



CAN WE GIVE BACK TO THE FOGGARA ITS SOUL?

PEUT-ON RENDRE A LA FOGGARA SON AME ?

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ABSTRACT

This paper briefly describes the contribution of the Foggara to the development of the oases of the Algerian Sahara during more than 20 centuries of exploitation. Over a 20-year period of study in the Touat and Gourara regions (2000-2020), we learned a lot about the social and technical aspects of the Foggara system. The benefits of Foggara are enormous. The Foggara is the only hydraulic system that adapts to arid environments. The Foggara is the only technique that protects the ecosystem from dry environments. The Foggara is the only hydraulic system that consists of a technical part (the work itself), and a social part (which is represented by the sharing of water). The Foggara remains an evolving hydraulic system that is about to evolve in time and space. Today the Foggara in view of the socio-economic and environmental problems is about to disappear. So can we let such a thousand-year-old hydraulic system disappear? Despite the efforts of rehabilitation and renovation, we never returned the soul to the Foggara.

Keywords: Foggara- the soul- hydraulic work- social- rehabilitation

RESUME

Le présent papier décrit brièvement l'apport de la Foggara dans le développement des oasis du Sahara algérien durant plus de 20 siècles d'exploitation. Sur une période de 20 années d'études dans les régions de Touat et Gourara (2000-2020), nous avons appris

beaucoup de choses sur le social et la technique du système de Foggara. Les avantages de la Foggara sont énormes. La Foggara est le seul système hydraulique qui s'adapte au milieu aride. La Foggara est la seule technique qui protège l'environnement d'un milieu sec. La Foggara est le seul système hydraulique qui est constitué d'une partie technique (l'ouvrage lui-même), et d'une partie sociale (qui est représenté par le partage de l'eau). La Foggara reste un système hydraulique évolutif qui s'apprête à évoluer dans le temps et dans l'espace. Aujourd'hui la Foggara au vu des problèmes socio-économiques et environnementaux s'apprête à disparaître. Alors peut-on laisser un tel système hydraulique millénaire disparaître ? Malgré les efforts de réhabilitation et de rénovation, nous n'avons jamais rendu l'âme à la Foggara.

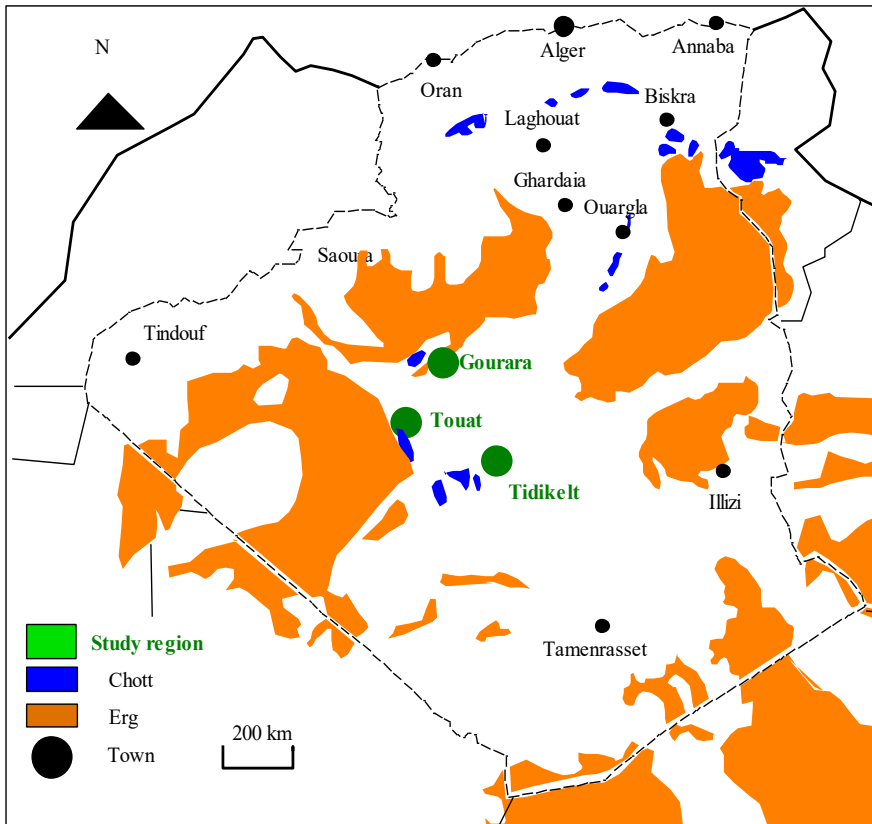
Mots clés : Foggara- l'âme- ouvrage hydraulique- social- réhabilitation

