A New Dynamic of Saharan Agricultural Transformation: Thermal Area of Zelfana (Southern Algeria)

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Summary

The Agricultural Land Development Program has led to an increase in agricultural areas in Zelfana (Algeria) as in other Saharan regions. The creation of development areas in this zone has generated a certain progress through a set of measures that have had different impacts on the components of this Saharan agro-ecosystem. The objective of this research is to study the realities of the new dynamics of Saharan agriculture through the diversity of agrarian systems established in the oasis of Zelfana and its extensions. The results of the management study of this particular agro-ecosystem have shown inadequacies at different levels that could compromise its sustainability and even its dynamics. The measures to be taken are discussed not only to preserve the ecosystem but also to give meaning to the strong investments made by the public authorities.

Key words

agro-biodiversity, Algerian Sahara, dynamic, landscape, oasis, sustainability

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Introduction

The different programs of agricultural land territory development since independence to the present day in the Saharan regions and more particularly the thermal region of Zelfana have resulted in a very significant development during the last decades. It should be noted that results below the agricultural break-even point are far from the objectives expected by the public authorities (Bensaha et al., 2016). Some sources are currently advancing a figure of more than 15 million date palms (Bouammar, 2010). Evolving in a severe climatic and hydraulic environment, the farmer of this region has always made efforts to adapt and make the most of the natural resources of his territory (Saker et al., 2011). The oases of this region are better forms of agricultural intensification since they represent agricultural areas intensively cultivated in areas where agriculture remains unpredictable and unprofitable (CDARS, 2002).

Indeed, the old agricultural system is being degraded and marginalized in relation to the profound changes that oasis societies are experiencing in general, whereas the new agricultural system is subject to a particular interest in agriculture on the part of the public authorities (MADR, 2015). It seems interesting that from a diagnosis we can determine the causes that generated this dynamics of agricultural and territory developments in this thermal groundwater rich region.

However, oasis areas are now at the core of the concerns of governments, seeking to meet the growing social and economic demand. Just after independence, the Algerian government wanted to promote agricultural development in the Sahara (Hamamouche et al., 2018), through the initiation of investment in agriculture since the 1970s, and the application of the law of the agricultural revolution which gave a recovery to the agricultural sector. Its development is based primarily on tree crops, livestock and palm trees (Addoun, 2021).

In this study, we have aimed to identify the different types of date palm groves in the Zelfana region and the surrounding extensions. In the following step, we speculate on the future diversity of the agro-system in the Oasis of Zelfana.

Our research focuses on the Zelfana Oasis, one of the Algerian Oases that faces a rapid dynamics in the north-central Algerian Sahara. Although there is a tangible local effort in the cultivation of date palm in such areas, still there is gab in the documentation and more knowledge or experience transfer are needed. On the other hand, Zelfana is well known for its high number of dense palm groves in its northern part and many agricultural farms, which is an important source of livelihood for farmers and local families (Addoun and Hadeid, 2022).

Context and Methodology

The study focused on the analysis of agricultural land in the region of Zelfana through aspects, positive and negative development programs. Our approach is based on interviews conducted with farmers, agricultural institutions and local authorities.

