Workshop on Developing the Capacities of the Human Settlements Sector for Climate Change Adaptation Using Integrated Water Resources Management (IWRM) Tools
Amman, 22-24 May 2016

The Oases Cities Irrigated by Aflaj in Wilayat Nizwa in Oman

Middle Eastern Human Settlements Practicing a Specific Water Management Under Climate Change and Socio-economic Mutations

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Introduction

In arid and semi-arid zones, man has developed a spectacular procedure of **water acquisition** to overcome the rarity of precipitations and their irregular rhythm.
This system is called **qanat**.

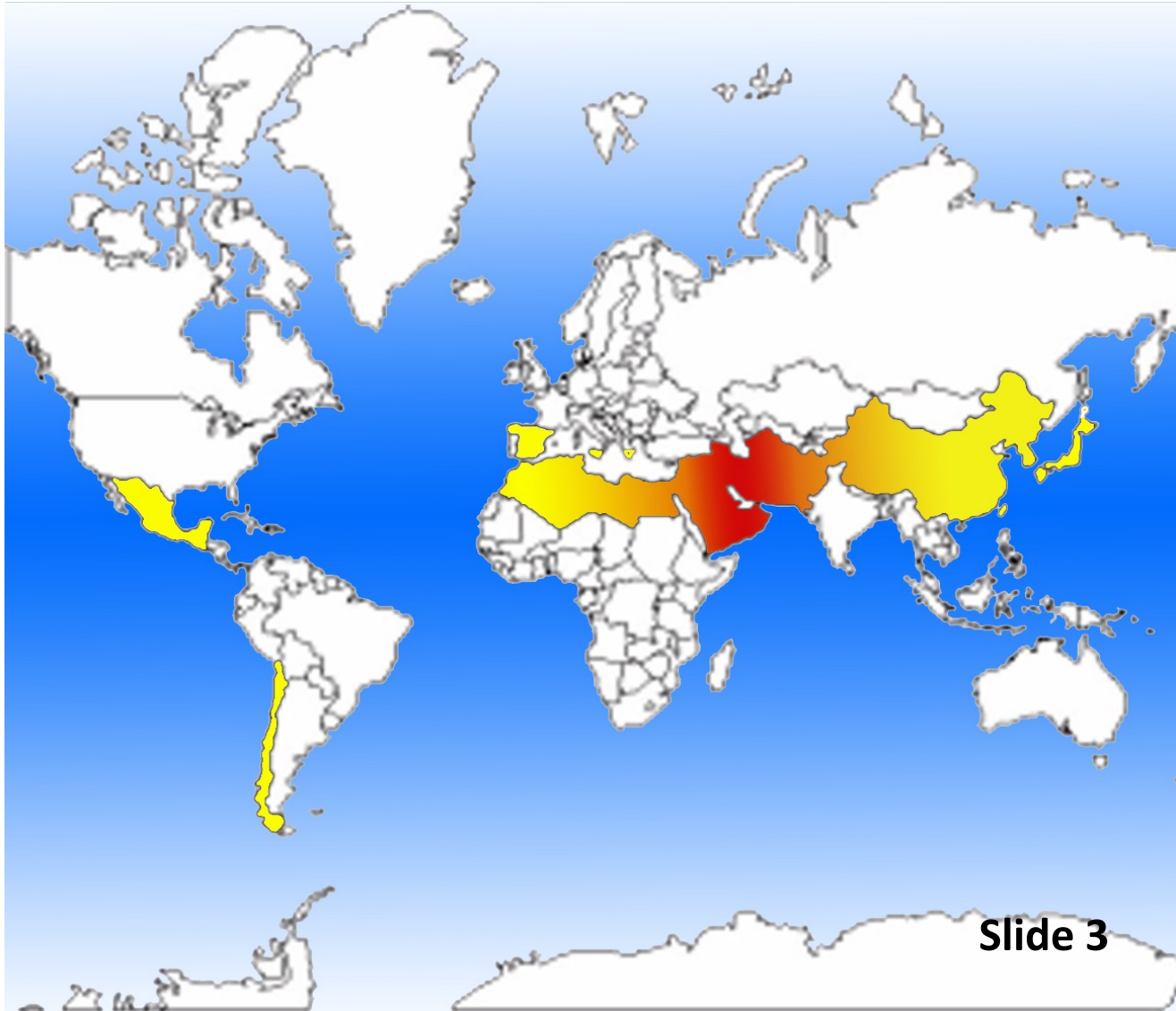


Figure 1: Origin and diffusion of qanats in the world (adapted from Al-Ghafri et al., 2003: 33)

