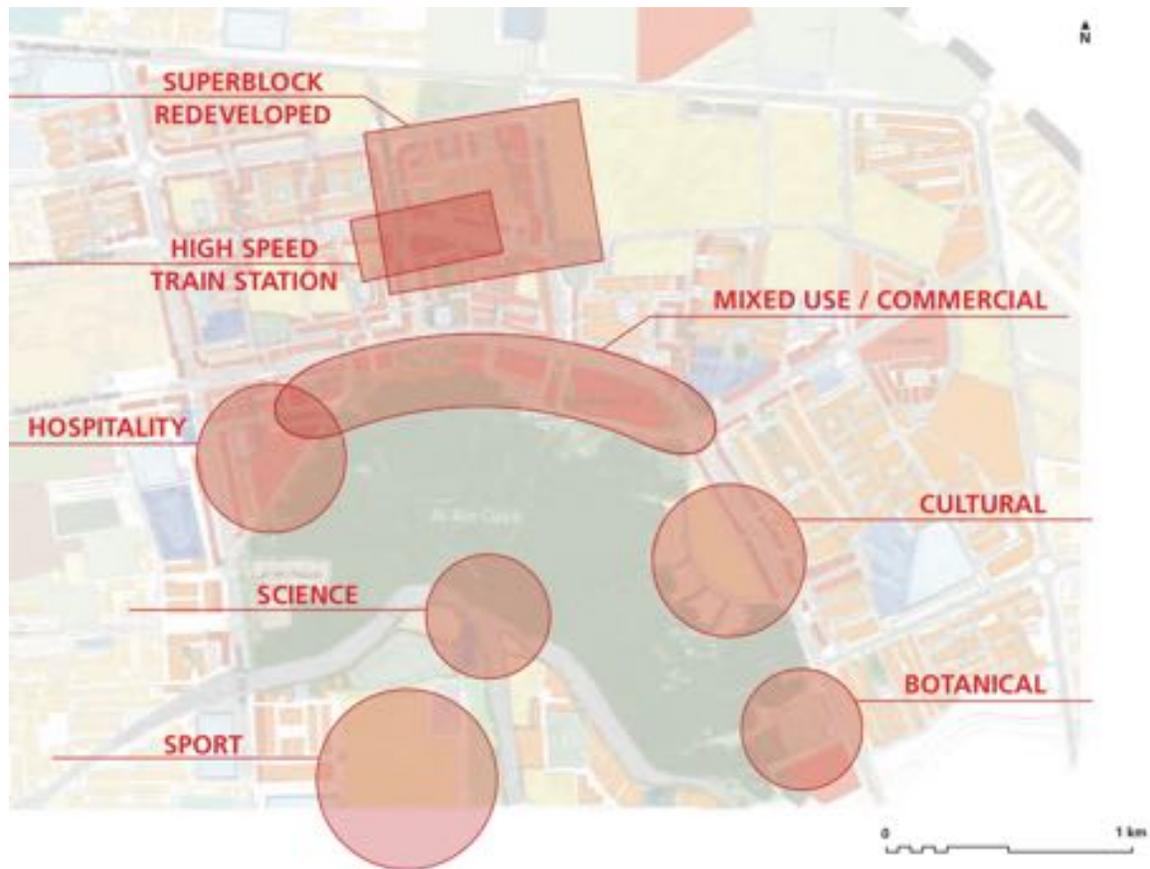


**Figure 15.** Al Ain Oasis (Source: Plan Al Ain 2030, Urban Structure Framework Plan)

The east edge is envisioned as a new cultural complex, with new museums and interpretive centres around the existing Al Ain Museum (see Fig. 16). The potential scope and breadth of cultural programming is diverse and exciting: a falaj museum telling the story of this ancient engineering marvel, an adobe brickyard “working museum” ensuring the maintenance of the walls at the city’s forts and oases, a traditional agriculture interpretive centre, and an expansion to the Al Ain Museum focusing on Al Ain’s role as the cultural repository of the UAE.

As schematically represented in Fig. 16, large open space at the southeastern corner of the oasis is an ideal place for a botanical garden, an amenity many world class cities enjoy. The very special place where the ridge finger and wadis intersect in the middle of the oasis’ south side, requires some very special programming, such as natural history museum featuring Al Ain’s landscape, geomorphology and climate of Al Ain, and its role in shaping the culture over the millennia.

Finally, the northwest corner of the oasis is a key interface with the city and a good point to introduce hospitality programming to make the oasis accessible to tourists. A hotel and resort complex is proposed, consistent with the current vision for that site.



