



Received 30.09.2018
 Reviewed 31.12.2018
 Accepted 20.03.2019

A – study design
 B – data collection
 C – statistical analysis
 D – data interpretation
 E – manuscript preparation
 F – literature search

Study of ancestral irrigation systems in the oasis of Taghit in the South West of Algeria

Elhadj BELHADJ ELMEHDI¹⁾, Boualem REMINI²⁾,
 Cherif REZZOUG¹⁾, Saaed HAMOUDI¹⁾

¹⁾ Chlef University, Faculty of Civil Engineering and Architecture, Hay Salem, National Road 19, 02000 Chlef, Algeria;
 e-mail: ✉ elhadjdz@yahoo.com; cherifrezzoug@yahoo.fr; hamoudisaaed@yahoo.fr

²⁾ Blida University, Faculty of Technology, Blida, Algeria; e-mail: reminib@yahoo.fr

For citation: Belhadj Elmehdi E., Remini B., Rezzoug C., Hamoudi S. 2020. Study of ancestral irrigation systems in the oasis of Taghit in the South West of Algeria. *Journal of Water and Land Development*. No. 44 (I–III) p. 13–18. DOI: 10.24425/jwld.2019.127040.

Abstract

The unique oasis of Zousfana, on the western edge of the Grand Erg Occi-dental, Taghit is the pearl of the oases of Saoura, a palm grove of 180 ha over an 18 km length crossed by Oued Zouzfana. It regroups the different types of landscapes of an arid zone (erg, hamada, barga – a small hill, oued ...). Taghit is known for its hydraulic civilization, the oasis in its hostile environment has survived thanks to the exploitation of rare groundwater irrigation according to the traditional customs applied to the whole of society. The peasants spur out the water resources through foggaras and traditional wells. But the intervention of modern irrigation techniques in an anarchic way has disrupted the fragile mode of irrigation and the abandonment of the palm grove. The over-exploitation of groundwater by the use of boreholes and motor pumps leads to the drying up of water sources, mists and traditional wells. Today, only 45 000 palm trees are productive and less than 1500 fruit trees. There are 500 fellahs in the entire agricultural area of Taghit, the majority of them is fleeing work in the oasis because of the lack of income from it. When comparing the results of analyses from different campaigns (2015 and 2008), a spectacular increase in the salt concentrations in the groundwater of the different palm groves is noticed. According to our investigations, the main causes of this jump are: the overexploitation of the water tables by motor pumps, the abandonment of land inside the palm grove, the lack of maintenance of the gardens, the exploitation of domestic wastewater in the irrigation. According to this preliminary study, it is important for the State to make farmers aware of the role of their traditional irrigation systems in the continuity of the oasis and life in it.

Key words: *foggara, motor pump, oasis, source, Taghit*

INTRODUCTION

The scarcity of the surface water in arid region pushed the man to exploit the groundwater. Various techniques of water catchment have been used for centuries. One technique that has marked the history of hydraulics is the qanat. On the Iranian origin [GOBLOT 1979], the qanat is called foggara in Algeria and the khettara in Morocco [LIGHTFOOT 1996].

Thanks to its success, the foggara has spread to 52 countries worldwide [REMINI *et al.* 2014]. In the Algerian

Sahara, several foggaras were realized in the Ahaggar [REMINI, ACHOUR 2013a], in the region of In Salah [REMINI, ACHOUR 2013b], in the Mزاب valley [REMINI 2016], in the oasis of Ouled Said [REMINI, ACHOUR 2013c], in the region of Kenadsa [REMINI *et al.* 2014b] and in the Saoura valley [REZZOUG *et al.* 2016]. In the Touat and Gourara the Algerian Sahara, the foggara has been developed for over 10 centuries [REMINI *et al.* 2011]. Over 1400 foggaras were dug around the Tadmait tray; which is considered the true water tank qanats of Touat and Gourara. A flow rate of $3 \text{ m}^3 \cdot \text{s}^{-1}$ in a continuous manner in more than 2 000 km

of gallery which has developed approximately 200 palms [ABIDI, REMINI 2011].

93 km South-East of Bechar and 1000 km South of Algiers, Taghit is on the old road that connects Algeria to Niger by Tanezrouft (Fig. 1). It is composed of five small palm groves: Zaouia Fougania, Taghit, Barrebi, Bakhti and Zaouia Tahtania. Taghit is one of the most beautiful oases of the Sahara, a real nest of greenery on the edge of the Grand Erg Occidental.

