

THE SAOURA FOGGARAS: DEGRADATION OF HYDRAULIC SYSTEM MILLENNIUM CASE OF BENI ABBES, OUAKDA, BENI OUNIF AND LAHMAR (ALGERIA)

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Abstract

In this article, we studied, for the first time, the foggaras of Saoura. Five missions were carried out in the oases of Kerzaz, Lahmar, Boukais, Beni Ounif, Ouakda, and Beni Abbes during the years 2009, 2010, 2011, 2012 and 2013. The first results showed that there was a difference between the foggaras of Touat and those of Saoura. The galleries of Saoura are much shorter than those of Touat and Gourara. On the contrary, the distribution of water from the Touat and Gourara foggaras is carried out per unit volume, whereas from the Saoura foggaras per unit time. The foggaras we visited are practically in a degraded condition. The contribution of modern technology (pumps and wells) in the oases of Saoura is the principal cause of the decline of the hydraulic system millennium.

Key words: Foggara, Valley, Saoura, Sahara, Oasis

1 INTRODUCTION

Saoura is a hyper arid region situated in south-western Algeria. Faced with low rainfall, the oasis exploits groundwater. It is thanks to the expertise and genius of the oasis that traditional hydraulic techniques were invented for the exploitation of subsoil water, such as rockers wells and foggaras. Water tables are recharged by the devastating floods that are drained by the wadis – Oued Guir and Oued Zouzfana – to form the wadi called Oued Saoura. It is the latter along which the oases as Kerzas, Beni Abbes, Igli and Boukais have developed over several centuries. All the oases use the foggaras to power the „ksar“ (castle) and irrigate the palm groves. From Iranian origin, a foggara known as “qanat” was developed on the Iranian plateau since 3000 years ago [3], [4], then it has been developed in more than 30 countries around the world, including Algeria [5]. The foggara is an underground gallery of low slope, equipped with a multitude of air shafts and intended to convey the waters to the groundwater towards the soil surface. The Touat and Gourara regions are known as the country of foggaras in Algeria: over 1400 foggaras were inventoried in 2012 by the National Agency of Water Resources [7]. One hundred of the foggaras of the same type as those of Touat and Gourara were dug in the In Salah region [1], [8], [9], [10]. Indeed, in our literature searches on foggaras of Touat and Gourara we met little information and data on the foggaras in the area of Saoura. It is from there that we organized a series of missions to the oases of Saoura.

This study examines, for the first time, the foggaras in the valley of Saoura, and more accurately, the foggaras of the oases of Ouakda, Lahmar, Beni Abbes, and Beni Ounif.

2 STUDY AREA AND DATA USED

2.1 Presentation of the region

On an area of over 745000 km², the Saoura region encompasses the oases: Igli, Kerzas, Beni Abbes, Boukais, Beni Ounif, Ouakda, Taghit, and Lahmar. The region of Saoura is considered a real paradise. Saoura delimits the stony desert which extends to the west. Huge sand dunes of the Great Western Erg extend to the east and south. Part of the Oued Saoura, an intermittent river, rises in the Saharan Atlas and flows from north to south and then gets stuck in the desert. During winter, it sometimes carries a considerable amount of water. In the bed

of the Oued Saoura, there are gardens and palm groves. The region of Saoura is situated 1000 km southwest of Algiers (Fig. 1).