Introduction

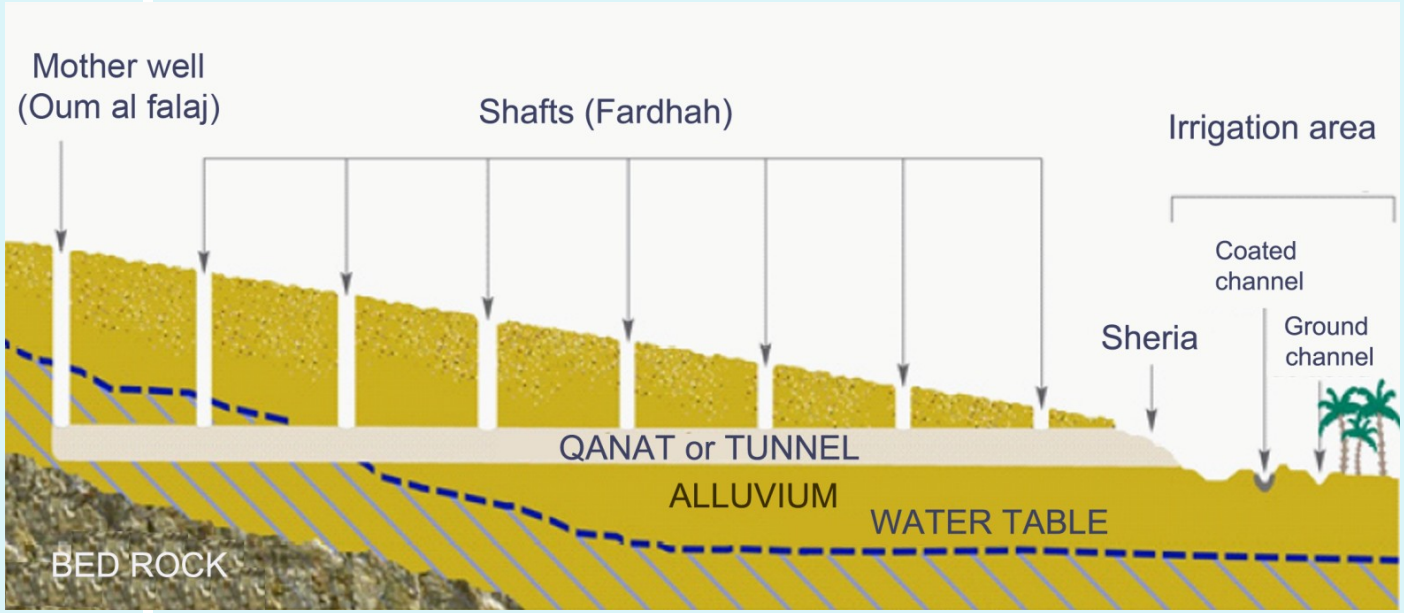
In arid and semi-arid zones, man has developed a spectacular procedure of **water acquisition** to overcome the rarity of precipitations and their irregular rhythm.
This system is called **qanat**.

Country	Name of the system
Afghanistan	*Kariz*
Algeria, Tunisia, Libya	*Foggara*
China (Xinjiang Uyghur)	*Kanjing, Karez*
Iran	*Qanat*
Italy (Sicilian)	*Ingruttato (s.), Ingruttati (pl.)*
Japan	*Mambo, Mappo*
Korea	*Ma-nan-po*
Latin America	*Galerias, Puquio*
Morocco	*Khattara, Rhettara*
Oman	*Falaj (s.), Aflaj (pl.)*
Spain and Canary Islands	*Galerias, Mayrit*
Syria	*Qanat Romani*
Yemen	*Felledj, Ghail, Miyan*

Table 1 : Diverse appellations of qanats in some countries (adapted from Al-Ghafri et al., 2003:33)

Description of the qanat

Figure 2: Typical cross section of a qanat (adapted from Hermosilla (dir.), 2008 as cited in Hermosilla (dir.), 2011, p.32)



Beaumont (1971) describes the qanat as "a method for developing and supplying groundwater and consists of a gently sloping tunnel (...) which leads water by gravity flow from beneath the water table at its upper end to a ground surface outlet and irrigation canal at its lower end" (as cited in Megdiche-Kharrat and Moussa, 2014, p. 2).