**Figure 16.** Development vision for Al Ain Oasis according to Plan Al Ain 2030 (Source : Plan Al Ain, Urban Structure Framework Plan)

In conclusion, the conservation plan for the Al Ain GIAHS Heritage site foresees for all oases: (1) The restoration of traditional intercropping methods with date palms, fruit trees and vegetables as, upper, middle and lower canopy layers, respectively; (2) A ban on synthetic pesticides and fertilizers in favour of traditional methods of integrated pest control; (3) Design Guidelines for the Oases that permit cultural buildings around the perimeter, with a soft gradient of planting transitioning to the historic boundaries of the oases.

In Al Ain oasis specifically, the conservation plan seeks to: (1) Remove the perimeter concrete walls that have been recently added to Al Ain Oasis and replace them with adobe walls built with the traditional technique and at the traditional scale; (2) Surround Al Ain Oasis with cultural installations, including a traditional adobe brickyard to ensure ongoing maintenance of the oasis; (3) Solidify the edge of Al Ain Oasis, introduce new buildings, cultural programs depicting significant aspects of Al Ain's natural surroundings, heritage, traditional agriculture, and royal character.

### 6.1.2 Conservation plan for Liwa (Plan Al Gharbia 2010)

The result of a sequence of interactions between major public and private sector players, Plan Al Gharbia 2030 is a government-sponsored planning framework comprising planning policies, sustainability principles and a conceptual function for each of the seven townships in Al Gharbia including Liwa. The planning process has been a collaborative effort between municipal officials, developers and local residents. The public played an important role in the planning via public consultation sessions, which were discussed in local papers.

A set of overarching principles was developed, which will guide the future development of the Al Gharbia region. These include:

- **Managed Responsible Growth:** model sustainable development which accommodates appropriate growth and offers a high quality of life;
- **Environmental Responsibility:** ecosystems will be protected and enhanced including the desert, oases, and coastal and marine habitats;
- **Social Health:** access to quality social services for health care, education, community & cultural facilities;
- **Cultural Identity:** preserve and ensure traditional Arabic, Bedouin, and Islamic rural culture, character, lifestyle and heritage;
- **Growing Population:** reduce out-migration of Emiratis by encouraging people to return/remain through the provision of quality services, housing, and job/business opportunities;
- **Economic Development:** support the Oil & Gas industry and diversify the economic activity, while returning wealth to the region by the provision of economic opportunities, social amenities and housing.

## 6.2 Sustainable water management

Al Ain's ancient ancestors devised the ingenious falaj system to bring mountain water down to the oases. Water is still crucial to their health and the health of the community. Water, particularly ground water, is severely constrained and needs new conservation measures to regulate it. A long-term vision is proposed to replenish Al Ain's diminished aquifer to restore its water level to its original state, while protecting it from contamination. Over time, the original gravity-based falaj system of delivering water to the oases will be restored. Throughout Al Ain, appropriate and drought tolerant trees, plants, and landscaping will be used to conserve water while shading and cooling Al Ain's public realm.

Vision 2030 proposes the formation of a public trust that will regulate and maintain ground water supplies. The trust will also be charged with maintaining the oases,

bringing back the traditional agricultural practice of intercropping three crop spheres to ensure that this sustainable knowledge is not lost. The trust will preserve and maintain the oases, but it will not own them; the ownership structure will remain unchanged.

### **6.3 Sustainable tourism**

The oases and its surroundings are identified as the focus of tourism activity, and it is clear that tourism in Al Ain and Liwa is a vital force that can help revitalize the oases. However, potential pressures on carrying capacities are being monitored and managed. The Abu Dhabi Authority for Culture and Heritage (ADACH) has aimed to integrate the oasis heritage into the tourism portfolio of Al Ain and Abu Dhabi, while taking measures to mitigate its negative impact and balance it with the wider community benefits of heritage.

Visitor centers and cultural venues for concerts are set to expand within the Al Ain Oasis Cultural Quarter, and other new hospitality developments in the area as described in section.

### **6.4 UNESCO designations of Al Ain**

For Al Ain Oases to be designated as a GIAHS site, it is also highly relevant to consider that Al Ain's cultural sites have been inscribed in 2011 in UNESCO's World Heritage List. The Cultural Sites of Al Ain comprise the Hafit Assemblage, Hili Assemblage, Bidaa Bint Saud site; and the oases (Al Ain Oasis, Mutared, Muwaiji, Hili, Jimi and Qattara) spread across the city's interior. UNESCO's decision recognizes a landscape characterized and deeply shaped by the oases' history, agriculture and hydrology. It highlights the cultural sites as expression of distinctive technological developments such as the ingenious falaj system and its associated management system.

The decision furthermore points out the significance of the cultural sites of Al Ain in terms of the evolution of society in that part of the world from mobile hunter-gatherer groups of the Neolithic period to larger oasis-agriculture communities. The Iron Age settlement at Hili Archaeological Park, with its distinctive fortified architecture and circular tombs, includes one of the most ancient extant falaj irrigation systems in the world. The Beit al Falaj public building provides insights into this complex culture, which challenged the environment, developed a distinctive repertoire of defensive settlement architecture and produced a funerary tradition representative of highly sophisticated communal burial traditions and rituals.