At the Saoura level, the oases suffer from almost the same problems, the overexploitation of groundwater, the salinization of soil and water, parcellization of gardens because of the inheritance (more than 80% of the parcels do not exceed 1 ha) and the abandonment of land by their owners and they are certainly what suffers the oasis that interest us in this work.

One of the subjects in the field of the environment is undoubtedly the traditional systems of water collection and sharing in the oasis [REZZOUG *et al* 2014]. For centuries, farmers in Taghit exploit the groundwater of the Grand Erg Occidental and Wadi Zousfana inferflux to provide their basic water and food needs in a way that indicates their

intelligence and inherited experience since generations. However, the intervention of modern irrational irrigation techniques leads to a significant imbalance in the oasis, which has suffered for generations and is unfolded its consequences day after day [REZZOUG 2019].

STUDY AREA AND METHODS

THE OLD KSAR OF TAGHIT

Below the Grand Erg Occidental, the ksar of Taghit is connected with the palm grove by a system of Seguia and underground galleries spring water from the springs towards the gardens of the traditional palm grove (Fig. 2). Today the ksar of Taghit and suffered from several problems: every attempt at restoration failed because of a lack of expertise and poor planning, lack of skilled labour, the drying up of most of the sources that feed the ksar, Pre-dominance of the modern urban fabric at the expense of old ksar and the degradation and weakness of the financial performance of the population.



Fig. 1. Location of Taghit; source: own elaboration



Fig. 2. The Taghit oasis; source: REZZOUG *et al.* [2016]

FAUNA AND FLORA OF TAGHIT

The figures discovered by the conservation of the drills of Béchar give in figures 1 500 sheep (the race D'man), 200 goats, 200 donkeys and about 30 horses. In each household, hens, pigeons, and rare rabbits are raised. The nomads, using the rangelands, have, in addition to goats and sheep, dromedaries [BENKHALIFA 2005].

The spontaneous flora includes some resources such as *Rumex vesicarius* L., *Zizyphus spinachristi* L., *Rhus tripartitum* var. *oxyacantha*, *Matricaria pubescens* Desf., *Salsola vermiculata* L., *Zygophyllum album* L., *Pithuranthus chloanthus* Goss and Dur., *Aristida ciliate* Desf., *Echium pycnanthum* Pomel, *Pergularia tomentosa* L. These quotes are incomplete if we do not mention the two stars of the Sahara; the first is almost permanent *Acacia raddiana* Savi and *Terfeziaceae* parasitizing other species of plants and found abundantly on the banks of the hamada and in the dunes exceptionally rainy years [BENKHALIFA 2005].

PALM GROVE OF TAGHIT

Due to the availability of water, the majens and seguias, as well as the condensation of palms, fruit trees and fence plots, oasis and peasants are benefiting from the creation of a cooler microclimate, that he can relieve the rigors of the desert heat. The palm grove of Taghit has an area of 180 ha from Zaouia Fougania to Zaouia Tahtania with more than 100 000 trees of palm trees, only 45 000 trees are productive and more than 4600 fruit trees. There are 500 fellahs throughout the agricultural area of Taghit.

TAGHIT WATER SOURCES

The oasiens exploited the water of the Great Western Erg aquifer by 45 sources of which 22 sources are today functional; the fellahs spring these waters by a set of underground tunnels called foggaras of sources. They use the waters of the Wadi Zousfana infotrans flow aquifer through traditional wells (up to 15 m high) currently equipped with motor pumps. But the contribution of modern methods of water abstraction (boreholes and motor pumps), deteriorate ancestral techniques of irrigation from one year to another and their future is threatened [REZZOUG 2018].

SOURCE OF FOGGARA

The foggara is an underground pipe spilling water from the water source to the surface by gravity. Through a series of subterranean foggaras, oasiens of Taghit exploit the waters of the artesian springs to irrigate the palm grove and to assure the water of consumption of the population of the different agglomerations of Taghit by gravity, at the exit of each foggara is an open main canal terminated by an accumulation basin locally called majen (Photo 1), then they are distributed the accumulated water through a hierarchy of secondary channels (seguias) network leads the water to the gardens of the owners (Fig. 3), who participated in the creation of these foggaras that it is by their money

or by their physical efforts. The process of division and distribution of water within the oasis are subject to a complex set of customs and traditions according to the effort of each person in the realization and restoration of the foggaras. Taghit has more than 70 accumulation basins. This explains the problem of individualism and causing heavy losses at the oasis of Taghit.

Such as the ancient architecture of ksar, the foggara system is part of the cultural and physical heritage of the oasis hard to ignore and waste.

At the oasis of Taghit and these palm groves there are 25 sources foggaras (Tab. 1), only 5 are operational until now.