Water Resources in Oman

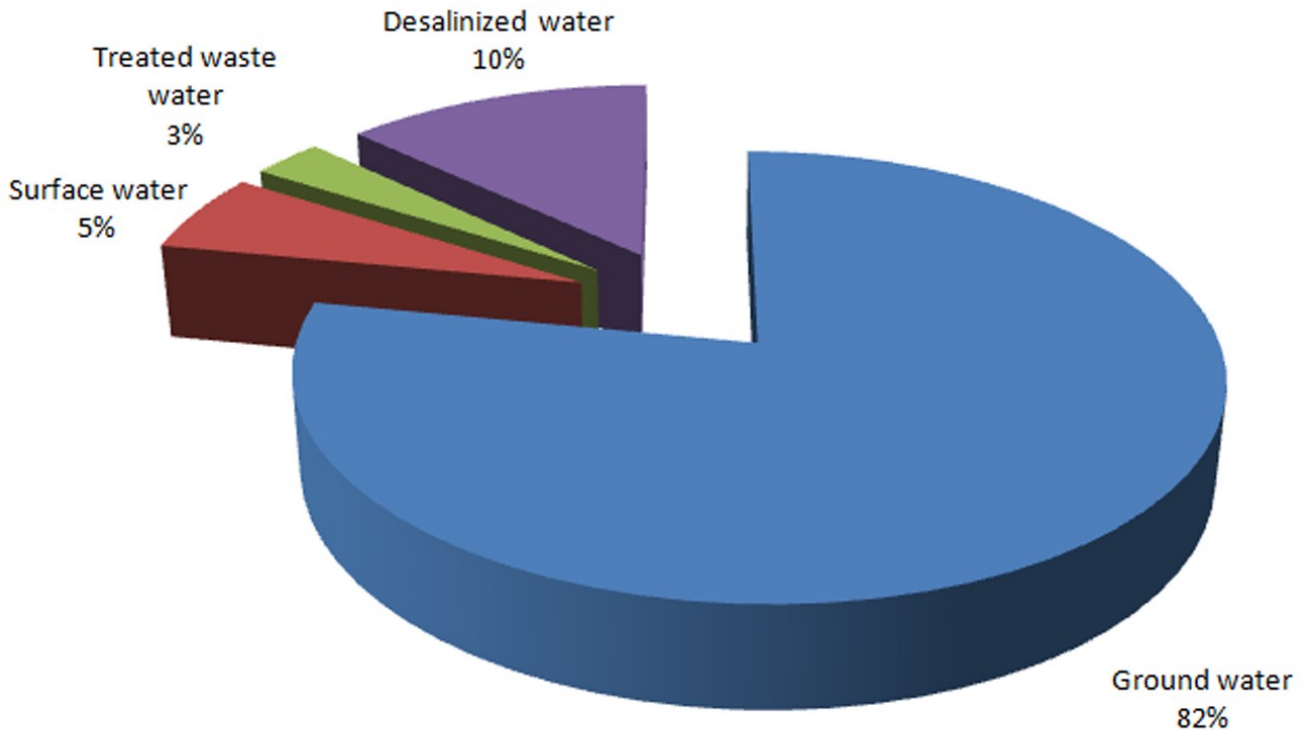


Figure 3: The various water resources in Oman (MRMWR, 2014)

Aflaj in Oman

Aflaj are classified into three different types:

- **Ghaili** (49%)
- **Dawoodi** (28%)
- **Aini** (23%)

Omani authorities reported the existence of **4112** *aflaj* of which **3017** are live systems (MRMWR, 2008, p. 10).