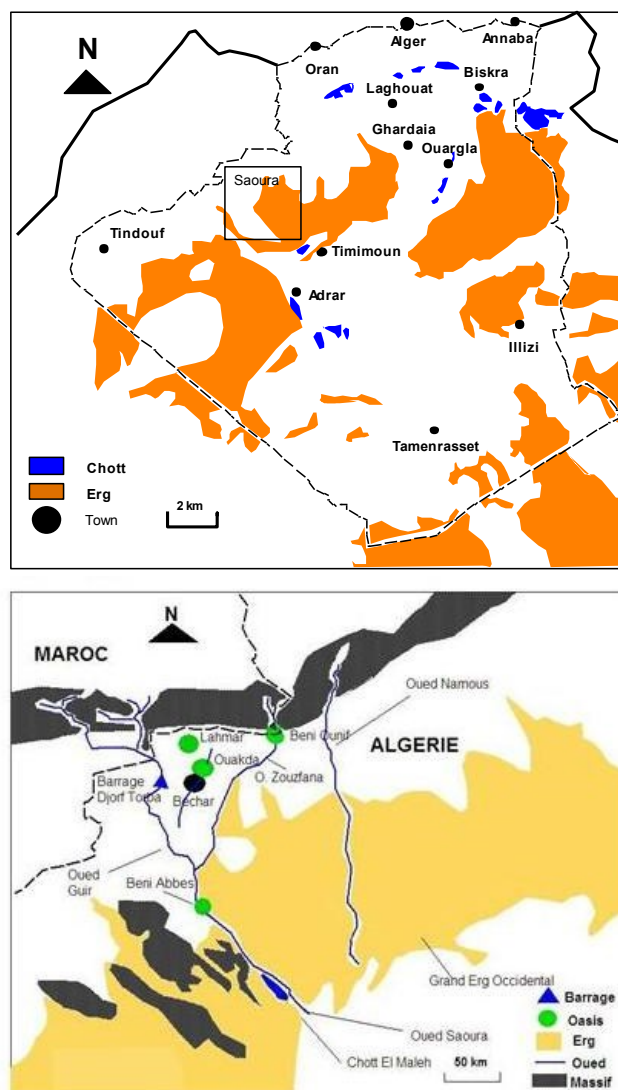


Fig. 1 Location of the Saoura

2.2 Hydrology of Saoura Valley

2.2.1 Surface waters of Saoura

The Saoura area is an arid region with hyper rainfall not exceeding 60 mm/year. However, the region has a considerable potential in water. The Oued Saoura which bears the same name as the region is considered the powerhouse of the region. It is known for the devastating floods before the construction of the Djorf Torba dam. The discharge of the rise of 1967 reached 3000 m³/s [2]. It is through this river that the different layers are recharged. A large valley full of palm trees is located on the border of the Erg and fits between the sands of the Great Occidental Erg and Hamada of Guir. The Oued Saoura follows the southwest part of the Great Occidental Erg resulting from the junction between the Oued Guir and Oued Zousfana at the Igli Oasis. From this confluence, the Oued Saoura has an average width equal to 250 m, and traverses a length of 250 km, ending in the desert around Bouda in the Adrar region. On its way, several oases have been developed, such as, the oases of Igli, Beni Abbes, Guerguiz, Kerzas. The Oued Guir and Oued Zousfana are two branches that feed the Oued Saoura. This is the Oued Guir that feeds the Oued Saoura mostly. The Oued Guir begins in the High Atlas (Morocco) and runs a length of over 350 km to the Oasis of Igli. About 60 % of the total length of this river is in Morocco. With the contribution of 200 Mm³/year, it feeds the bulk of the Oued Saoura [6]. The Oued Guir is known by frequent heavy floods and abundant water collected in the Atlas in the northern region and Boudnib and Bouanane. The floods of the Oued Guir are cyclical, one to two floods per year. Much of this water is lost in the area of spreading Abadla, the other part travels about 400 km feeding the Sebket el Melah, an endorheic salt lake, and even it can reach the Adrar Oasis. The second branch – the Oued Zousfana – is a desert low flood river, which begins in the mountains between the „ksour“ (castles) of Figuig and Beni Ounif and ends at the Igli Oasis. With a length of 230 km and its width, the Oued Zousfana drains a rate of 6 Mm³/year (Merzougui et al, 2008).

So in total, the Oued Saoura drains a rate of 206 Mm³/year, which after travelling 160 km reaches the Ksabi Oasis, and one part water feeds Sebkhet el Melah through the Oued Messaoud, the other part through the Oued Souiregue flows to lose at Bouda around the Adrar region. Another river, the Oued Bechar is of great importance as well. It starts in the mountains north-east of Ouakda, crosses the town of Bechar, from which it takes its name, and then reaches Ksiksou; its waters are lost in Hamada of Guir.