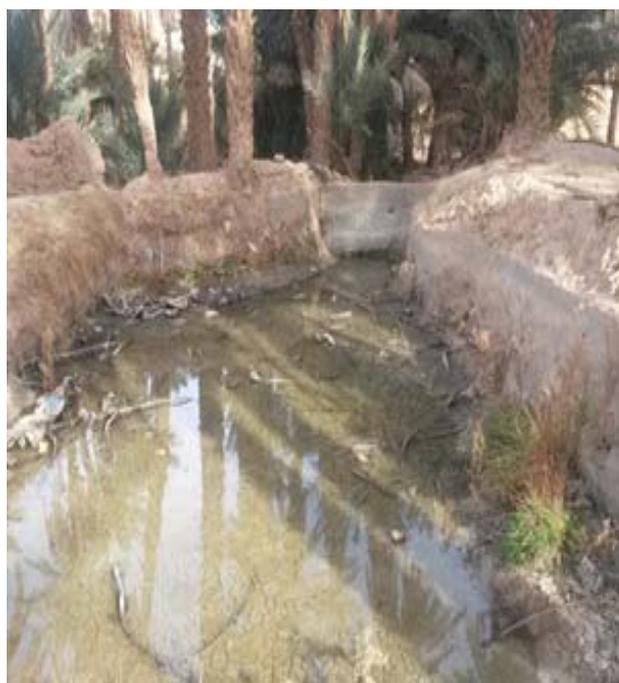


Photo 1. Old pools of water accumulation of ksar and palm grove (phot. C. Rezzoug)

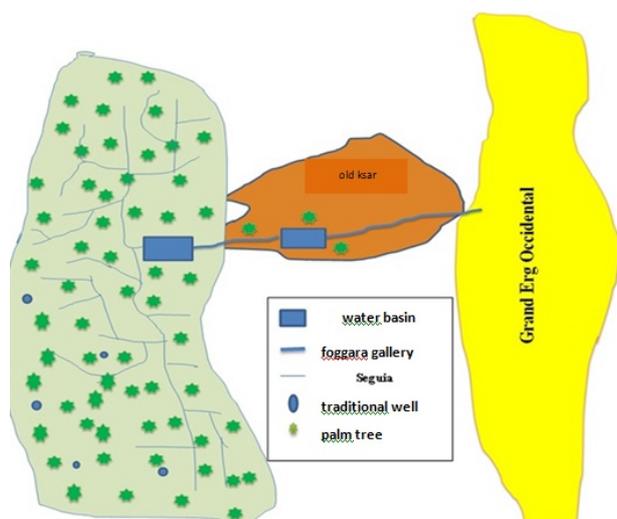


Fig. 3. Diagram of the source, foggara, well, basin and seguia of a Taghit palm grove; source: own elaboration

Table 1. The number and condition of foggaras in Taghit palm groves

Palm grove	Number of foggaras	Total length (m)	Debit ($\text{dm}^3 \cdot \text{s}^{-1}$)	State of foggara
Zaouiafougania	3	2 140	3.33	symbolic flow
Taghit	4	5 300	3.20	not operational
Barrebi	9	1 260	3.70	4 operational
Bakhti	6	1 970	2.80	not operational
ZaouiaTahtania	3	400	3.33	1 operational

Source: own elaboration.

TRADITIONAL WELLS

In Taghit, there are over 300 traditional wells between 3 and 15 m high and 2 m in diameter, most of which are protected with concrete or stone nozzles (Photo 2). They get the waters of the Wadi Zousfana inferoflow aquifer. Most of them are equipped with motor pumps that contribute to the drying up of the water sources. Generally, traditional wells are private properties; each owner has the freedom to water their fields whenever he wants.



Photo 2. A traditional well in the palm grove of Taghit (phot. C. Rezzoug)

RESULTS AND DISCUSSION

PROBLEMS OF TAGHIT FOGGARAS

For centuries, the oasis has managed to maintain their social, cultural and religious specificity, it has managed to preserve their customs and traditions, the latter still occupy an important place in the life of the population [SALMI, MAMOUNI 2014]. However, it stood powerless against the anarchic encroachment of modern irrigation techniques, which had a profound impact on the destruction of the palm grove, the water table and a whole system of social and traditional management of water shares.

The oasis suffering today from several problems, the most important are the lack of water either for the palm grove or for the drinking water supply of the population according to the remarkable depletion of the water tables, as well as the lack of qualified manpower to rehabilitate the foggaras and these channels, degradation of the systems of catchment and sharing of water such as the irrigation canals and the accumulation basins as well as the catchment foggaras (Photo 3), the abandonment of plots because of fragmentation of gardens by inheritance, the aging of palm feet, the immigration of youth to sectors more profitable than agriculture inside the palm grove.



