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Evolution of capture technologies of water in the oases: Moghrar, Tiout and Boussemgouhoun (Algeria)

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Abstract

This article discusses the various water harvesting techniques used in the oases of Boussemgouhoun, Moghrar and Tiout for more than nine centuries. Several hydrological assessments have been conducted in the three oases since 2002 including surveys and investigations with the local communities. The results obtained showed that after the decrease in discharge of the sources, the population had resources to various ancestral hydraulic infrastructures such as: well, foggara, and small dams (Essad). The water harvesting technique is specific to the region and depends on the hydrogeology and the topography. Traditional low-flow water-saving technologies preserve the environment, modern hydraulic techniques give more water but have a negative impact on the environment. The drying up of springs and lowering of water tables are the result of the population growing and the socio-economic development. They require more and more water. A compromise between traditional and modern techniques (or types of management) can solve this problem.

Key words: *capture, drilling, environment, oasis, traditional pump, water*

INTRODUCTION

Arid regions such as the Sahara for example are characterized by low rainfall and strong evaporation. However, the floods that occur in these areas are very short, but drain very important inputs and can cause enormous material and human damage. For example, the rivers such as Mzab, Mzi, can reduce a significant amount of water in just a few hours, which results in seepage into the basement to replenish the upper water table. For the use of this rare deposit, oasiens have invented over time various water collection techniques that are adapted to their environments. Thus in the regions of Touat and Gourara to extract groundwater, the population uses the foggara system which is based on underground tunnels [REMINI *et al.* 2012].

Thus more than 1400 foggaras have been realized on the outskirts of the oases (eg. ABIDI, REMINI [2011], REMINI, ACHOUR [2013a], REMINI *et al.* [2014], REMINI, ACHOUR [2016], BENSAAIDA, REMINI [2016], LEDUC *et al.* [2017]). Even oasis in the middle of the dunes has been fed by erg foggaras [REMINI, ACHOUR 2013b]. Small foggaras that capture the water lost in the subsoil were dug in the palm grove of Timimoun [REMINI *et al.* 2015]. In the oases of Saoura, farmers used khottaras; a multi-pole pendulum well system [REMINI, ACCHOUR 2016]. More than 600 wells have been dug in the middle of the palm groves [REMINI, REZOUG 2017]. In the valley of Mzab, it is another type of well that the Mozabites dug, it is the wells with animal energy. In addition to these techniques for collecting groundwater, Mozabites have installed

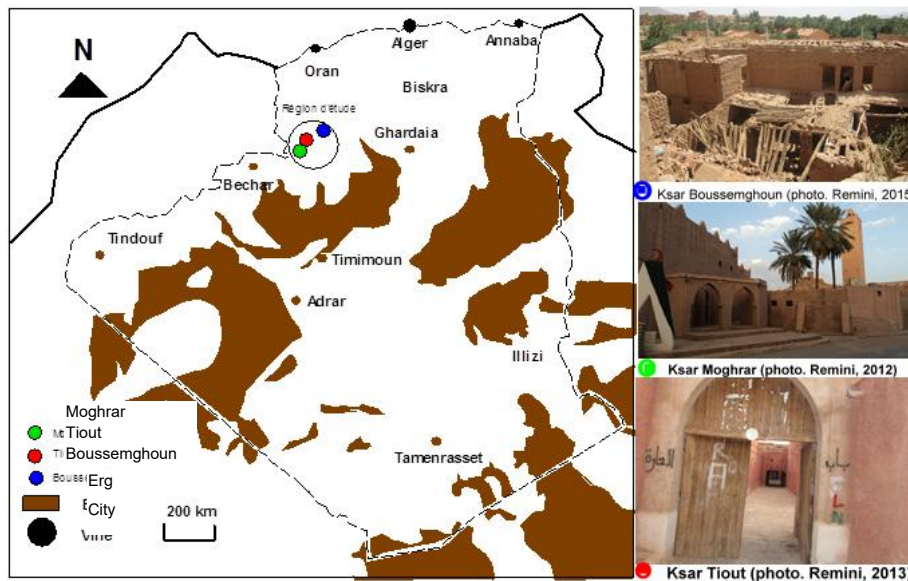


Fig. 1. Oases geographical location: Boussemghoun, Moghrar and Tiout; source: own elaboration