2.2.2 Groundwater of Saoura

The region of Saoura contains different sheets of water. These tablecloths are:

- The tablecloth of Intercalary Continental which is flushed with the west boundary of the Great Occidentalal.
- The tablecloth of Terminal Complex is shallower than that of the Continental Intercalary.
- The alluvial aquifer or infero flux powered by flood waters of the Oued Saoura. The water sits between 5 and 10 meters deep.
- The tablecloth of Paleozoic formations.
- The tablecloth of Jurassic.
- The tablecloth of Turonian.
- The tablecloth of Carboniferous.
- The tablecloth of Quaternary.

2.3 Presentation of the region

We organized three missions in 2011, 2012, and 2013 in the region of Saoura. The oases of Lahmar, Beni Abbes, Ouakda, and Beni Ounif were visited. The foggaras have been made in these oases for several centuries. The majority of the foggaras we visited are in a degraded state. The investigations were carried out with the locals and owners of foggaras on the causes of the decline of the hydraulic heritage.

3 RESULTS AND DISCUSSION

3.1 Traditional systems of water harvesting: the Foggaras

For centuries, the oases have settled along the Saoura valley and seen plenty of water characterized by the existence of artesian springs that helped develop oases agriculture. The disappearance of “artesianism” in the region has encouraged the farmers to make balancing wells and animal tractions. However, the appearance of foggaras in the regions of Gourara and Touat encouraged the development of this technique to replace the wells given its high efficiency. Although no one has been able to confirm that this technique came from Touat or Gourara, the foggaras of Saoura have differences compared with those of Touat and Gourara. Thanks to the ingenuity and know-how, farmers have adapted the foggaras of Touat and Gourara to hydrogeological and geological conditions of the valley of Saoura. Thus these foggaras have short galleries, the flow regime varies according to the seasons and the watershed of the following foggaras occurs on an hourly basis. We studied the foggaras of four oases in the Saoura region: Ouakda, Beni Abbes, Beni Ounif, and Lahmar.

3.1.1 The Foggaras of the oasis Ouakda

The oasis of Ouakda is located at the periphery of the Oued Bechar. In addition to the Oued Bechar which drains a significant flow during flood periods, farmers made dikes along the river to recharge the groundwater and hence to acquire this water from traditional wells. Over 12 foggaras were performed in the oasis whose galleries, not exceeding 200 m, are equipped with twenty ventilation spaced 8 to 10 m wells (Fig. 2). The foggaras of Ouakda exploit the tablecloth of Turonian, which during the period of drought weakens, in order to water it and increase the flow rate. According to the testimony of farmers during the seventies, the foggaras irrigated 80 % of the area of the palm. For twenty four years, thanks to the contribution of modern technology (boreholes and pumps), new palm groves have been developed upstream of the “ksar”. In recent years, the increasing number of wells for irrigation of new land has led to the abandonment of oasis agriculture (Table 1). This new situation has created a drawdown, and consequently the decline of all foggaras in 1989. Various floods that hit the region, particularly the flood of 2008, accelerated the collapse of foggaras.



Fig. 2 Output of a foggara below the „ksar“of Ouakda

Tab. 1 Wells and drilling in the oasis of Ouakda (DHW of Bechar)

Place	Designation	Type	Usage
Ouakda	Belghrou	Wells	irrigation
Ouakda	Tounsi	Wells	irrigation
Ouakda	Bourgrg	Wells	irrigation
Ouakda	Hakkoumi	Wells	irrigation
Ouakda	Aissi	Wells	irrigation
Ouakda	Arabi	Drilling	irrigation
Ouakda	Feyez	Drilling	irrigation
Ouakda	Ayat	Drilling	irrigation
Ouakda	Bessadat	Drilling	irrigation
Ouakda	Affoun	Drilling	irrigation
Ouakda	Tayeb	Drilling	irrigation
Ouakda	Hassi	Drilling	irrigation
Ouakda	S N C F	Drilling	irrigation
Ouakda	Jardin public	Drilling	irrigation
Ouakda	EPEB	Drilling	irrigation