2900 km of tunnels and surface channels are reported in 2001 (MMWR 2001 cité dans Al-Ghafri 2012, 194).

Aflaj are the main source for irrigating farmlands.

They currently provide **680 million** cubic meters yearly for around **26,500** ha of farmlands; rainfall varies from under 50mm to over 300 mm (Al Amri, Al Ghafri & Abd Rahman, 2014).

In July 2006, five Omani *aflaj* were added to the World Heritage List.

Wilayat Nizwa in Oman

Figure 4. the city of Nizwa in the North of Oman (MRMWR 2012 cité dans Megdiche-Kharrat et al. 2015b, 325)

Wilayat Nizwa in Oman

Figure 5: Al-Jabal Al-Akhdhar in Wilayat Nizwa (June 2015)

Wilayat Nizwa in Oman

Figure 6: Cultivated plateform at Al-Jabal Al-Akhdhar in Wilayat Nizwa (June 2015)

Wilayat Nizwa in Oman

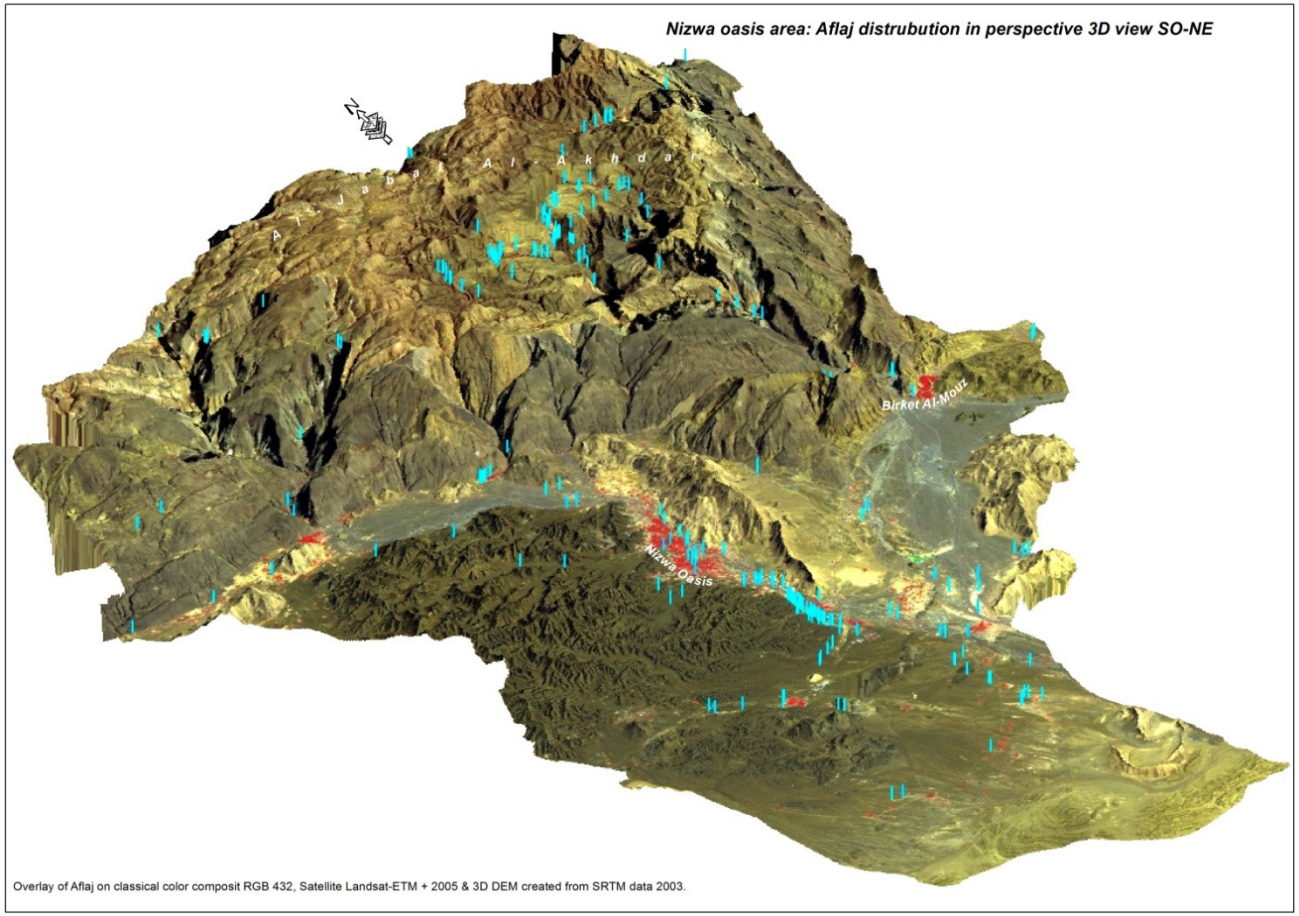


Figure 7: Willayat Nizwa (Governorate of Nizwa): Geolocalization of aqueducts (*aflaj*) in 3D perspective view SO-NE. (Ragala & Megdiche-Kharrat 2015)

Wilayat Nizwa in Oman

Figure 7: Village at Al-Jabal Al-Akhdhar in Wilayat Nizwa (June 2015)

Falaj Al-Khatmeen in Birkat Al-Mouz

General presentation

Play video

Figure 8: Satellite map/image of *falaj Al-Khatmeen* (MRMWR, 2009)

Falaj Al-Khatmeen in Birkat Al-Mouz

Table 2: General presentation of *falaj Al-Khatmeen*

General presentation	
Name	Falaj AL-Khatmeen
Reference	F3071
Type	Dawoodi (with underground tunnel reaching the acquifer)