INTRODUCTION

Can we give back the soul to the Foggara is the title proposed for this paper. It was after 20 years of work in the oases of Touat, Gourara, and Tidikelt, we felt that this thousand-year-old hydraulic system was threatened with disappearing. A hydraulic structure as important as that of the Foggara which lived more than 3000 years in ancient Persia (Goblot, 1963; Goblot, 1979), and more than 2000 years in the Algerian Sahara (Remini, 2017; Remini and Achour, 2016; Remini et al, 2015; Remini et al, 2011). This longevity is only the result of its success and efficiency. This hydraulic system discovered in the northern Iranian plateau has been exported to more than 50 countries around the world (Remini, 2014). Based solely on gravity, water flows from the subsoil to the ground surface without energy and without damaging the environment of the Region (Remini, 2011; Ghachi et al, 2021). If today, hundreds of hectares of palm groves exist, it is thanks to the water from the Foggara. It is no coincidence that today there is a relationship between the Foggara and the palm tree, since in all the oases of the planet, the traces of the Foggara have remained engraved (Remini et al, 2014; Remini, 2011). This is only obvious that the Foggara remains a collection and irrigation technique specific to arid regions (Remini, 2019a; Remini, 2019b). For more than a century, this hydraulic heritage has resisted competition from modern techniques for collecting water (motor pump and drilling). Unfortunately for about thirty years we have witnessed an accelerated degradation of this capture method which risks being abandoned in a few years. This study attempts to show the importance and usefulness of the Foggara in dry areas such as the Sahara. The socio-economic and environmental benefits provided by the Foggara will be the subject of this work.

STUDY REGION AND WORK METHODOLOGY

After twenty years of work on the sites of the Foggaras, more particularly in the oases of Touat, Gourara and Tidikelt. These Foggara oases, which are scattered over an area of crescent shape, are located between 1000 and 1400 km southwest of Algiers (Fig. 1). These oases that we consider to be beauty spots of the Sahara Desert are wetlands in a vast arid region. During our stays in these oases we met several owners of Foggaras, Kial El Ma, Imams of mosques, old people who took part in the Foggaras digging. Surveys were carried out among the Ksourian population to obtain information on the Foggaras. Investigations were carried out on a hundred Foggaras to find out the real problems encountered by this type of work. We have consulted documents, archives and also data on the Foggaras.





Timimoun, capital of Gourara (Photo. Remini, 2019)

Figure 1: Geographic location of the study region (Remini, 2021)

RESULTS AND DISCUSSION

Birth of Foggara

The Continental Intercalary water table is a captive water table, part of which is located under the Tademaït plateau. However, on the southwest, northwest, and western outskirts of the Tademaït plateau, the water table returns water to the surface of the soil through resurgences and springs. Man settled down and also created his environment consisting of a multitude of oases forming the regions of Touat, Gourara, and Tidikelt. Over the centuries, the oases have multiplied and the irrigated area has increased. The water sources went out and the farmer then used outrigger and animal-drawn wells to deal with the lack of spring water. The appearance of Foggaras in the region of Touat, Gourara and Tidikelt has disrupted irrigation and changed the way of life of the local population. From a historical point of view, it is difficult to locate the exact birthplace of the Foggara. However, only Goblot's work asserts that the Foggara is of Persian origin, since the first qanat (Foggara) was dug more than thirty (30) centuries ago (Goblot, 1963; Goblot, 1979). On the other hand, the first Foggara was carried out for more than 20 centuries in the southwest of the Tademaït plateau. Despite the age difference of 10 centuries, some old Ksourians claim it to be a local invention. According to several studies, the Iranian qanat was exported from Arabia to the Maghreb through the axis of the spread of Islam (Remini et al, 2014; Remini, 2011). Is this a local invention or a transfer of know-how from Persia to North Africa?