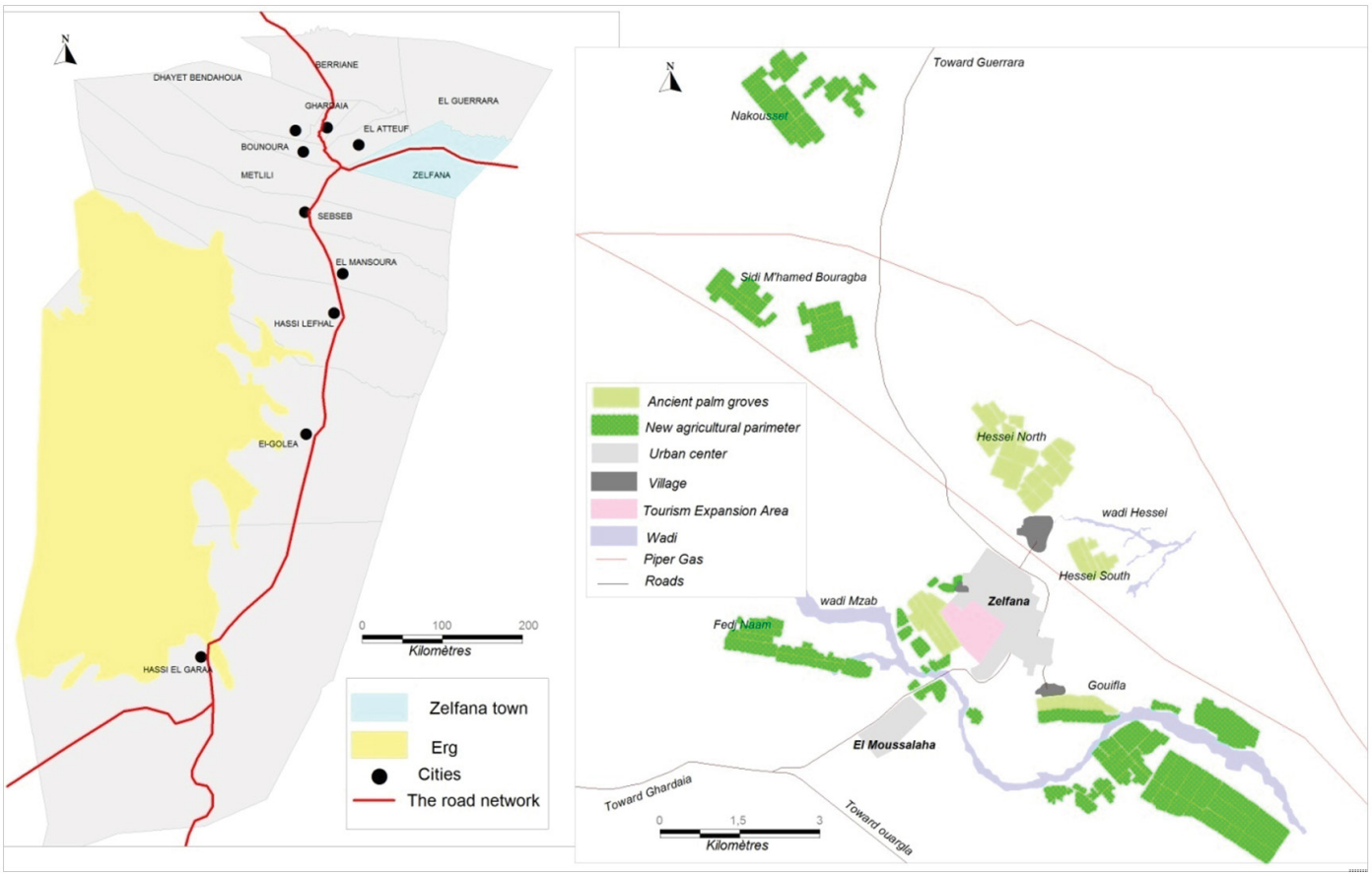

Figure 1. Location of the working area (Source: Author's work)

Description of Study Area

Our work took place in the Oasis of Zelfana which is part of the southeast of Algerian Sahara; now it is relatively a new town, established following the administrative division in 1984. It is located in the wilaya of Ghardaia 60 km far from the capital of the wilaya. Its borders are, from the north Guerrara, from the south Metlili, from the west the municipality of El Atteuf, and finally from the east the wilaya of Ghardaia (Fig. 1). Agriculture developed in this region through palm grows which were near the oasis in three localities (Zelfana El Oued, El-Hessei and Gouifla). It is an area of 454 ha and the new agriculture extensions (1.330 ha) were developed around the outside of the oasis in three perimeters (Fedj Naam, Sidi M'hamed Bouragba and Nakousset) (see Fig.1).

