

Chapter 11

Saharan Agriculture in the Algerian Oasis: Limited Adaptation to Environmental, Social and Economic Changes



M. Hadeid, T. Ghodbani, O. Dari, and S. A. Bellal

Abstract Climate change and its management through public policy have had a profound impact on the natural balances of oases in the Sahara of Maghreb. Modern irrigation techniques are practiced increasingly on the margins of traditional oases with appropriate adaptation methods. The pressure on water resources has led to intense power dynamics between water owners and new agricultural investors. The juxtaposition of local traditional knowledge in the use of resources to current approaches to technical and administrative management is the basis of a new territorial dynamic that is currently shaping the oasis space of the Maghreb. In this chapter, we propose a multiple-criteria analysis of the dynamics of transformation at the human-nature interface. The subject of this study was derived from an analysis of several research projects conducted over the past two decades (1999–2019).

Keywords Climate change · Public policies · Oases · Irrigation · Adaptation · Water resources

1 Introduction

For more than a century, the Algerian region of the Sahara has been the scene of significant social and spatial changes. The water management baseline considered in this chapter was established during the territorial and economic integration and appropriation of the colonial period, after which the State took action, which accelerated and consolidated water policy and incentives. As they entered the urban era, the Algerian Saharan territories were profoundly reconfigured, which gave rise to multifaceted tensions. These environmental, economic and social transformations have challenged the traditional balances and functioning of these territories. The gradual regrouping of populations and the many fold increase in urban populations have led to a weakening of ecosystems, an increase in economic inequality and, more generally, the emergence of structural territorial disparities. Spatial planning

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and management policies designed to develop these areas economically have not prevented the creation of clear spatial inequalities, despite huge investments to open up the social facilities and economic infrastructure of this vast and constrained area by the creation of a relatively dense transportation network.

The regions of Touat, Gourara and Western Tidikelt are administratively part of the Wilaya¹ of Adrar, a vast Saharan area occupying nearly 18% of national territory but containing less than 1.2% of the national population and more than 12% of the total Saharan population, according to a 2008 survey (Kouzmine 2007; Hadeid et al. 2018). Having experienced the same development policies (administrative divisions, equipment program, agricultural development), this region of southwestern Algeria has suffered from the same policy exclusions, leading to the marginalization of a number of sectors and, consequently, a part of the population. Faced with this marginalization, traditional practices (sometimes informal), are maintained or even developed in the face of insufficient state support, leading to the disruption of local ecosystems. In some cases, these practices reflect the failures of civil society to address existing spatial disparities and their environmental and health effects in this area. This has resulted in the pauperization of the oases and a consequent mass departure of the most vulnerable populations, from the least coveted ksour to the most dynamic cities. The new rural policy launched in the 1980s through access to agricultural land ownership and the PNDA² in 2000 came respectively with the aim of correcting the disparities induced by this urbanization policy, but the application of this vast program has also been subject to criticism insofar as users have been much more attracted by the generous subsidies of this program than by a genuine interest in reviving agricultural activity in these arid and semi-arid spaces. The balance sheet, particularly after the State gradually withdrew its commitment to fund these agricultural development operations, has been mixed. Faced with the disengagement of the State, the saturation of the tertiary sector and the instability of oasis agriculture, a part of oasis society has sought mechanisms to revive their activity and improve their standard of living. Although interesting as well as ambitious, its solutions do not seriously address the issue of sustainability and hence their effects on non-renewable water resources in this vast, arid region. Thus, social strategies, or “social technologies” are really only a form of temporary adaptation of a society to an immediate crisis situation in the face of the State’s failure to create a public policy for effective management of these arid, hostile spaces.

In addition to this territorial complexity, there are new challenges related to climate change. The local expertise in water mobilization and tillage of people in the far south has become a model for adaptation to climate change—not only to increasingly extreme natural conditions but also to frequent social and economic changes. How

¹The Wilaya is an administrative entity, the equivalent of a “department” in France.