The inscription also reflects appreciation for the fact that Al Ain oases and cultural sites managed to retain a high level of authenticity. The city of Al Ain maintains its unique environmental setting consisting of a lush canopy of palm trees and other native desert trees, desert dunes and mountainous ridges. Moreover, Al Ain maintains strict regulations over building heights in the city. The authenticity of materials and substance is high, but original building materials (earthen masonry, earthen finishes, and palm logs and fronds) are fragile, requiring continuous maintenance and repair.

Although a long and complicated process, the World Heritage Site nomination has been a key element of ADACH efforts to protect the historic environment in Al Ain, as an awareness-raising issue for other stakeholders, as a tool of persuasion to control development trends, and as a target that drives many of ADACH's heritage management activities. This has been translated into new conservation initiatives, notably (1) the drafting of a law on the protection of water resources for the traditional aflaj system; (2) the restoration of mud brick constructions performed prior to the 2000s within and outside the oases; and (3) expanded and systematic monitoring of the impact of tourism.

## **6.5 Awareness creation**

### **6.5.1 Emirates International Date Palm Festival**

In November 2014 Abu Dhabi hosted the eighth edition of the annual Emirates International Date Palm Festival (EIDPF), which celebrates dates and the date tree as an integral part of the history and cultural heritage of the UAE. In 2014, the festival attracted more than 175 exhibitors from over 15 countries, and approximately 25,000 visitors, including many tourists.

Each year, new activities and programmes are planned, to help create a better understanding of the significance of the palm tree to Emirati culture, and beyond in the Arabic world. The festival features traditional theatre, cooking workshops, date tree climbing, date tree planting and a date tasting.

Visitors learn about new date varieties and date-based products awaiting their UAE market launch. As well as providing insights to a lay audience on the cultivation of dates, such as pollination, harvesting and drying of dates, EIDPF also conveys a sense of the history of the palm tree in the UAE and the significance of dates within Islamic traditions.

The EIDPF also showcases state-of-the-art technologies and innovations in the field of date farming, harvesting, sorting and packaging, opportunities that attract also date retailers in large numbers.

### **6.5.2 Liwa Dates Festival**

Another recurrent event that celebrates Abu Dhabi's date heritage is the Liwa Date Festival, the 10<sup>th</sup> edition of which took place in 2014 during the Holy Month of Ramadan, under the patronage of HH Sheikh Mansour bin Zayed Al Nahyan, Deputy Prime Minister and Minister of Presidential Affairs. Over the past nine seasons over 70,000 people attended the Liwa Dates Festival. Held on an area of more than 20,000 square metres in the city of Liwa, the festival has actually turned into a major event on the calendar of tourist festivals in the UAE. The festival hosts a wide range of popular heritage and art activities, incl. traditional Emirati folklore, cooking competition, and the popular date palm farmers' souk.

As for quality competitions, there are seven different dates categories, each awarding cash prizes to the top contestants, as well as a mango and a lemon competition. The

competitions are open to any UAE farmer, although most competitors are from Al Gharbia and Al Ain.

The Liwa Dates Festival always takes place in the summer, when the ratab dates are in season, thus providing the opportunity for quality competitions in several dates categories, each awarding cash prizes to the top contestants. The announcement of the results follows the evaluation of farms according to precise and strict norms and conditions that involve the general hygiene at the farm, the palm tree maintenance, and the commitment to use the best irrigation methods to save water.

In parallel with efforts of heritage conservation, the festival also provides a forum to divulge scientific and research successes that have been achieved by the UAE in the field of palm tree cultivation, with significance for improved cultivation, irrigation, and the conservation of genetic diversity.

## 7 References

Abboudi H (2000) United Arab Emirates paper. Report of the twenty-fifth FAO regional conference for the near east, Beirut, Lebanon, 20-24 March 2000, NERC/00/REP. Food and Agriculture Organization of the United Nations. FAO Regional Office for the Near East, Cairo 2000.

Al Ain City Municipality (2011) Al Ain City Municipalities. [Census of date palm numbers and holdings].

Al Tikriti WY (2002) Aflaj in the United Arab Emirates. Archaeological studies on ancient irrigation systems. Abu Dhabi, Ministry of Information and Culture. 161 p.

Beech M, Shepherd E (2001) Archaeobotanical evidence for early date consumption on Dalma Island, United Arab Emirates. *Antiquity* 75: 83-89.

Boudries H, Kefalas P, Hornero-Méndez D (2007). Carotenoid composition of Algerian date varieties (*Phoenix dactylifera* L.) at different edible maturation stages. *Food Chemistry* 101: 1372-1377.