Indeed, the Foggara has revolutionized the world of hydraulics, since it is exported to more than 50 arid countries around the world (Remini et al, 2014; Remini, 2011).

We defined the Foggara as a horizontal well (Remini, 2017). The Foggara is a slightly inclined horizontal drain that allows water from an aquifer to drain to the surface of the

ground (Fig. 2 and 3). The underground gallery is equipped with several ventilation shafts which served as a means of evacuating the spoil to the surface of the ground during the digging of the Foggara. During the operation of the Foggara, these wells are used for the aeration of the gallery (Remini and Achour, 2016; Remini et al, 2014) (Fig. 4).

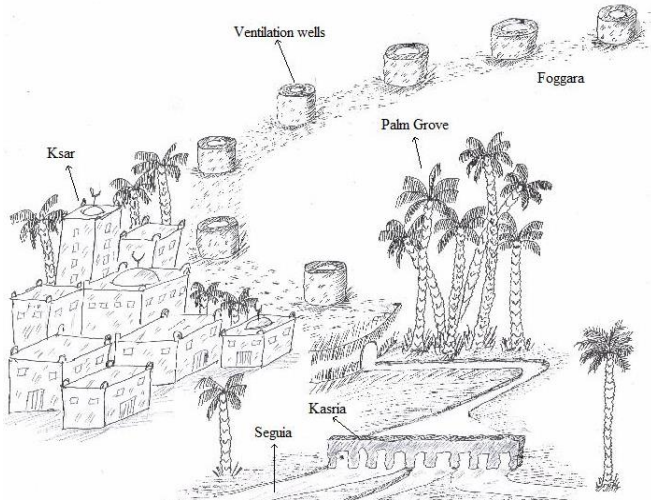


Figure 2: Block diagram of a Foggara (Diagram, Remini, 2021)



Figure 3: Gallery of the Foggara La Salma in the Gourara (Remini, 2008)



Figure 4: Ventilation wells of a Foggara in Tidikelt (Authors, 2013)



Figure 5: Block diagram of the water distribution network of a Foggara in Touat, Gourara and Tidikelt (Diagram, Remini, 2021)

The most important in the Foggara system is the water distribution and sharing network (Fig. 5). Once it reaches the surface of the ground, the water from the Foggara is distributed by a triangular (pyramidal) network. Each co-owner receives his share of water according to his contribution to the maintenance of the Foggara. Thanks to the different types of kasriates, water is shared equally between subscribers (Figs. 6, 7 and 8). Each garden is equipped with a madjen sized according to the flow rate of each farmer (Figs. 9 and 10). Each madjen is filled for 24 hours with water, which is transported by seguias of different sizes.



Figure 6: Secondary Kasria of a Foggara in the Tidikelt (Authors, 2013)



Figure 7: Tertiary Kasria from a Foggara in the Tidikelt (Authors, 2013)



Figure 8: Small kasria in the Tidikelt (Authors, 2013)



Figure 9: Madjen in a garden in Tidikelt (Authors, 2013)



Figure 10: A Gemoun in a palm grove in Tidikelt (Authors, 2013)

Contribution of Foggara to social cohesion in Oasis

When the Foggara arrived in Touat, Gourara and Tidikelt a new era took hold in these hyper arid regions; this is the era of community and group work. People's behavior changed and people quickly adapted to this new life. Everyone talks about the Foggara in the ksar in the mosque. Once the digging of the Foggara (upstream part) is completed and water gushed to the surface of the ground: this is the event in the ksar. An immense joy for the population, the party in the ksar. The day of the water gushing out of the Foggara, this day remains an unforgettable date in the memory of the local population, since it took years of sacrifice and hard work to reach this stage. No one has described when water came out of the basement to the surface of the ground. This moment was lived only by

the people who took part in this gigantic ancestral hydraulic work which took several years of hard work.