Research Approach

Data were collected between the period (2018-2020) in six agricultural zones of Zelfana, each period was covered by conducting interviews and a semi-open type questionnaire about various agricultural areas of the Zelfana region with comprising field observations and 100 samplings. Our questions concerned the major events that had contributed directly or indirectly to these transformations, such as state intervention (agrarian reforms, agricultural programs and subsidies, development programs, etc.).

In order to achieve our goal, we used the various variables; seniority, location and legal status of the farm, age, level and professional identity of the farmer, the importance of agriculture, farm size and area, dominant culture, variety, alignment and age of palms, equipment of irrigation and drainage.

A methodology was adopted to understand the current situation of old palm plantations in this region which preserves the oldest palm groves in Algeria. However, this vulnerable agro-ecosystem is suffering an alarming situation hence leading to an advanced degradation, due to several factors (sociological, economic and environmental).

The six targeted palm groves we have found in the ancient oasis and new extensions outside the oasis are:

The ancient oasis composed of three palm groves, namely: Zelfana El Oued, El Hessei and Gouifla, covers an area of 454 ha.

- Zelfana El Oued (Diyar Tahata): located three kilometers northwest of the Zelfana oasis, composed by small gardens; they are fragmented into very small parcels and occupy an area of less than 1ha.
- El Hesseï (El H'sy): a few kilometers northeast of the Zelfana oasis. It is limited to the east by the perimeter of El Hesseï South.