Photo 3. Degradation and silting of irrigation canals in the palm grove of Taghit (phot. C. Rezzoug)

SALINITY PROBLEM IN THE OASIS OF TAGHIT

Today, the most important obstacle to agricultural development in the Taghit Oasis is the lack of irrigation water and the high rate of water salinity, which has been imposed on most people peasants to bring on the new plain of Elouina to practice their agriculture, and the state's demand to build a water dam to provide water for their crops.

To study the impact of the irrational use of the pumps on the soil salinity in the oasis, we focus mainly on the physicochemical analyses carried out in the oasis during two different periods, the first in 2008 and the second in 2015 by the services of the National Agency of Water Resources of Bechar (Fr. Agence Nationale des Ressources Hydrauliques de Bechar – ANRH) [ANRH 2015].

Table 2. Physicochemical evolution of the waters of Taghit palm groves

Year	Zone	Type	pH	EC mS·cm ⁻¹	RS	Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	Cl ⁻	SO ₄ ²⁻	TH (°F)	TAC (°F)
2008	Taghit	wells	7.62	0.72	440	75	19	37	12.8	70	140	26	8
	Zaouia Fogania	drilling	7.52	1.41	870	88	49	130	5.5	221	280	42	10
	Zaouia Tahtania	drilling	7.12	0.79	530	70	44	34	12.8	80	150	35	13
	Bakhti	drilling	7.08	0.71	490	79	27	23	9.5	47	160	31	11
	Zaouia Tahtania	wells	6.90	1.48	920	101	49	90	14.0	203	190	45	13
2015	Taghit	wells	7.65	1.14	740	111	27	50	16.1	87	170	36	10
	Zaouia Fogania	drilling	7.58	1.60	1 028	121	72	184	6.9	290	401	58	11
	Zaouia Tahtania	drilling	7.01	1.54	680	85	62	43	13.6	120	210	43	24
	Bakhti	drilling	7.14	1.02	645	102	43	35	12.6	66	231	54	20
	Zaouia Tahtania	wells	7.10	1.59	1 030	123	45	102	22.0	257	265	59	17

Explanations: EC = electrical conductivity, RS = solid residue, TH = total hardness, TA = total alkalinity.
Source: ANRH [2015].

In comparison with the results of the analyses of the year 2015 compared to those of 2008, there is an alarming increase in the groundwater salt concentrations of the various palm groves (Figs. 4–7). The main causes of this jump are: overexploitation of water tables by motor pumps, abandonment of land inside the palm grove, lack of maintenance of gardens, exploitation of domestic wastewater in the irrigation.

CONCLUSIONS

For centuries, the Taghit peasants could maintain their fragile environment in an arid and hostile region by the rational consumption of water which is the main cause of the creation of the oasis and their environment, by the exploitation of this source with traditional techniques based on collective management of catchment and sharing of water. But the intervention of motor pumps and individualism caused the disturbance of this environment. Local authorities through their quest to preserve the survival of the people in their areas, working to revive the old techniques of rational water management through modern rules consider the area planted for each person. The most important thing has been done in most palm groves is digging a single borehole and building a single pond with a collective distribution. Today, the most important obstacle to agricultural development in the Taghit oasis is a lack of irrigation water and high water salinity, Taghit farmers suffer from many such as the scarcity of groundwater from the Western Great Erg aquifer and the inferflux of wadi Zousfana due to the intervention of modern irrigation techniques (more than 100 boreholes with motor pumps) leads to a significant imbalance in oasis.

So, it is necessary for the state to work on restoring traditional irrigation systems and systems and to make farmers aware of their importance in maintaining the source of scarce water important for the survival of the oasis.

REFERENCES

ABIDI S., REMINI B. 2011. Les foggaras de Touat : la fierté de la population locale [The foggaras of Touat: The pride of the local population]. *Annales des Sciences et Technologie (Ouargla University)*. Vol. 3. No. 2 p. 107–113.

ANDREW W. 2016. Foggara irrigation, early state formation and Saharan trade: the Garamantes of Fazzan, Oxford Roman Economy Project. Oxford, England. University of Oxford.

ANRH 2015. Etude hydrogéologique de la région de Bechar [Hydrogeological study of the region of Bechar]. Internal report. Bechar, Algeria. Agence Nationale des Ressources Hydraulique p. 122–132.