a system of foggaras to capture floodwaters [REMINI *et al.* 2014]. The oases of Tiout, Moghrar and Boussemghoun located in the North-West of the Sahara are characterized by their richness in groundwater which is manifested by the appearance of numerous sources of water on the bottom and the banks of the wadis. Various ancestral techniques of catchment and storage of water have been carried out for centuries in these regions. Our study focuses on the evolution over time of hydraulic systems used in the oases of Tiout, Moghrar and Boussemghoun. The impact of the introduction of new hydraulic techniques in oases on the environment will be addressed in this study.

REGIONS OF STUDY AND METHODOLOGY OF WORK

GEOGRAPHICAL LOCATION OF THE STUDY AREA

Tiout, Boussemghoun and Moghrar: very beautiful oases (Fig. 1) with a high tourist potential character. The three oases have the same route concerning the water techniques adopted since more than 9 centuries. The oases are located in the mountains of ksour which are characterized by an arid climate. Belonging to the wilaya of Naama, the oasis of Moghrar is located 580 km as the crow flies South-West of Algiers. The oasis of Tiout is located 45 km of South of the wilaya of Naama and 550 km as the crow flies South-West of Algiers. On the other hand, the oasis of Boussemghoun is located 130 km in the southwest and in 525 km in the air in South-West of Algiers.

CHARACTERISTICS OF THE STUDY AREA

The common point between the three oases the abandonment of groundwater, which is characterized by the appearance of several resurgences and springs,

especially at the bottom and in the banks of the wadis. Thus the three ksour were built around the sources of water. The availability of water in the region has allowed farmers to develop new land and expand the palm grove. In addition to the palm orchards, there is a very rich variety of vegetables and fruits such as lemon, pomegranate, as well as lettuce, wheat, barley, turnip and carrot (Phots. 1 and 2).



Photo 1. General view of the palm grove of Moghrar (phot. B. Remini)



Photo 2. View of a part of a garden of the oasis of Tiout (phot. B. Remini)

METHODOLOGY OF WORK

Our study is based essentially on the investigations and surveys carried out near the local population as well as the hydraulic and local agricultural services. Indeed, 4 work missions were carried out on the three oases during the period 2002–2017. We visited all the ancestral and modern hydraulic infrastructures of the three oases. We have collected data, information and documents from the technical services of the three commissions, hydraulic and agricultural services of the wilayas of El Bayadh and Naama.

RESULTS AND DISCUSSIONS

EVOLUTION OF Ksour ACCORDING TO THE WATER

It is the presence of water that allows human settlement in arid regions. The three oases: Tiout, Moghrar and Boussemghoun in common the availability of groundwater which is reflected in many springs along the beds and banks of the wadis (Fig. 2, Photos 3, 4).

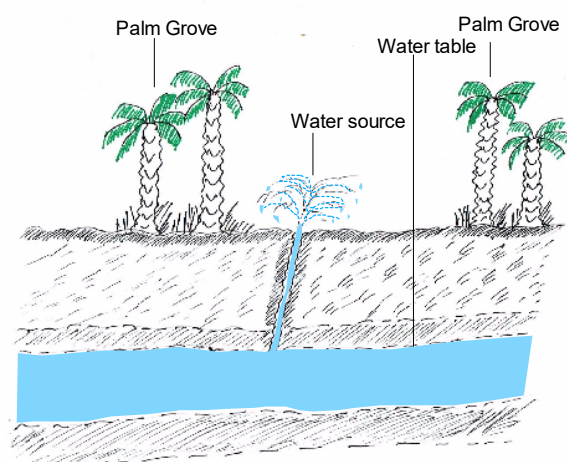


Fig. 2. Diagram of a water source that manifests itself in the three oases; source: Remini's elaboration



Photo 3. A water source in Wadi Boussemghoun of appreciable flow (phot. B. Remini)



Photo 4. A source of water in the oasis of Moghrar (phot. B. Remini)

Thus, at the beginning of the 11th century, man settled on the outskirts of these wadis while building his habitat and landscaping his garden (Fig. 3). Over time, the demand for irrigation water and drinking water has increased. This growth is due to the increase in the local population and the increase in the area of irrigated land. The continued exploitation of these resources has caused the drying up of many sources. This new situation has pushed the oases population to invent techniques of water collection and storage. Depending on the topography and hydrogeology of the region, man has established his hydraulic system that adapts to his environment. Thus, for the oasis of Tiout, the population adopted an ancestral dam that allows the storage of spring water [AIT SAADI *et al.* 2015] (Fig. 4, Photo 5).