²PNDA (National Agricultural Development Plan). This program represents, in a way, a return of the State, particularly to boost agricultural activity after a period of disengagement that lasted more than a decade (Hadeid 2011). The orientations contained in this agricultural program are intended to ensure socio-economic and technical obligations (improving Algeria’s agricultural competitiveness, increasing production and yields), but they also and mainly aim at rebuilding the agricultural territory, protecting fragile ecosystems and developing land for agricultural use (Bessaoud 2002).

do old techniques for the exploitation of natural resources still survive? What are the weaknesses of the new state-led development model? Can lessons be learned to better mitigate the effects of human activity on sustainable adaptation?

2 Method

This study is a synthesis of the research carried out in the Adrar region in order to determine the basis of the oasis system and its evolution over time. It also examines many case studies identified through continuous investigation of oases over more than two decades.

Two approaches were used:

- An evolutionary approach in order to identify the transformation of the oasis system through different historical phases, with an emphasis on the postcolonial period. This is the period during which our study reveals the most profound socioeconomic changes.
- A multi-factorial approach that accounts for an increasingly arid environmental framework, dynamic social capital and the actions of the State in different contexts. Direct surveys were conducted at the household level to determine the basic activity and challenges faced by individuals and families. What has driven and informed people as they develop strategies to protect their livelihoods? Who are the actors involved? What is the role of the State (passive and/or active)? How do oasis adaptation systems fit into global mitigation of climate change?

Areas for the survey were selected based on field observations, the dynamics of agricultural land use, the use of new irrigation techniques, the improvement of traditional means of access to water, and other factors. The twenty oases studied represent the nexus of traditional and new techniques in water use.

3 Theoretical and Conceptual Framework

Based on the different solutions adopted by the oasis societies studied, this research seeks to learn how “social technologies” can be applied to water use adaptation in the face of climate change. This is a concept that bridges the social values of solidarity and modern technological solutions for sustainable adaptation. It was first characterized at the University of Chicago by Albion Woodbury Small in the late 19th century, who described social technology as using knowledge and laws of social life to apply rational social objectives (Small 1898). Today, “social technology” has come to mean the use of technology in service to social, societal and citizen action, such as mitigating inequalities, building social solidarity and catalyzing social innovation. Investment in technological capabilities promises the ability to act in the public interest. This concept, with the similar concept of “social innovation”, is used

in Europe as a lever for territorial development. At a time when economic and social models are being undermined by the shocks of climate change, addressing unmet social needs is a particular challenge. According to the CSESS³, “*there is a tremendous inventiveness on the part of citizens, civil society actors and companies that only needs a little favourable ground to grow, develop and provide significant responses to the main societal challenges: increased impoverishment of the population, limitation of energy resources, digital divide, suppression of public services in rural areas, ageing population, isolation of the elderly, increased demand for organic food... These challenges are reflected in the need for innovative solutions in terms of energy, accommodation, mobility, etc. On all these subjects and many others, the collective imagination is essential to bring out new responses in a context of scarce public funding.*” The CSESS has proposed a fulsome definition of “social technologies” that can be applied to any country in the world: the development of new responses to new or insufficiently- met social needs under current market and social policy conditions, involving the participation and cooperation of all actors concerned, in particular the users. These innovations concern both the product or service, as well as the mode of organization and distribution, in broad areas such as aging, early childhood, housing, health, the fight against poverty, exclusion, discrimination, etc. The stages of social process development consist of emergence, experimentation, dissemination and evaluation. This desire to integrate social technologies into the development process of the territories is not exclusive to France—the entire European Community supports it. In a speech to the European Parliament, the President of the European Commission, José Manuel Barroso, made it clear that innovation in general and social innovation in particular should be recognized as factors for sustainable growth, job creation and strengthening the competitiveness of the territories.