The water that flows on the surface of the ground becomes a good that belongs to the group of people who have contributed to the realization of the Foggara. This is when the sharing of this property between these people must take place. A genius social organization was brought to light by the djamaa (group of wise men) of the ksar. It is a question of granting each participant a share of water which is a function of his contribution in the digging of the Foggara. These water shares are determined by the genius of the Foggara called Kiel El Ma. This is how each ksar is equipped with a measuring instrument (Hallafa) calibrated to units of measure specific to each ksar. Usually, the unit of measure for volume is the Habba, an opening whose diameter corresponds to the diameter of the core of dates. It is once this character has quantified the total flow of water leaving the gallery that he must proceed to share the water between the co-owners of the Foggara. It should be remembered that no one can predict the value of the flow before the digging of the Foggara. Once the flow rate is known in terms of the Habba number, we move on to the second step, which corresponds to measuring the water shares of each participant. At this stage also begins the realization of the distribution network. After the event of the digging of the gallery, comes the event of the sculpture of the great (main) kasria called kasria El kbira. Another genius, artist of the ksar who takes charge of the realization of the kasria. Everyone goes in search of the flat rectangular rocks. Once the rock arrives at the level of the Foggara, the sculptor arranges openings of different dimensions which are linked to the contribution of each family who are shareholders of the Foggara. Such work can take several days. Once the El Kbir kasria is finalized and then linked directly to the gallery by Aghisrou (a covered seguia about a hundred meters in length), the event is celebrated by the local population. From there, it is the beginning of the distribution network. The presence of Kial El Ma and his Hallafa becomes essential. A new construction site for several kilometers of seguias, kasriates, as well as the Madjens. The first team takes care of the hydrometry and the quantification of the water shares of each subscriber. Once the number of beneficiaries and their flow rates are mentioned on the Zemâm (register), the second (technical) team begins making the seguias, which are sized according to the water shares. The length of each seguia is a function of the location of the gardens. Each garden (Guemoun) is equipped with a madjen (storage basin) and it is dimensioned in such a way that it can be filled in 24 hours. It should be remembered that each subscriber receives his irrigation quota regardless of the location of his garden. This second project concerning the distribution network may take several years to complete. Once completed, we can say that the Foggara system (collection and distribution) can be classified as an ancestral work of art. The operation of the Foggara is governed by rules and laws established by the "djamaa" (council of elders) of the ksar. Water is free to feed the ksar. Part of the water from the Foggara is channeled directly through a seguia to the mosque. Except that the irrigation of the palm grove remains dependent on the contribution (effort, contribution) of each shareholder. However, each co-owner has the right to buy, sell or borrow one or more shares of water from the same Foggara or another Foggara, belonging to the same or another ksar. With each transaction (purchase, sale or loan), everything will be mentioned on the Zemâm.

As well as improvements can be made to the distribution network such as the addition of a new *segua* (purchase or borrowing of a share of water) or removal of a *segua* (sale). In the case of a purchase, even the dimensions of the *madjen* will be changed. This shows that the Foggara system is not a fixed structure, but rather a dynamic structure which requires modifications over time. In the upstream part, that is to say the gallery of the Foggara also undergoes modifications to improve each time the flow of the Foggara. These changes are mainly due to the increased demand for water for irrigation or to feed the *ksar*. It should be noted that the *ksar* is sized according to the flow of the initial Foggara. Only over time, the demographic growth of the population of the *ksar* requires an additional volume of water for the supply of drinking water and for the irrigation of the new gardens, or the extension of the palm grove. In such a situation, the oasis is faced with three possible cases:

- Digging of new Foggaras;
- Plunge into the old gallery by digging a section upstream of the Foggara, locally called "Tarha" (Remini, 2016; Remini et al, 2015).
- Addition of one or more ramifications of new galleries, locally called "kraa" (Remini, 2016; Remini et al, 2015).