Founder	Imam Sultan bin Saif Al-Yorubi
Age	300 to 350 years
Activity level	Very active
Management type	Private common ownership system under governmental supervision
Executive director (*wakil)*	Sheik Khamis Al-Dreishi
Gender	Male
Age	42
Duration of Management	10 years (since 2004)
Management level	High

Falaj Al-Khatmeen in Birkat Al-Mouz

Table 3: Collected physical data of *falaj Al-khatmeen*

Physical Data of falaj Al-Khatmeen	
Location	Birkat AL-Mouz in Wilayat Nizwa (Northern Oman)
Geographical context	Foothill of Jabal Al-Akhdhar (2000 m height mountain)
Actual mother well (Oum al falaj)	40 Q 0569207 E, 2536980 N/ 606 m
UTM coordinates/ altitude	17.5 meters
Depth	
Sheria	First surface appearance of the underground channel
UTM coordinates/ altitude	40 Q 0568340 E, 2535479 N/ 583 m
Water data	
Flow	2000 liters/second
Electric conductivity	440 µS/cm
pH	7.61
Temperature	30°C
Underground tunnel or qanat	
Length	2.45 km
Condition	Excellent
Side branches	0
Number of shafts (fardhah**)**	11
Condition	Good condition- 4 open shafts and 7 half closed
Used shafts for tunnel access	2
Total demand area	1004,340 m^2
Farmlands area	723,124 m^2
Palm trees	4000 trees (2010 census)
Crop growing	Nile (wheat, corn and vegetables about 30 years ago)
Livestock	Few in some houses, (About 20 years ago, 10 to 20 heads from each house/family)