Several doctoral theses have also applied the concept of social needs, for example, in France (Patureau 2010) and on the water in Brazil (Coutinho 2015). Patureau (2010) uses social technology as a means to address major social issues: reduce poverty and fight exclusion, protect the environment, promote the integration of people with disabilities, enable young people to integrate professional and civic life, combat unemployment, manage an aging population, support the education and development of children, etc. In other words, the social technology movement is the recognition that neither government policy nor the market alone can provide complete solutions to big societal challenges. Coutinho, for example, studies the semi-arid region of Paraíba, Brazil. After the failure of efforts by the Brazilian government to mitigate inequalities in access to the water supply through the construction of dams and large capacity reservoirs, various civil society networks implemented a new development model based on the introduction of social technologies for access to water using tanks, stone reservoirs (reservoirs built on impermeable outcrops) and underground dams. The deployment of these techniques has resulted in a social network that has transformed the spaces in rural Paraíba. Another example is the use of social technologies to enable the local population to manage their new

³CSESS: Higher Council of Social Economy and Solidarity in France.

city. The philosophy on which Isle d'Abeau⁴ was developed is to enable people to organize themselves instead of responding to external requests to organize. This approach, while not unique, was well-suited to L'Isle d'Abeau where the population is committed to building and managing its own development projects (Hominal 1982).

These social technologies are not only useful in their direct role in addressing social needs, but also because they facilitate new relationships among different stakeholders. This frames the current study on the arid southwestern Algerian region, with emphasis on identifying the actors who are effective social “translators” between state planners and the social networks that take up these innovations.

In the Sahara of North Africa, the development of the oasis areas is increasingly complex. Despite their small surface area compared to the size of the desert, oases play a fundamental role in maintaining the population in the great south of the Maghreb (Bisson 1996). Extensive research on this topic has been contributed by French geographers (Despois 1967; Bisson 1996 and 2003) as well as German (Suter 1959) scientists, who considered natural constraints, including water scarcity, in Saharan environments. Richter (1995) proposed a typology of oases based on four oasis resources: springs at the foot of a mountain, on rivers, in the foggara and with drainage tunnels. Water mobilization techniques are different in each setting, but have common requirements for effective water management. Sociological studies of the oases of the Maghreb note a stratification based on race (Touat, Gourara, Ouarzazat, Tafilalet) and/or other ethnic criteria (Ghardaïa). Marouf (1980, 2010a, b) and Moussaoui (2011) highlight inequalities in access to water and agricultural land, with land and foggara in these oasis societies considered socially inferior because it is traditionally the domain of a class of black descendants of slaves from Sub-Saharan Africa. In contrast, land and water ownership is often reserved for Chorfa (nobility). This distinction, extant since the Middle Ages, has diminished markedly since the independence of the Maghreb countries but still arises, for example, in marriage between men and women belonging to different groups, sharing of natural resources or in local power politics. Studies of transformations that have impacted society and the environment in a profound way have served as interesting laboratories to observe the evolution of the relationship between society and its environment. For example, Kassah (2010) looked at Southern Tunisia, Côte (2002) at the Souf, Schmit (2008) at the Mzab and Bencherifa and Popp (1992) at the Todra valleys in Algeria and the Drâa in Morocco. They all highlight the role of centralized public policies in the creation of a new socio-spatial order, as well as the failures of efforts to implement sustainable development in these oases.

⁴Old French New Town located in Nord-Isere, south-east of Lyon (France), whose creation was decided in 1968.

4 Forms of Social Adaptation to Government Disengagement

Oasis society naturally tries to address its own unsatisfied needs. The cases studied predominantly concern water and agriculture. For example, oasis agriculture in southwest Algeria has developed indigenous responses to overcoming an environment hostile to settlement, supplying water to both the oasis populations and the caravanners who cross the Sahara (Côte 2002). Traditional economic frameworks change over time as non-agricultural activities are introduced, leading to a diversification in employment and a corresponding decrease in dependence on oasis agriculture, which is based on a marked social stratification. Indeed, by introducing other types of employment, particularly in the tertiary and even secondary sectors (south-eastern Algeria and, recently, southwestern Algeria), the independent state has severely disrupted this traditional agriculture. As a result of the disruption of the social stratification established over centuries, agriculture has lost significant ground to other introduced activities. State policy based on agricultural development has been in place since 1983 in the arid and semi-arid regions (Steppe and Sahara) in order to replace traditional agriculture that operates in difficult (scarce labor, dried foggaras, etc.) and less profitable environments. This directly affects cereal production, negating previous social and feudal organization. Despite generous government subsidies, government policy has not achieved its objectives. Recent years have been marked by a gradual disengagement of the State, leaving new agricultural dynamics to emerge in both the modern and traditional agricultural sectors.