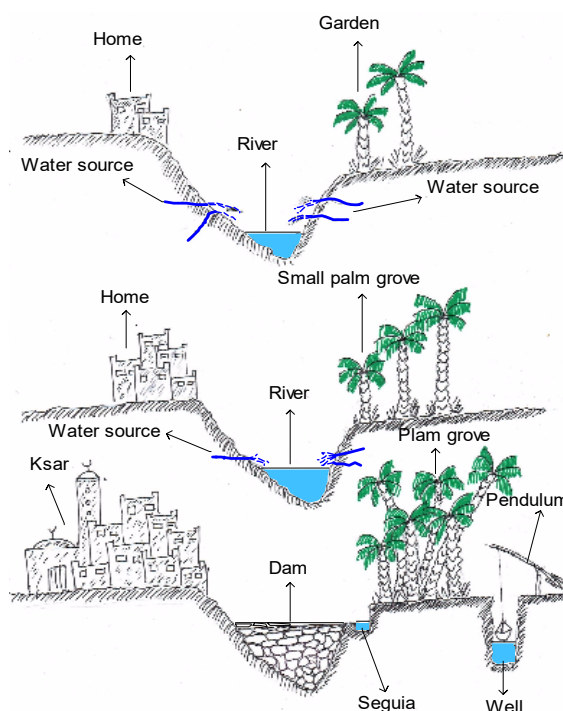


Fig. 3. Diagram of socio-economic evolution of the wadi oasis; source: Remini's elaboration

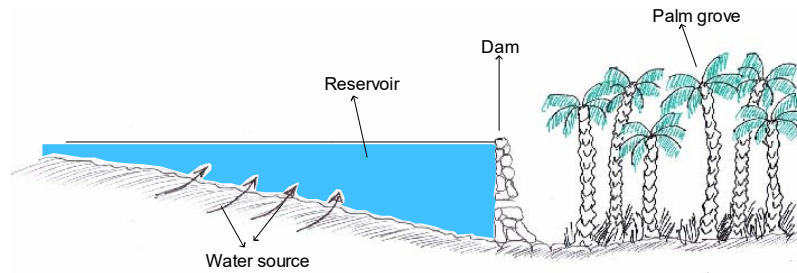


Fig. 4. Diagram of a traditional dam designed to store water of sources; source: Remini's elaboration

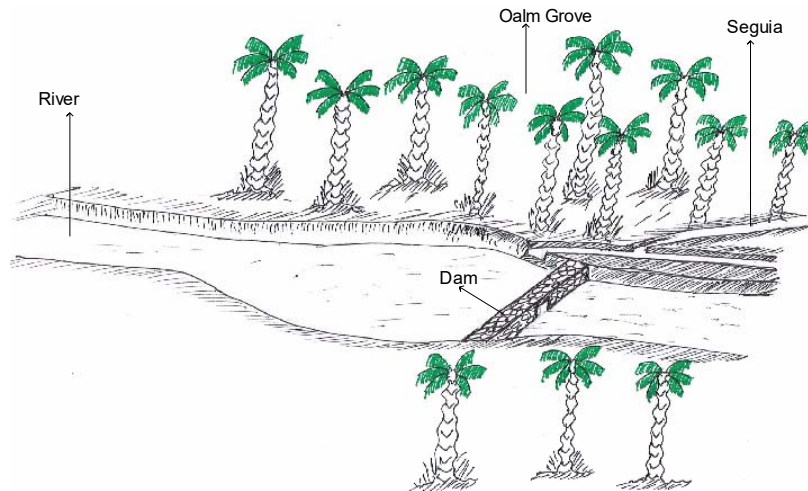


Fig. 5. Diagram of part of the ancestral hydraulic complex dam and network of seguias; source: Remini's elaboration