The choice of one of these three variants is made during one or more meetings between the *djamaa* and the concerned (owners, specialists). The choice is dictated by a technico-economic study.

Digging of the Foggara

Digging a Foggara more than 10 km long in a desert environment and with rudimentary means for several years is a miracle. We do not dig at random, but such a project requires exceptional know-how. Everything is planned and well prepared to achieve the goal long awaited by the local population. It is the gushing of groundwater on the ground. Once the water and its piezometric level are determined by a specialist, we first dig the "mother" well which can be located more than 10 km from the gardens to be irrigated. The difference in level of the piezometric level by the aquifer in relation to the level of the gardens must be known. This is necessary data to dig the gallery of the Foggara. Getting a slope of the drain to allow water to flow slowly for several miles to reach the gardens is a delicate job. Once the "slope" parameter is determined, digging begins from downstream to upstream, that is to say from the outlet to the mother well. An exceptional organization of the Foggara site with a project manager and specialist workers. Everything is prepared in advance, namely: the rope, the animal and the winch (Figs. 11 and 12).



Figure 11: Equipment used for the digging and maintenance of a Foggara (Authors, 2013)



Figure 12: Simplified installation for digging wells ventilation of a Foggara (Authors, 2013)

The project begins with the excavation of the gallery in the transport part going from downstream to upstream. As the excavation progresses and the spoil is evacuated outside, the workers encounter difficulties with light and breathing as well as the evacuation of the land (Fig. 13). The excavation cannot go beyond the threshold of 25 m in length. So to help ventilate the gallery and facilitate soil evacuation, the first team will continue digging the second section to stop around 20 meters away. The second team of 3 to 4 workers will then dig the second vertical shaft, and so on until it reaches the mother shaft. It is from there that the Foggara project will end. All that remains is to clean up the earthen debris that remained in the gallery (Fig. 13). Once the works are completed, we move on to quantifying the flow of the Foggara to estimate the real value of the Foggara or the cost of the project (Fig. 14). The project of the realization of a Foggara is not a simple affair; it is a very complex project which requires a lot of sacrifice. Thus, when digging a Foggara, many work accidents are reported. Injuries and even deaths were recorded during the implementation of the project. Landslides and landslides in the gallery and wells are the main causes of workers' deaths. Death from asphyxiation (absence of oxygen and the presence of toxic gases). One of the common accidents is the loss of sight of the workers due to the light shock caused by the sudden change of the individual from a dark environment to a light one. Sometimes the worker spends several hours working at the back of the gallery without the presence of light, but once he leaves his environment to go to the surface of the ground, the individual loses his life.