5 Relaunch Traditional Oasis Agriculture and Revitalize Modern Agriculture

The withdrawal of the State has left a void filled predominantly by farmers from the Sétif⁵ region, who have started growing market gardening products, especially cucumbers, used in the manufacture of cosmetic products in the center of the country (Algiers, Blida). This activity has filled a market gap, particularly in the south-eastern Ziban region, taking advantage of the relatively conducive growing conditions there during the cold winter period in the north (Table 1). Moreover, these cucumbers transport and weigh well. By renting land from indigenous farmers, who themselves have been less enthusiastic about farming after the decline in State subsidies, the Sétif people have been able to institutionalize greenhouse cultivation in the Aougrout⁶ region, known for its soil and water potential, in few years.

⁵Located 270 km east of Algiers, this important city in eastern Algeria is home to more than 300.000 inhabitants.

⁶Large commune of the Gourara region between Adrar and Timimoun.

Table 1 Greenhouse cucumber compared to other vegetable products in Aougrou (2015/2016)

	Area (ha)	(%)	Production (Qx)	%
Cucumber	27,50	63,0	23.165	77,8
Other market garden products	16,15	37,0	6.594	22,2
Total	43,65	100,0	29.759	100,0

Source Reconstitution of the data of the subdivision of agriculture, Aougrou (Adrar)

People from Sétif had already been in direct contact with the traders in the region for the transport of food products. Despite the unavailability of reliable data from the Wilaya of Adrar, our study estimates the greenhouse agricultural area cultivated at more than 70 ha in the community of Aougrou alone (Hadeid et al. 2018), and it continues to increase; currently, more than 2200 greenhouses are identified in Aougrou by satellite imagery. However, there is a danger that mining, use of fossil water and other unsustainable practices that support irrigation are significant and without reliable evaluation by authorities (Directorate of Hydraulics, ANRH). The number of wells drilled in the entire Adrar region exceeds 900, with 75% used for agriculture. Monoculture and the absence of fallow periods and mineral salt leaching cycles lead to a displacement of greenhouses and causes soil degradation cycles every 2–3 years; uncontrolled use of fertilizers also represents an enormous risk of contamination of aquifers.

The artisanal pivot (Photos 1 and 2) technique is another interesting application of social technology for irrigation. It has already been used, for about 20 years, in the Souf region (South-East Algeria), allowing the emergence of market garden production basins by mobilizing deep groundwater on the margins of oases. Based on the principle proposed by Akrich et al. (1988) that “adopting an innovation means adapting it; it needs to be transformed, modified according to the site where it is implemented”, Souf craftsmen and farmers have been able to design a small irrigation system (less than 1 ha) that meets the needs of farmers who do not have financial resources or whose land is not cultivable for large pivots (between 30 and 50 ha), which in turn demand more expensive and technical resources for operation (Fig. 1). Having seen the success of this irrigation technique in the Souf region, farmers in the Aougrou region have begun to use it where plasticulture is the most widespread.



Photo 1 and 2 Handcrafted pivot used in Aougrou (Adrar). (Hadeid M. 2018)



Fig. 1 Size of the pivots used in the irrigated perimeters of Aougrou. *Source* Image Google Earth, 2016

Indeed, about ten farms have equipped themselves with this tool, as demonstrated by small pivots in the irrigated areas north of Aougrou. It is a very low price—a one-ha pivot costs 50 times less than a professional 30 ha pivot—lowers a major barrier to adoption. An area of about one hectare in the Souf region can be irrigated by a single artisanal pivot, the purchase price of which is €1000 (about US\$1140) (Ould Rebai et al. 2017).