Management system

Falaj administration structure

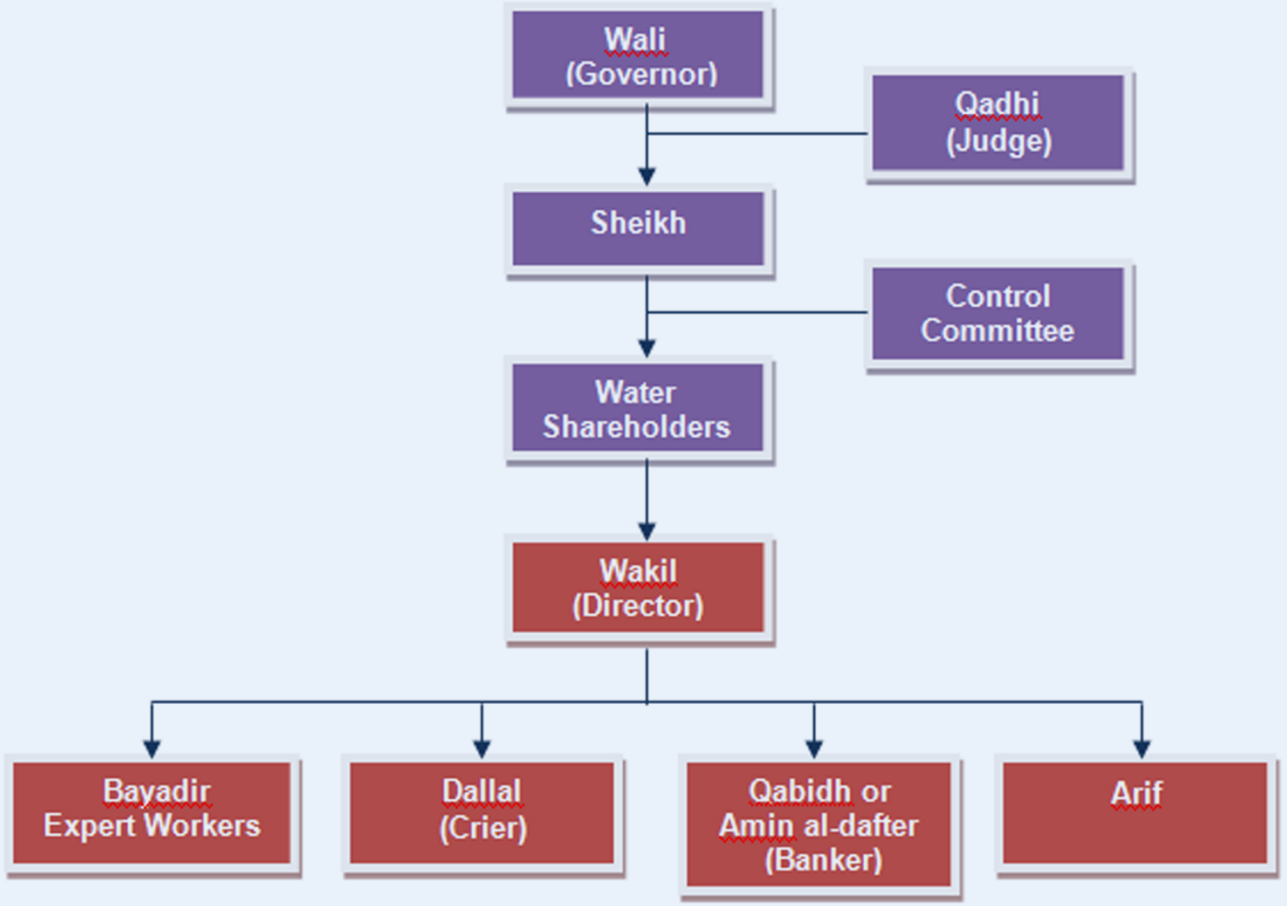


Figure 9: Typical Omani aflaj administration structure (adapted from MRMWR, 2009, p. 23)

Management system

Falaj ownership and various stakeholders

In general, there are two kinds of water ownerships:

[1] Public ownership (using the water of the falaj for domestic),;

[2] Private ownership (water used for irrigation regarding shares distribution).

For large Omani aflaj, there are four various types of private ownership:

[1] Owners of land and water;

[2] Owners of land and renting water;

[3] Owners of water and renting land;

[4] Renting land and water .

(Al-Ghafri et al., 2003b, p. 30)

Management system

Falaj ownership and various stakeholders

In *falaj Al-Khatmeen,* two *aflaj* diverge:

[1] ***Falaj ettaht*** (down falaj) which represents the 2/5th owned by local farmers (of which 20% belongs to the government);

[2] ***Falaj alfawq*** (upper falaj) which represents the remaining 3/5th owned by the government (of which 20% belongs to local farmers).

Figure 10: Water divider of falaj Al-Khatmeen (February 2014; April 2015)

Management system

Water rights and shares distribution

Water is distributed to farmers regarding the number of **shares** each one owns.