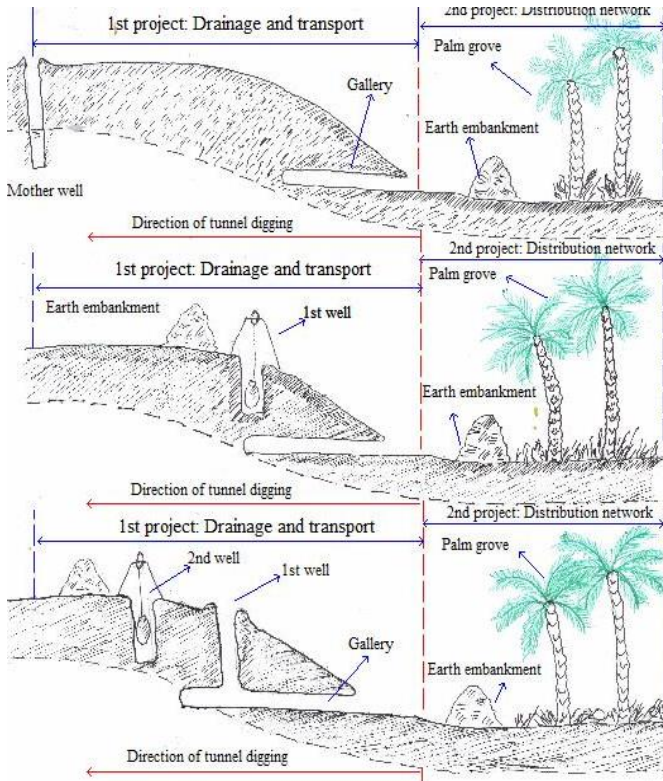


Figure 13: Synoptic diagram of the different parts of a Foggara digging (Remini diagram, 2021)

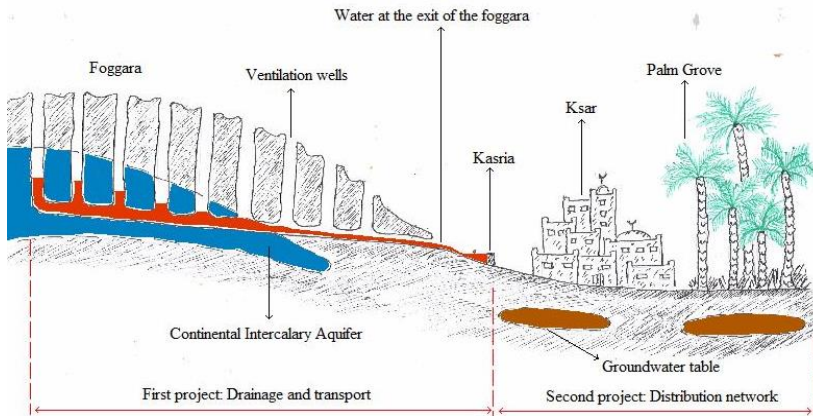


Figure 14: Diagram of a Foggara in operation (Remini diagram, 2021)

The Foggara is made up of two parts: the draining part and the transport part. When digging a Foggara, it is in the draining part that the worker encounters enough problems. Once the transport gallery is completed, the digging of the draining part begins. From there, the workers will start digging in the wet area soaked in water. The work is carried out under complex conditions. Water is everywhere; the worker is wet with water and stained with clay. The number of accidents multiplied in this part. This is how landslides and landslides are quite common in the draining part. As we move towards the mother well, the working difficulties accelerate due to the increased flow of water. Even, the working environment becomes an impassable because of the mud.

The Foggara: an ecological hydraulic system

It is in an arid environment that water regains its value. In the Touat, Gourara, and Tidikelt, and in view of the sacrifices made during the digging and maintenance of the Foggaras, water has become a precious commodity. It is in this sense that in the oases of the western outskirts of the Tadmait plateau that water is the real land and not the land. Land without water has no value in these regions. At the level of these oases, the Foggara is sacred and has an inestimable value among the local population. It is in the same rank as the mosque of the ksar. Besides, even the magic tree which is the date palm has a relation with the Foggara. The two parameters palm tree and Foggara lie on the axis of the diffusion of Islam (Remini, et al, 2014). The Sahara is a dry environment that does not like too much water and a very fragile ecosystem. So there is a threshold that must not be exceeded, otherwise we must expect an ecological disaster such as the case of the rise of groundwater in the oases of Souf and Ouargla (Remini and Souaci, 2019; Miloudi and Remini, 2018). This phenomenon took place during the 90s following an excess of irrigation water preventing the aquifer of the intercalary continent. The Foggara is a thousand-year-old hydraulic system intended to irrigate thousands of palm trees for more than twenty centuries. So we can conclude that the Foggara is the only means of irrigation that can protect the aquifer (neither drawdown, nor rise), and the soil (salinity, and subsidence).