Drip equipment for one hectare costs about €2000 (US\$2280) and a sprinkler kit to fully irrigate a hectare costs between €2000 (US\$2280) and €5000 (US\$5700), depending on the quality of the equipment. The more expensive systems require removal during tillage and harvesting to allow access, unlike the artisanal pivot that can be left in place.

The sufficiency of the artisanal pivot irrigation system for potato production, with its low cost, has resulted in the rapid expansion of cultivated areas.⁷ But the question remains about its impact on natural resources (soil depletion and lower yields, nematode⁸ invasion and spread of phytopathogens,⁹ overexploitation and groundwater pollution), as experienced in the Souf region, where its use has been intensive (Ould Rebai et al. 2017). It is understandable that smallholder farmers consider short term revenue a priority over long term environmental impact, including water resilience and saving the long term sustainability of agricultural development. In fact, the artisanal pivot irrigation system is inconsistent with the National Climate

⁷In the Souf region, 35% of potato production is provided by this method of irrigation.

⁸Nematodes are very small worms, most of whose species are invisible to the naked eye. Many species live freely in the soil, and parasitize many plant species, without causing them great harm, as long as the plants are not exposed to too much stress.

⁹A phytopathogenic agent is a living or almost living organism (bacterium, virus, fungus, etc.) that can infect plants and trigger diseases. Phytopathogenic agents belong to all pests of crops alongside pests and weeds.

Plan (NCP 2018), National Land Use Plan (SNAT 2010) and the local-scale Wilaya d'Adrar Development Plan (PAW 2015).

Inevitably oasis agriculture will thrive as modern agriculture thrives generally. For example, a good part of the existing palm groves in the Adrar region is maintained by members within the same oasis community, where individuals contribute according to their experience (education, administration, trade, etc.) and work the grove in addition to their primary livelihood, in the evening and on weekends, including children and women.

Apart from the broadly-disseminated practice of market gardening, oasis people dedicated themselves to tomato cultivation after the reopening of the Reggane factory. The field sales contracts with farmers throughout the Wilaya allows the company to guarantee the marketing of their products. The government of the Wilaya of Adrar has even implemented an awareness campaign targeting farmers to drive massive production of industrial tomatoes, with a guarantee of purchase by the factory. In Tilouline (a large ksar located in the commune of In-Zeghmir), farmers report that the tomato harvest lasts almost 4 months, a significant contribution to the income of the oasis population there.

Tobacco cultivation is beginning to gain momentum in several palm groves in Touat, a speculative crop in a region where the populations of Sub-Saharan African origin have increased. Tobacco is in high demand for local use, and can be exported to the Sahel countries. Tobacco growing is popular because it is profitable: a kilo of semi-processed tobacco can sell for 600 to 1000 DA (Hadeid et al. 2018). Our field missions over the last 5 years have enabled us to see the progressive extent of this crop in terms of land use. "Dried tobacco leaves are marketed in their raw state. In most cases, they are used to make snuff using traditional formulas. The contribution of tobacco cultivation to local agricultural income is important, although harvesting and processing remain traditional and artisanal" (Touzi and Merzaia-Blama 2008). The revival of traditional oasis agriculture has contributed to the stabilization of a significant number of families in the oasis population, but questions remain about the sustainability of their crops and methods, which are more demanding of irrigation water than the foggara can provide.

6 Solutions to Ensure Irrigation Water: New Challenges, New Effects

Oases are one of the driest environments in the world, where rainfall is less than 40 mm/year. Moreover, heat waves have increased in frequency in the last 50 years (1970–2019). However, this vast, arid space contains huge underground, though non-renewable, water reserves. The underground reserves are created by nappe, known as "Continental Intercalaire" or "Albian nappe", a fossil reservoir that covers an area of 1,100,000 km² over Algeria, Tunisia and Libya. This aquifer covers the entire northern Algerian Sahara, where access to water between 120 and 150 m has enabled