The number of shares depends on the sizes of the owned lands and/ or the contribution in the construction of the falaj itself (Al-Ghafri et al., 2003b, p. 29).

For the majority of aflaj, shares are distributed on time basis (for example: **1 *baddah*** is equal to 12 hours, and **1 *athar*** is equal to 30 min).

Management system

Irrigation scheduling

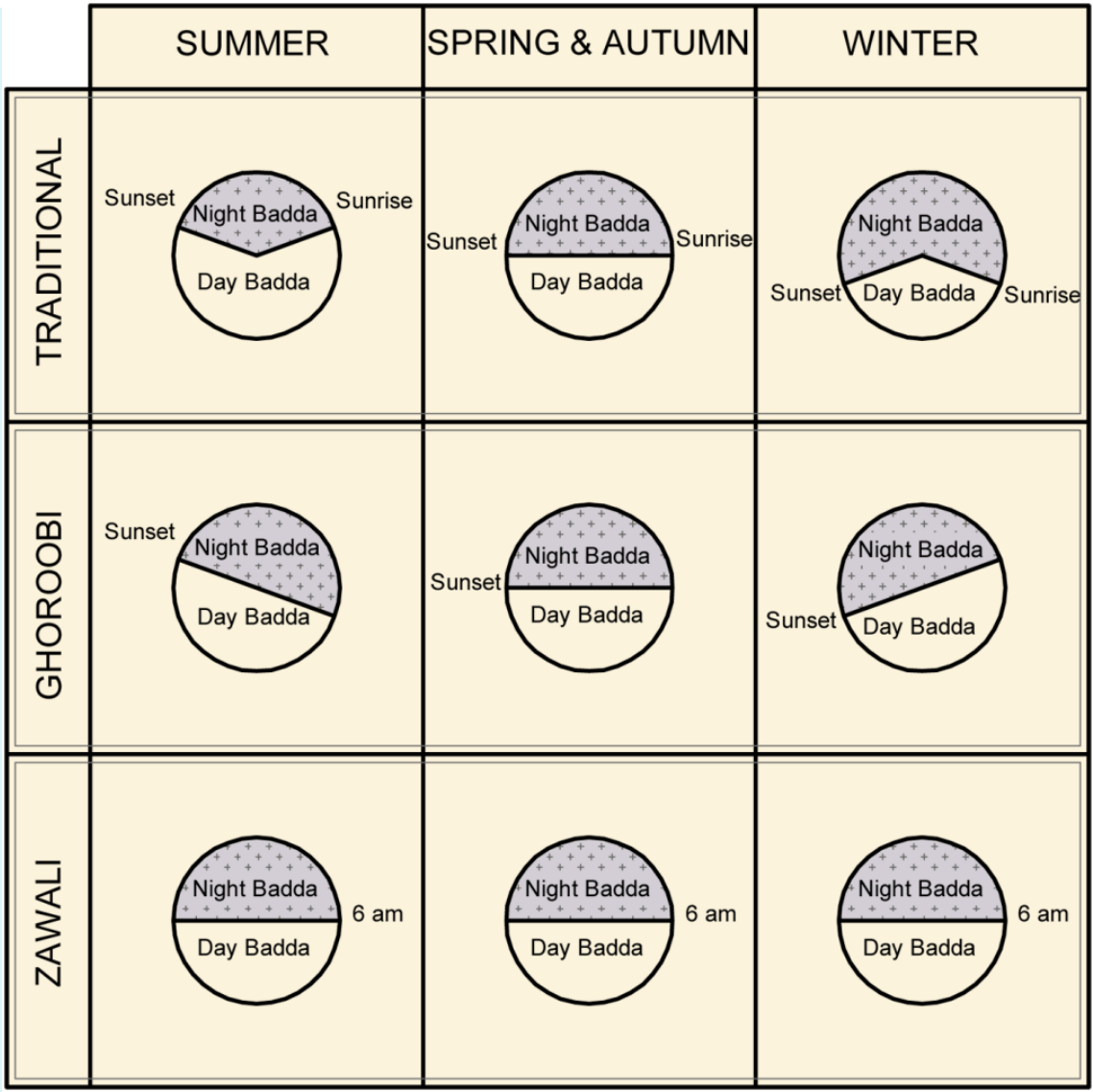


Figure 11: Different methods of irrigation timing in Omani aflaj and their variations regarding seasons (adapted from Al-Ghafri et al., 2003a, p.164)