Photo 5. The ancestral Tiout dam is filled with water leaks (phot. B. Remini)

The foggara is a collective work, so the water belongs to the oases people who participated in the construction and maintenance of the dam. For the distribution of water, rules of water sharing between the co-owners have been adopted by the oases. For example, farmers agreed on the principle that "the share of water is a function of the contribution of each co-owner". The distribution is carried out by "Nouba" method, that is to say in turn, except that the duration of irrigation depends on the contribution of the individual as we mentioned at the beginning of this study. From the dam a network of seguia (channel) was

designed inside the palm grove to transport water to farmers one by one (Fig. 5).

With regard to drinking water supply, traditional pulley wells have been dug in specific ksar locations to facilitate women's access to drinking water. Individual and collective balance wells (two to three individuals) have been dug in the palm grove to improve garden irrigation (Fig. 6).

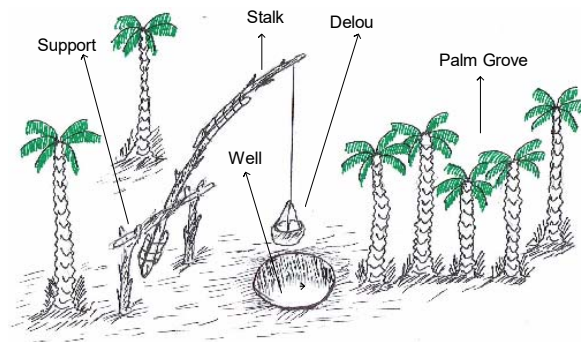


Fig. 6. Diagram of a typical balancing well used in the oases of Tiout, Moghrrar and Boussemghoun; source: Remini's elaboration

As far as the oasis of Moghrrar is concerned, the oasis people have also settled on the outskirts of the wadi Moghrrar near the water sources. Over the years, several water sources have dried up like those of their neighbors Tiout and Boussemghoun, oasiens have resorted to techniques of capture of spring water.

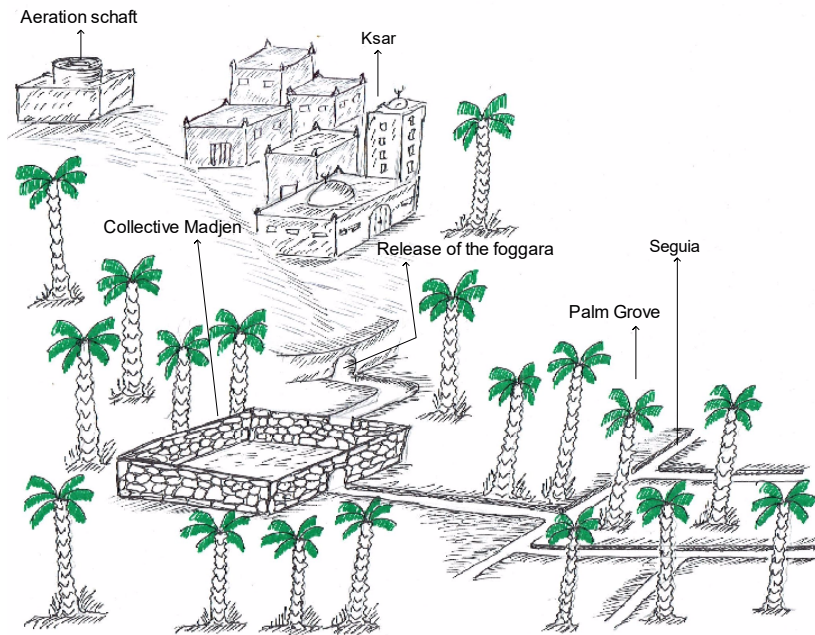


Fig. 7. Synoptic diagram of a source foggara of the oases of Moghrar Tahatani; source: Remini's elaboration

A source foggara has been used in the oasis of Moghrar Tahtani (Fig. 7). The source foggara called "Ain" is a 200 m-long gallery that captures the waters of two springs and stores them in a large pool called "Madjen" collective [REMINI, ACHOUR 2017] (Photo 6). From this reservoir, a network of seguias (canals) is started which is intended to convey the water for each farmer according to his contribution (Photo 7). To reinforce the irrigation of the gardens, two small dams (Essed) were built at the level of the Wadi Moghrar. Farmers whose shares of water have a low flow, have dug wells in their gardens whose purpose is to increase the flow of irrigation (Photo. 8). For the drinking water supply of the ksar of Moghrar, wells were dug in the alleys to allow the population to drink water.