A perennial Foggara, a green Oasis

When we pass through the oases of Touat, Gourara, and Tidikelt, we see green gardens synonymous with the existence of water, which can only be that of a perennial Foggara. On the other hand, you can find much degraded areas right next to this same garden due to the lack of water. This is reflected in the degraded state of the Foggara which feeds this garden. The Foggara is the lung of an oasis of Touat, Gourara, and Tidikelt. In addition to supplying water to the people of the ksar, the Foggara provides water for the palm grove and also gives a freshness that reduces the temperature to more than 15 ° C compared to the outside. However, the drying up of a Foggara can lead to desertification of the oasis. Thus, during the history of Touat and Gourara, a large number of the oases were abandoned during the absence of water. Today only vestiges and ruins of the old ksours remain. As a result, hundreds of the palm groves were invaded by sand and now

lie beneath the sand dunes. So these we are talking about the desertification caused by the Foggara.

The Foggara and nature; a continuous fight

In a hyper arid region like Touat and Gourara, the climate is very harsh and aggressive and does not make life easier for humans. Thus, after years of digging tunnels in a Foggara, the hard work never stops after the water comes out to the surface, but it continues even while the Foggara is operating. It is about maintaining and cleaning the Foggara, fighting against silting up and flooding. At each event (silting up, flooding, etc.), the population invents means to fight against silting up, such as covering kasriates, seguias, and wells with flat rocks to prevent sandy deposits in these structures. Sections of galleries have often been repaired following landslides and landslides. With each sandstorm, operations of cleaning and cleaning of galleries, kasriates, and madjens were carried out by the population. Even the gardens are often protected by barriers or palisades made by branches of palm trees (Djérid) to slow the advance of the dunes. In extreme cases, the population may abandon the ksar with the profile of a new ksar which will be built a little lower on the periphery of the palm grove. Another case is to be reported; the silting up of part of the palm grove pushes agriculture to develop new agricultural land located at the bottom of the palm grove (next to the sebkha).

CONCLUSIONS

What a genius, water flows 24 hours a day from the aquifer to the gardens without any energy, this is the Foggara system. For more than 20 centuries such a thousand-year-old hydraulic system has operated without damaging the environment. Irrigation by Foggara produces very good quality agricultural products. The water of the Foggara has plenty of time to acquire various nutrients. In addition to being underground water that has benefited from natural infiltration, it flows slowly along a gallery of several kilometers, while hugging several types of rocks. When leaving the gallery, the water, which is very rich in nutrients, benefits the plant to give very good quality fruit. In addition, the Foggara is the hydraulic system that can preserve dry environments. Indeed, such regions have a very fragile ecosystem that does not like too much water. There is a threshold when it comes to water that cannot be crossed, only the Ksourian people can spread to you. So how, after such a long period of irrigation (20 century), the Touat and Gourara region has managed to preserve its environment. The piezometric level of the water table has remained almost unchanged. On the other hand, in only 40 years, the drilling has caused a lowering of the water table in the southwest oases and an upwelling in the oases of the southeast of the Sahara. So can we abandon a Foggara or preserve it. It is true that today it is impossible to dig new Foggaras, on the other hand it is possible to rehabilitate and save the old Foggaras. Even if we manage to rehabilitate a Foggara, we will never be able to give it back its soul which is the social side.

ABBREVIATIONS

Guemoun: garden
Kial El Ma: the person who quantified the water of the Foggara
Kasria El Kbira: Main Kasria
Zemâm: register
Hallafa: method of quantifying the flow of the Foggara
Chegfa: process for quantifying the flow of the Foggara
Aghisrou: covered seguia about a hundred meters in length
Tarha: extension of the gallery
Kraa: a gallery attached to the main gallery
Ksours: plural of Ksar
Kasriates: plural of Kasria
Madjen: Water storage basin
Ksar: city of farmers
Foggara: horizontal well
Kasria: parter
Seguia: earthen canal
Souagui: plural of seguia

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