Management system

Table 4: Shareholders water rights and water distribution system in *falaj Al-Khatmeen* (adapted from MRMWR, 2009: 35-39)

Ownership & Stakeholders	
Owners	Government (local authorities) and inhabitants from Birkat Al-Mouz village
Public ownership (domestic usage of water and livestock drinking)	Free access (All community, about 8000 people) Some of the shares from the private ownership are for public livestock drinking and pasturage irrigation
Private ownership (Water for irrigation)	Regarding irrigation water rights 309.5 shares (*athar*)
Government (bait al-mal)	129 shares (*athar*)
Community benefit (waqf)	96 shares (*athar*)
falaj benefit (waqf al-falaj)	330.5 shares (*athar*) - 900 owners of falaj water
Farmers	865 shares (*athar*)
Total	
Water distribution system	
Method	Zawali
Period of irrigation cycle (dawaran)	9 days (8 + 1 for falaj benefit known as Al-Qaada)
Share (*athar*) duration	30 min
Numbers and names of raddah (complete water share of an owner) in a full irrigation cycle	**[1]**Al-Qaada **[2]**Makhlaf Saif **[3]**Arradida **[4]**Mabda bait al-mal **[5]**Baqi bait al-mal **[6]**mabda Al-Aseela **[7]**Thalathat Arbaa**[8]**ibn Ismail **[9]**Baddah wa tisaa
For 1 Irrigation day	1 raddah
Number of baddah	2 (night baddah and day baddah)
Shares (athar) per baddah	24
Shares (athar) per day	48

Discussion

1. The *Dawoodi falaj* as sustainable water acquisition technique

The mechanism of *dawoodi aflaj* allows a moderate and sustainable exploitation of the water table;

It offers sustainable solutions for overcoming drought: digging back into aquifers; enlarging the underground tunnel; reviewing the areas of cultivated lands and types of crops; updating the irrigation cycle or rotation to meet all farmers needs.

Aflaj construction, maintenance and management relay mainly on manpower.

Discussion

2. Equity in access to *falaj* water for stakeholders

Access to water for drinking and domestic use is free and available for all community;

The administrating body of the falaj distributes water-shares equitably regarding ownership of land and water, and resolves conflicts between farmers;

The traditional system used for shares distribution (sundial or water clypsidra in day *baddah* and star system in night *baddah*) may lead to inequity in water allocation. But, the newly adopted *zawali* method is accurate and allows precise shares distribution.

Discussion

3. Aflaj management system assessment regarding water integrity (TAPA concepts)

Transparency is insured by: direct contact between the managing body and multi-stakeholders; besides an available book of records for sharing information;

Accountability is covered by the fact that being the *wakil* is assigned by the sheick after water shareholders recommendation. The wakil should own important shares, and then he will be directly affected by a bad management of the system;

Anti-corruption is insured by the **participation** in decision making regarding the *falaj* and its water management at multi-stakeholder levels.

Discussion

4. Problems facing *falaj Al-Khatmeen*

Since 2004, the conflict between the two managers was solved, they are acting as wakil and assistant wakil;

Water table lowering for successive droughts led to extending the tunnel by digging back into the aquifer since 1960;

One legal borehole exists near the *falaj*'s source area but it doesn't affect too much its efficiency;

Wastage of the *falaj*'s fresh water in some side activities such as washing cars;

Usage of some chemical products while cleaning clothes or bathing in the falaj ;

Urban expansion menacing farmlands;

Youth disinterest in farming and trades related to the falaj and its management.

Conclusion

Falaj Al-Khatmeen is a very important falaj among Omani *aflaj*, it is famous for its high water flow during the whole year and its famous divider. Its present management seems to be very efficient and successful.

Thus, aflaj are facing many issues that menace its survival among the future generations, mainly namely, Climate change, urban expansion, youth disinterest and new habits that lead to wastage and pollution of the water.

Thank you very much for your attention