Photo 7. A seguia in the oasis of Moghrar (phot. B. Remini)



Photo 6. A collective Madjen in the oasis of Boussemgoun (phot. B. Remini)



Photo 8. A pendulum well model at the entrance from the oasis of Moghrar Tahtani (phot. B. Remini)



Photo 9. The water level is flush with the soil surface in a well of the oasis of Boussemgouh (phot. B. Remini)

A system of seguias has been installed to collect and drain these waters to the farmers' gardens. Three dams have been built on wadi Boussemgouh, which is intended to store spring water and regulate floods in the wadi. Regarding the drinking water supply of ksar Boussemgouh, a dozen wells were dug in the alleys of ksar. There are even wells in some houses.

With the exception of the oasis of Boussemgouh, the constant women' going-and-coming between the ksar and the palm grove to obtain drinking water from the water sources located on the outskirts of wadi Boussemgouh.

CONTRIBUTION OF MODERN TECHNIQUES

The contribution of modern water abstraction techniques in the regions studied has a favourable impact on the increase of the quantity of water and consequently on the socio-economic development of all regions. However, these techniques have a negative effect on the environment and the social side. Thus, the intensive exploitation of the water table associated with prolonged drought has caused a lowering of the piezometric level of the water table. Such a situation has resulted in the drying up of several water sources. In the early nineties, the ancestral Tiout Dam dried up following the drying up of several water sources supplying the dam. In the oasis of Moghrar, the flow of foggara has greatly decreased following the pumping of the waters of the water table. In the oasis of Boussemgouh, the contribution of the motor pumps did not have any damage like those of Tiout and Moghrar, only, we recorded a fall of flow of sources. It should be noted that the demand for water has increased since the 1980s to satisfy the irrigation of the Boussemgouh palm grove, which has reached an area of 250 ha (Fig. 8).

Managed by 250 families, the palm grove of Boussemgouh is irrigated by 6 sources and 32 wells. However, it is interesting to note that a new dam was built during the 1970s upstream of the palm grove on wadi Boussemgouh to improve the irrigation of gardens and regulate floods. Such a work has greatly

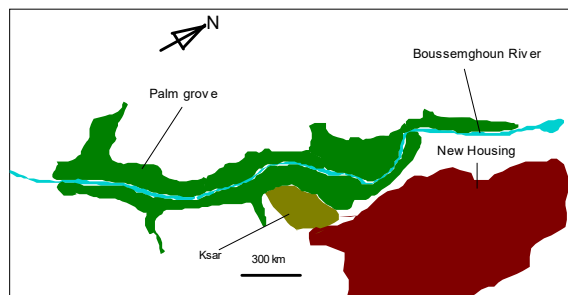


Fig. 8. Location of the Boussemgouh palm grove in relation to the wadi; source: Remini's elaboration

contributed to the lowering of the water table. The 125 boreholes installed throughout the municipality of Boussemgouh have contributed much to the draw-down of the water table. It is interesting to note that part of the palm grove suffers a lot of water since the year 2008 following the rise of the water table. According to the testimony of several Ksourian this phenomenon is the consequence of the earthquake of the year 2008. Covering an area of 20 ha, the Moghrar Foukani palm grove contains 5000 date palms and is fed by two sources, 10 traditional wells and 1 borehole (Fig. 9). Before water sharing between farmers, water is stored in 3 collective madjens. More than 60 families lived in the palm grove. In addition, the network of seguias was damaged by the flood of 2008, which pushed the local authorities to rehabilitate the system of seguias. At the oasis of Moghrar Tahtani, the palm grove with an area of 40 ha contains 8000 palm trees is irrigated by foggara (which is fed by two sources) and 20 traditional wells in service. In contrast, another 40 wells were silted by the 2008 flood. Throughout the Moghrar region, irrigation is carried