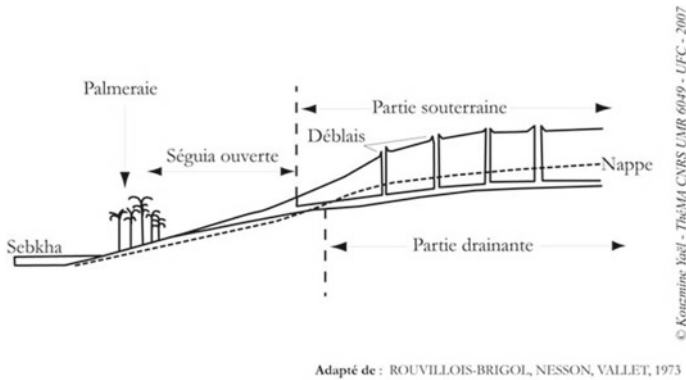


Fig. 2 Sketch explaining how a foggara works

irrigation in the Adrar region. The exploitation of this aquifer has been continuous over nearly 11 centuries by inhabitants of the oases, using an ingenious technique called “foggara”: the collecting of groundwater that flows by gravity from below the plateau (Fig. 2).

The water is transported underground to the land to be irrigated. The tunnels that transport the water are perforated by vertical shafts for access and ventilation and have four major elements: the kasria (distributor), seguia (canal), madjen (collection basin) and guemoun (garden) (Fig. 3). However, maintenance of the foggara suffered in the post-independence period with insufficient financing by the central government, complicated by social traditions of servility in the ksour in addition to disregard for the foggara as a valid traditional irrigation technique. This explains much of the distrust between landowners and the government (Bendjelid et al. 1999).

The people of Tilouline (a large ksar located in Touat) offer another example of a local community collectively developing a strategy to provide as much palm grove irrigation as possible despite a diminishing water supply from the foggara (Fig. 4).

Ksourian population diverted drinking water intended for households in order to extend the plots¹⁰ under cultivation. Ksourian households pay a flat quarterly charge of 1500 DA (US\$13) for drinking water, so Oasis farmers take advantage of the fixed-rate by installing a long pipe¹¹ from their houses to their gardens (Photos 3, 4, 5, 6, 7 and 8).

It is striking that although the network of pipes required for the diversion is apparent, indicating that local authorities are aware of the “illegal piracy” of drinking

¹⁰Since it’s difficult to define in detail the plots irrigated by drinking water and the houses affected by this operation, it can still be estimated that more than 40% (96 hectares) of the palm grove of Tilouline is partially irrigated by drinking water.

¹¹These pipes can reach 300 m in some cases.

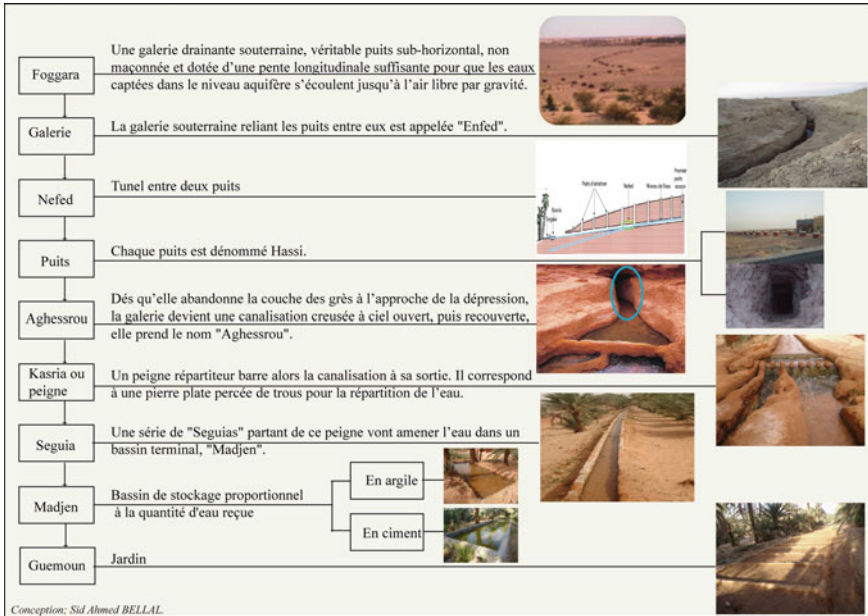


Fig. 3 Components of the hydraulic system of the foggara

water, they turn a blind eye to the practice as long as it strengthens agricultural activity. The question is whether this can be considered a “social technology” or simply a form of adaptation to the shortage of irrigation water because neither the foggara nor the wells drilled to reinforce them supply sufficient water to the oasis? (Fig. 5).