BENKHALIFA A. 2005. Taghit be a case study model for sustainable development. [Workshop 'Knowledge and know-how and their impact on the valorization and sustainable management of resources']. [14–18.02.2005 Taghit, Algeria].

GOBLOT H. 1979. Les qanats une technique d'acquisition de l'eau [Qanats: A technique for acquiring water]. Paris. Mouton. ISBN 2-7193-0459-X pp. 231.

GUIDO M. 2005. Well design pressure in the continental intercalary. Proceeding of the international symposium on groundwater resources of the Sahara – CIRESS. Ouargla, 12–13.12.2005 pp. 194.

HEGUI H. 2018. Etude des systèmes hydro-agricoles traditionnels en zone aride. Cas des oasis des Ksour du Nord de Béchar (Sud Ouest Algérien) [The traditional hydro-agricultural systems in arid zone. Case of the oasis of ksour north of Bechar (South West Algérien)]. PhD Thesis. University of Bechar, Algeria pp. 123.

LIGHTFOOT D.R. 1996. Moroccan khattara: traditional irrigation and progressive desiccation. *Geoforum*. Vol. 27. No. 2 p. 261–273.

MERZOUGUI T., KABOUR A., BOUANANI A., MEKKAOUI A., CHEBAH L. 2008. A model of integrated management of water resources in a hyper zone: Case oasis of Beni Abbes (Saoura Valley, southwest of Algeria). In: 13th IWRA World Water congress. Montpellier, France p. 23–34.

REMINI B. 2016. The role of the gallery in the functioning of the foggara. *Journal of Water and Land Development*. No. 29 (IV–VI) p. 49–57. DOI 10.1515/jwld-2016-0011.

REMINI B., ACHOUR B. 2010. The foggara in Algeria: A global hydraulic heritage. *Journal of Water Sciences*. Vol. 23. No. 2 p. 105–117.

REMINI B., ACHOUR B. 2013a. Foggaras of Ahaggar: Disappearance of a hydraulic heritage. *Larhyss Journal*. No. 14 p. 149–159.

REMINI B., ACHOUR B. 2013b. The foggaras of In Salah (Algeria): The forgotten heritage. *Larhyss Journal*. No. 15 p. 85–95.

REMINI B., ACHOUR B. 2013c. The triple foggara of Ouled Said (Algeria): The ingenuity of the Saharan peasantry. *Larhyss Journal*. No. 15 p. 113–122.

REMINI B., ACHOUR B., ALBERGEL J. 2011. Timimoun's foggara (Algeria): An heritage in danger. *Arabian Journal of Geosciences*. Vol. 4. No. 3 p. 495–506. DOI 10.1007/s12517-010-0139-9.

- REMINI B., ACHOUR B., KECHAD R. 2010. Les types de foggaras en Algérie [The types of foggara in Algeria]. *Revue des Sciences de l'Eau (Canada-France)*. Vol. 23. No. 2 p. 105–117.
- REMINI B., ACHOUR B., KECHAD R. 2012. Traditional techniques for increasing the discharge from qanats in Algeria. *Irrigation and Drainage Systems*. Vol. 25. No. 4 p. 293–306. DOI 10.1007/S10795-012-9125-6.
- REMINI B., ACHOUR B., KECHAD R. 2014. The collecting of groundwater by the qanats: A millennium technique decaying. *Larhyss Journal*. No. 20 p. 259–277.
- REZZOUG C. 2018. Les techniques et pratiques hydro-agricoles traditionnelles dans les oasis de la Saoura : Situation actuelle et perspectives [Traditional hydro-agricultural techniques and practices in the Oases of Saoura: Current situation and prospects]. PhD Thesis. University of Chlef. Algeria.
- REZZOUG C. 2019. The impact of using modern irrigation techniques on the ancient Mougheul palm grove, South-West of Algeria. *Journal of Water and Land Development*. No. 40 (I–III) p. 97–102. DOI 10.2478/jwld-2019-0010.
- REZZOUG C., REMINI B., HAMOUDI S. 2014. Le devenir de la gestion traditionnelle des eaux après l'envahissement des systèmes modernes d'irrigation. Oasis de Boukais, Sud-ouest algérien [The future of traditional water management after the invasion of modern irrigation systems. Oasis of Boukais, Southwest Algeria]. *Cinq Continents*. Vol. 4. No. 10 p. 109–119.
- SALMI S., MAMOUNI A. 2014. Etude ancestrale des techniques d'irrigation hydro-agricole dans l'oasis de Lahmar (W de Bechar) [Ancestral study of hydro-agricultural irrigation techniques in the Lahmar oasis (Bechar W)]. University of Bechar, Algeria pp. 78–81.