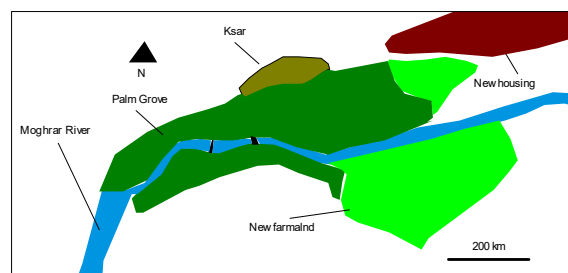


Fig. 9. Situation of the palm grove of Moghrar compared to the wadi; source: Remini's elaboration

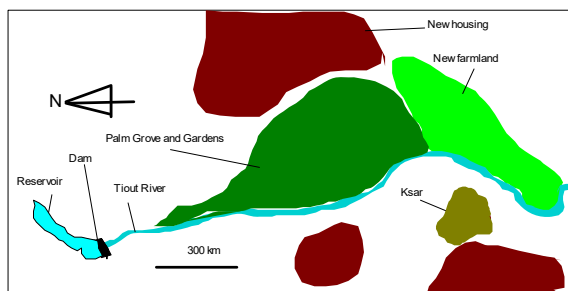


Fig. 10. Situation of the Tiout palm grove in relation to the River; source: Remini's elaboration

out by 4 sources, 162 wells, 38 boreholes and 97 motor pumps.

The Tiout palm grove is irrigated by 1 drilling of a flow of $8 \text{ dm}^3 \cdot \text{s}^{-1}$, 11 traditional wells with an average flow of $15.5 \text{ dm}^3 \cdot \text{s}^{-1}$ (Fig. 10). The ancestral dam Tiout located upstream of the palm grove was fed by a dozen sources. Today, the dam can no longer ensure its irrigation function. In addition to the drying up of the dam lake, the sand has accumulated in the basin to more than 90% of the initial volume of the dam.

CONCLUSION

If for more than 9 centuries the traditional techniques of overturning and water storage have allowed oasis irrigation in the oases of Tiout, Bousse-mghoun and Moghrar to develop. However modern techniques such as motor pumps were introduced in the oases in the early seventies. These techniques have greatly contributed to increasing agricultural yield. In return, they were the cause of environmental degradation such as the drying up of the water table and the disappearance of several water sources. On the social side, the oases have moved away from collective irrigation to the detriment of individual irrigation. This new situation in the oases has lost many good habits and traditions. Population growth and the socio-economic development of the entire region require more and more water. However, to protect the oasis ecosystem which is quite fragile, the exploitation of the aquifer must be done in a moderate way. A compromise must be found between traditional and modern techniques of water abstraction to preserve the tourist hiding of the three oases.

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Zmiany w technologii przechwytywania wody w oazach Moghrar, Tiout i Bousse-mghoun w Algierii

STRESZCZENIE

W artykule omówiono są różne techniki gromadzenia wody stosowane w oazach Moghrar, Tiout i Bousse-mghoun od ponad dziewięciu stuleci. Przeprowadzono kilka analiz hydrologicznych w tych oazach od roku 2002, włączając w to sondaż i badania lokalnych społeczności. Uzyskane wyniki wskazują, że po zmniejszeniu dopływu ze źródeł, społeczność miała dostęp do dawnej infrastruktury hydraulicznej, takiej jak studnie, foggary czy niewielkie zapory (Essad). Technika gromadzenia wody jest specyficzna dla regionu i zależy od hydrogeologii i topografii. W przeciwieństwie do tradycyjnych oszczędnych technologii o małym przepływie, które chroniły środowisko, nowoczesne techniki dostarczają więcej wody, ale wywierają niekorzystny wpływ na środowisko. Wysychanie źródeł i otwartych zbiorników wodnych jest wynikiem zwiększającej się populacji i rozwoju socjo-ekonomicznego, które wymagają coraz więcej wody. Kompromis między tradycyjnymi i nowoczesnymi technikami mógłby rozwiązać ten problem.

Słowa kluczowe: gromadzenie, oaza, środowisko, tradycyjna pompa, wiercenie, woda