7 Conclusion

In an environment as naturally arid as the Algerian Sahara, it is difficult to attribute its transformation to climate change. Clearly, government policy in the past decade (2007–2019) has had the most immediate effect on water and its management in the oases. Faced with a gradual disengagement of the government, local people have developed strategies to revive their agricultural activity in response to their immediate challenges: poverty, driven by the decrease of state subsidies. These strategies are collectively known as “social technologies” because they respond to specific needs for which the government has declined to take responsibility. Defined as the use of technology for social action to mitigate inequalities and create social cohesion, Oasis society has readily embraced this approach. While often ingenious, these strategies tend to ignore the long term issues of sustainability in favor of short-term survival. Thus they result in excessive pumping of non-renewable water from the Albian groundwater, health risks and soil degradation. It is therefore imperative that local

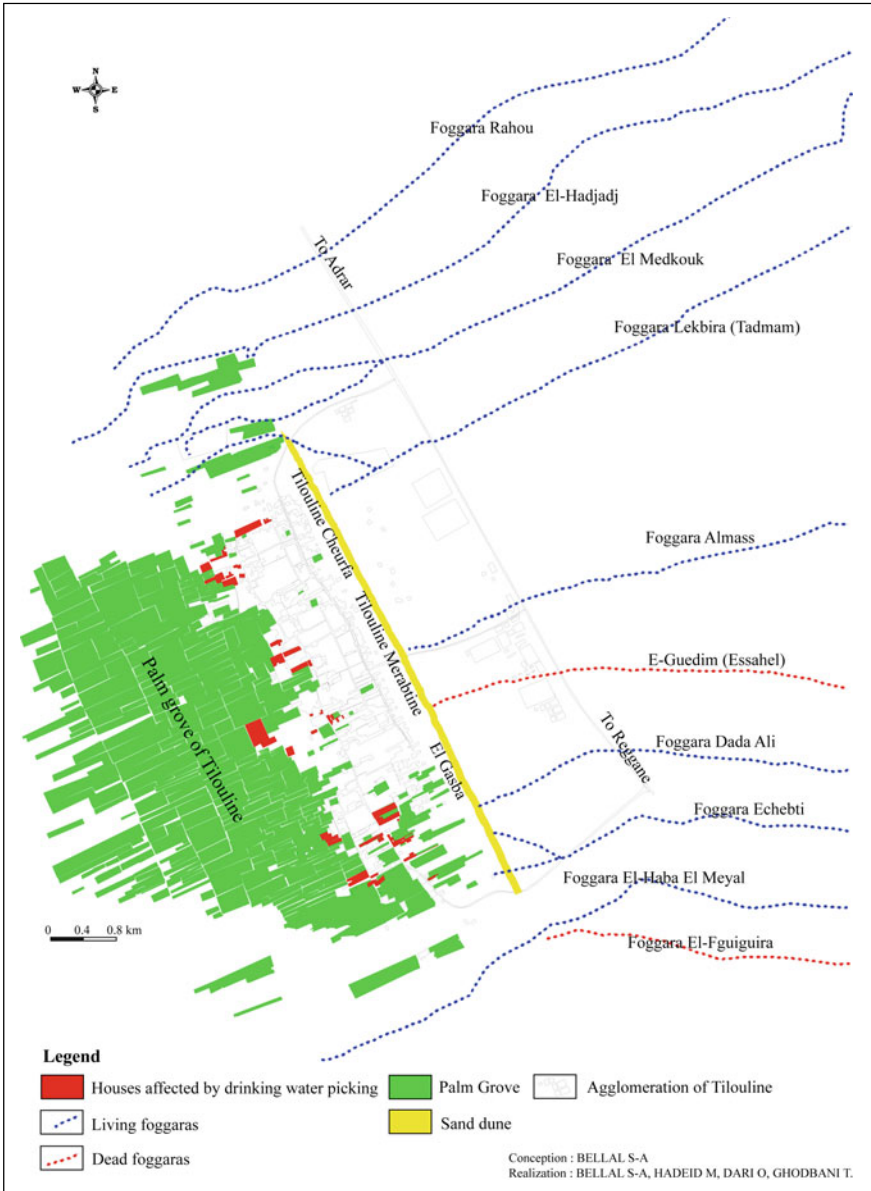


Fig. 4 Location of houses affected by the illegal connection to the drinking water network



Photos 3 to 8 Some landscape aspects of the diversion of drinking water for irrigation in the Tittaf and Tilouline palm groves. (Hadeid M. 2018)

strategies be integrated with the National Climate Plan, which will enable the use of renewable energy in water pumping, cultivation of genetically adapted local seeds, and adoption of complementary approaches to integrate traditional oasis agriculture and modern development.

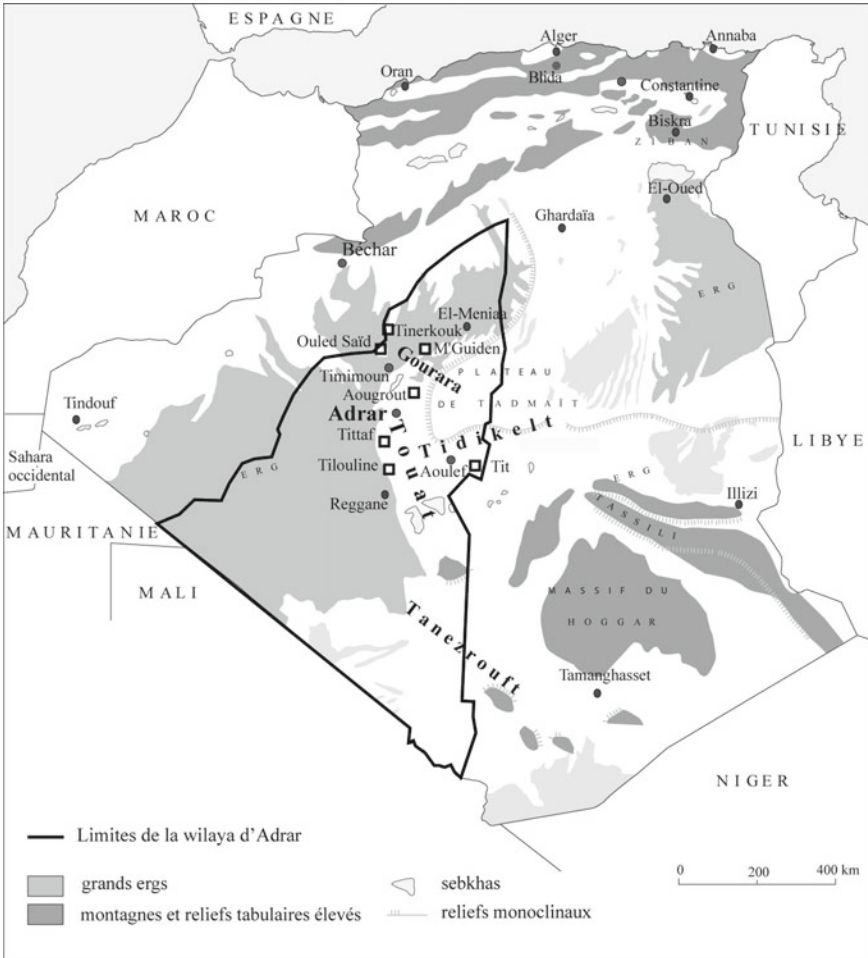


Fig. 5 Geographic location of the study area

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