3.1.2 The Foggaras of the oasis of Beni Abbes

The oasis of Beni Abbes is located at 200 km south of Bechar and at 1000 km south-west of Algiers. Thanks to the existence of significant amounts of water, the oasis of Beni Abbes has developed along the Oued Saoura, on either side of the Great Occidental Erg and Hamada of Guir, and is located between two water towers: the tablecloth of Hamada of Guir and the tablecloth of the Great Occidental Erg. The Oued Saoura is the powerhouse of the region. It recharges the tablecloth thanks to infiltration of the Oued Guir which is a branch of the Oued Saoura. The natural recharging of ground thanks to discharges from the Oued Bechar in Hamada of Guir increases the capacity of the aquifer. The reservoir of the Great Occidental Erg is regularly fed by flood waters of the Oued Saoura coming from the Oued Zousfana and Oued Guir. The water catchment of the Grand Erg Occidental water does not pose problems with extraction. The flow is affected naturally thanks to an underground drain that allows water to reach the natural outlet called the great source of Sid Othman whose flow rate is approximately 33 l/s. The distribution of water between different owners is carried out by means of a network of ancestral „seguias“. Concerning the water catchment of the water tower of Hamada Guir, farmers

have realized the foggaras systems. According to the last survey conducted in 2004 by GTZ, a number of the foggaras approximates 65. With a total length exceeding 11.5 kilometres, the total flow rate is 4 l/s. Today, all the foggaras are in a very poor condition. There are multiple reasons for the decline of these foggaras.

3.1.3 The Foggaras of the oasis of Beni Abbas

The oasis of Beni Ounif is located at 110 km north-east of the town of Bechar. It is known for its arid climate because the annual pluviometry does not exceed the 100 mm, but it contains a substantial underground water potential. The oasis of Beni Ounif was born thanks to the existence of artesian sources, gushing forth in several places in the region. The disappearance of “artesianism” time forced the local population to fetch water from a source system called the foggaras (Fig. 3). To feed the „ksar“and irrigate the palm, two foggaras capturing water from a source were dug by the “ksourienne” population. Throughput of the foggaras is related to the rate of the source, which varies depending on the season and rainfall. At the outlet of a foggara, a distribution network consisting of several kilometres of „seguias“(channels) and two collective “madjens” (reservoirs) is located (Fig. 4). The sharing of water between the owners occurs by turns, that is to say, the irrigation of gardens is carried out in series. The unit of measurement used in the oasis of Beni Ounif is “kharrouba” which corresponds to 45 min of flow from the spring. Round irrigation varies from three days in summer to 15 days in winter according to the farmers. The contribution of modern techniques of extraction of groundwater (wells and pumps) consists in the lowering of the water table and consequently the drying up of water sources. More than 30 wells have been installed around the oasis, which favours the abandonment of the foggaras. The hydraulic services today launched a rehabilitation program of the foggaras and “seguias” of the oasis of Beni Ounif (Fig. 5).



Fig. 3 Output of a foggara of the oasis of Beni Ounif



Fig. 4 Seguia in the oasis of Beni Ounif



Fig. 5 Rehabilitation of „seguias“in the oasis of Beni Ounif

3.1.4 The Foggaras of the Lahmar

The vocation agro pastoral oasis Lahmar is located 30 km from the town of Bechar. The existence of permanent water points allows the oasis to have self-sufficiency in agriculture. The sources of water are drained by 4 foggaras which are located in the northern part of „ksar“. These are Aine Djemal, Omran, Tawrirt and Lahmar. The Tawrirt foggara, the largest of them, includes 18 wells to a maximum depth of 25 metres. The smallest one, Omran, includes 4 wells, 6 metres in depth (Fig. 6). At the end of foggaras, the water is stored in the collective “madjens” (Fig. 7). At the end of “madjens”, each owner receives its share of water through „seguias“. The irrigation of gardens goes in turn. In the oasis of Lahmar, there are 24 families and their descendants who are affected by these water rights. The unit of measurement used in the oasis of Lahmar is “tanast” which corresponds to 45 minutes. Because of the contribution of modern techniques and inheritance issues, the foggaras have been abandoned.