Brook M, Al Houqani H (2006) Current status of aflaj in the Al Ain area, United Arab Emirates. Environment Agency, Abu Dhabi, 25 p.

Chao CT, Krueger RR (2007) The date palm (*Phoenix dactylifera* L.): Overview of biology, uses, and cultivation. *HortScience* 42(5): 1077-1082.

Devshony S, Eteshola E, Shani A. (1992) Characteristics and some potential applications of date palm (*Phoenix dactylifera* L.) seeds and seed oil. *Journal of the American Oil Chemists' Society* 69(6): 595-597.

El-Hadramy A, Al-Khayri JM (2012) Socioeconomic and traditional importance of date palm. *Emirates Journal for Food and Agriculture* 24(5): 371-385.

El-Juhany LI (2010) Degradation of Date Palm Trees and Date Production in Arab Countries: Causes and Potential Rehabilitation. Australian Journal of Basic and Applied Sciences, 4(8): 3998-4010.

FAOSTAT (2009) Crop Production 2008, Statistics Division, Food and Agriculture Organization of the United Nations. Rome, Italy.

Hellyer P (2012) Creating the four pillars of the Emirate. Liwa Journal of the National Center for Documentation and Research, 4(7): 3-12. [Link](#).

Iddison P (1998) A fish suq in the UAE Desert. In: Walker, H. (ed.). Fish food from the waters. Proceedings of the Oxford Symposium on Food and Cookery. Prospect Books, p. 163-182. [Available from Google Books](#)

Ismail B, Henry J, Haffar I, Baalbaki R (2006) Date consumption and dietary significance in the United Arab Emirates. Journal of the Science of Food and Agriculture 86: 1196–1201.

Jaradat AA (2011) Biodiversity of date palm. Land use, land cover and soil sciences. Encyclopedia of Life Support Systems (EOLSS), developed under the auspices of the UNESCO, EOLSS Publishers, Oxford, UK. [USDA link](#).

Jaradat AA, Zaid A (2004) Quality traits of date palm fruits in a center of origin and center of diversity. Food, Agriculture and Environment 2(1): 208-217.

Jorgensen DG, Al Tikriti WY (2002) A hydrologic and archeological study of climate change in Al Ain, United Arab Emirates. Global and Planetary Change 35: 37-49.

Kader, A.A. and A.M. Hussein, 2009. Harvesting and Post-harvest handling of dates, International Center for Agricultural Research in the Dry Areas (ICARDA).

Murad AA, Nuaimi HA, Al Hammadi M (2007) Comprehensive assessment of water resources in the United Arab Emirates (UAE). Water Resources Management 21: 1449–1463.

OBG (2010) The Report. Abu Dhabi 2010. Oxford Business Group. Selected Chapters available from [Google Books](#).

Piesik S (2012) Arish: Palm-Leaf Architecture. Thames and Hudson, London, UK. 192 p.

UPC (2009) Plan Al Ain 2030, Urban Structure Framework Plan. Abu Dhabi Urban Planning Council, 168 p. <http://www.upc.gov.ae/template/upc/pdf/PlanAlAin2030.pdf>

UPC (2009) Al Ain Architectural Guidelines. Abu Dhabi Urban Planning Council, 16 p. <http://www.upc.gov.ae/template/upc/pdf/Al-Ain-Architectual-Guidelines-English.pdf>

UPC (2010) Al Gharbia. Abu Dhabi Urban Planning Council, 26 p. <http://www.upc.gov.ae/template/upc/pdf/AlGHARBIA.pdf>

Wilkinson JC (2009) From Liwa to Abu Dhabi. Liwa Journal of the National Center for Documentation and Research, 1(1): 4-11. [Link](#).

Yagoub MM (2004) Monitoring of urban growth of a desert city through remote sensing: Al-Ain, UAE, between 1976 and 2000. International Journal of Remote Sensing 25(6): 1063-1076.

Yildirim E, El-Masri S (2010) Master planning for conservation in Al Ain Oasis, 46th ISOCARP Congress 2010.

Zaid A (2002) (ed.) Date Palm Cultivation. FAO Plant Production and Protection Paper No. 156. [Link](#)

Zaid A, de Wet PF (1999) Date Palm Cultivation. In: Zaid A (ed.). Chapter II: Origin, Geographical Distribution and Nutritional Values of Date Palm. FAO Plant Production and Protection Paper No. 156.

## 8 Acronyms

ADACH	Abu Dhabi Authority for Culture and Heritage
BP	Years before present
EIDPF	Emirates International Date Palm Festival
FAO	Food and Agriculture Organization of the United Nations
GIAHS	Globally Important Agricultural Heritage System
UAE	United Arab Emirates
UPC	Abu Dhabi Urban Planning Council