Fig. 6 A well of a foggara in the oasis of Lahmar



Fig.7 A “madjen” in the oasis of Lahmar

3.2 Presentation of the region

The foggaras of oases: Lahmar, Ouakda, Beni Ounif and Beni Abbas, numbering 83, have been irrigating the palm groves for centuries (Table 2). Unlike the foggaras of Touat and Gourara whose galleries can exceed 10 km, the galleries of Saoura foggaras do not exceed 200 m. Since the water in the foggara is a public good, it is shared between farmers depending on the contribution of each individual. Sharing the water of the foggaras in the studied oases is performed on an hourly basis and not by volume as it is in the oases of Touat and Gourara. The garden irrigation occurs one after another until the end of a turn, and so on. The distribution network is equipped with „seguias“ of several kilometres and collective „madjens“ (Fig. 8).

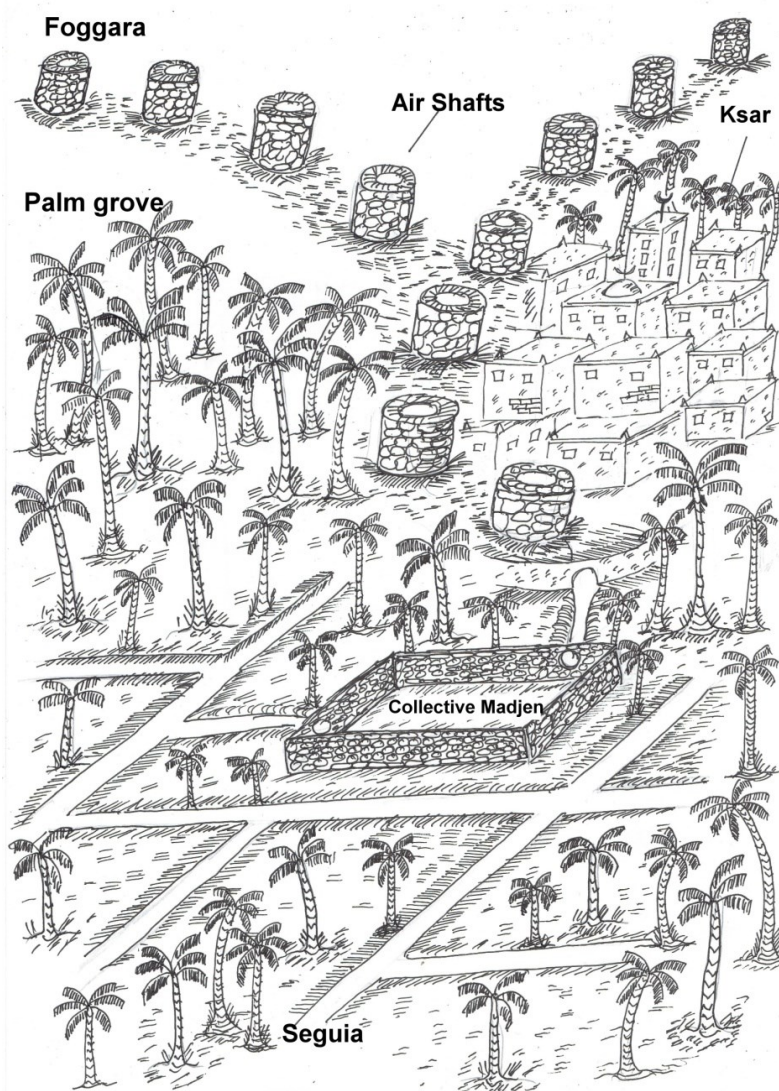


Fig. 8 Schematic of the distribution network of a foggara (on an hourly basis)

Tab. 2 Number of Saoura foggaras

Oasis	Number
Lahmar	4
Beni Abbes	65
Beni Ounif	2
Ouakda	12

4 CONCLUSIONS

As we mentioned earlier in this article, there are few studies on Saoura foggaras. It follows from this that the contribution of the foggaras degrades from year to year. There are almost ten of foggaras remaining in service there, but at a low rate. We identified two main problems for 4 oases. The contribution of pumps in the four oases has contributed greatly to neglecting the foggaras. The performance of pumps is significantly higher than that of the foggaras. The boreholes installed around the oases have contributed to lowering the water level and, therefore, the drying up of the foggaras. The second problem is social, it is inheritance. Several acres of gardens have been abandoned by their families without any solution. Despite some attempts at rehabilitation of these foggaras from the hydraulic services, we risk losing the hydraulic heritage in the short and medium term.

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