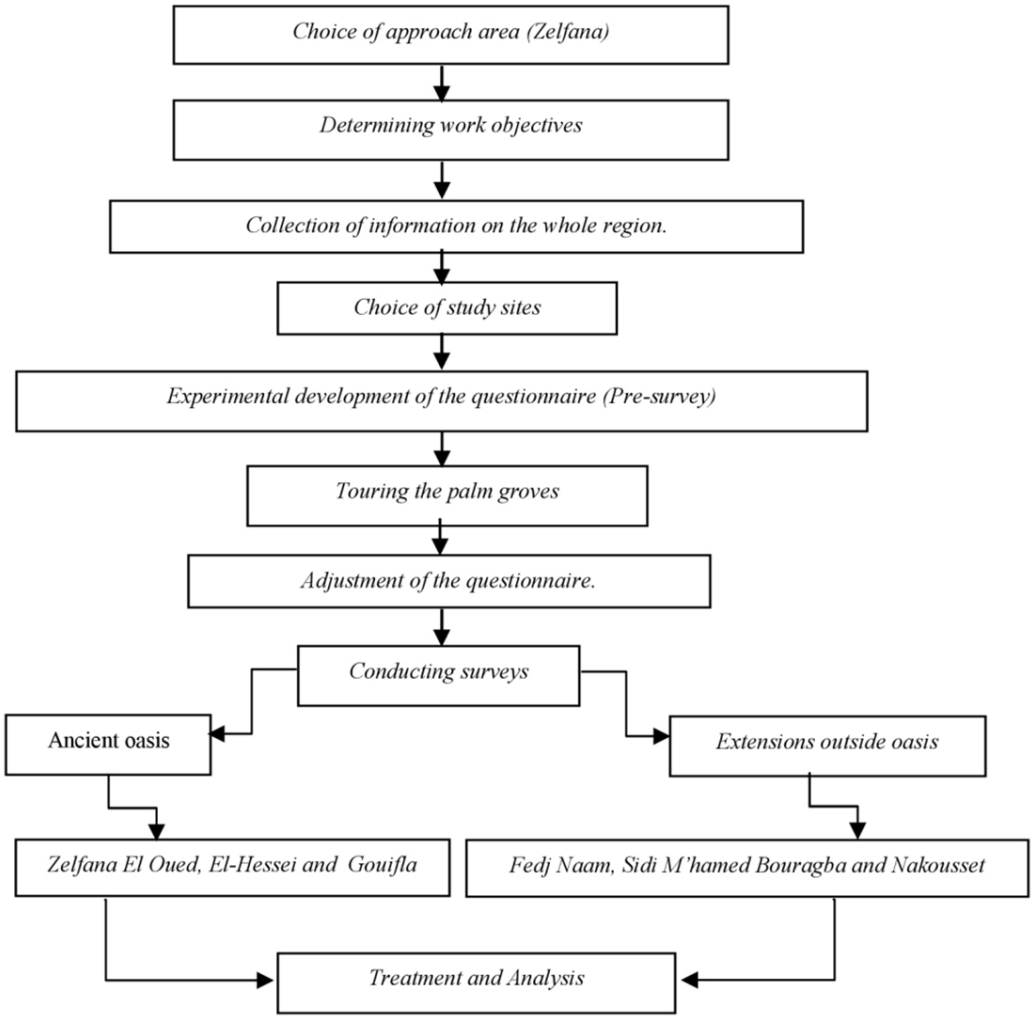

Figure 2. Work methodology (Source: Author's work)

- Gouifla: located ten meters south of the Zelfana oasis grove.

The extensions outside the oasis are composed of three spreading zones of Fedj Naam, Sidi M'hamed Bouragba and Nakousset, covering an area of 1.330 ha outside the ancient oasis.

- Fedj Naam (Fedj Ennaâme): located three kilometers southeast of the Zelfana oasis, it occupies about 110 ha.
- Sidi M'hamed Bouragba: located just in the north, three kilometers far from the Zelfana oasis.
- Nakousset: located six kilometers north of the Zelfana oasis, composed of small and middle perimeters; they are fragmented into parcels of an area between 1to 2 ha.

Results and Discussion

Characterization of the Structure of the Zelfana Agrosystem

In the Zelfana region, two types of agrosystems coexist; the traditional agriculture characterized by an old oasis agricultural system and the new extensions of so-called modern agriculture, which emerged during the last two decades.

The old ancient oasis system was created before 1900. Due to the presence of a water source, this oasis has greatly evolved through the ages (Bénédicte Veyrac et al., 2017). It is composed mainly of date palms.

The modern oases were created after 1900 due to new deep drilling colonial techniques. It was a stunning landscape, where the cultivation of the date palms (cvs. 'Deglet Nour' and 'Ghars') accounts for practically the main crop of this region.

The results in Table 1 show the landscape distribution of farmer according to the farm types and their characteristics. The majority are modern lands with the exception of the old oasis (Palm grove, CAPER) and other new farms aging more than 40 years. However, it was an effective start for local agriculture and the policy CAPER was to be achieved through the creation programme (*Decree of 26 March 1956*) which was undertaken for the first time in the Sahara during the colonial period when the goal was to give way to small farmers in the plots of land immediately exploitable. During the colonial rule the first tube-wells experimental drilling was done in the village of Zelfana El Oued (*Diyar Tahata*), the second in El Hessei Nour and the third in Gouifla.

Indeed, after the independence was gained, the state affected numerous agricultural (Hamamouche et al., 2015) programmes previously interrupted to enhance the situation of the agricultural sector.

In doing so, a lot of agricultural programmes such as the Agrarian Reform (RA)(1971), National Fund of the Agrarian Revolution (FNRA)(1972), Agricultural Villages Program (PVA) (1973), Accession to the Agricultural Fundamental Property (APFA)(1983), Commission for the Agricultural Development of the Saharan Regions (CDARS)(1986), Law on Agricultural Reform(1987), Law on Land Concession (1997), National Plan for Agricultural Development (PNDA)(2000), Local Development Program (PDL)(2010) and Local Initiatives Projects (LIP)(2012) came into existence to make agriculture work by boosting food production and farmers income. Those programs have provided agricultural infrastructure and inputs by their extension.

Palm Groves (CAPER)

Palm groves are located in Zelfana El Oued, El Hessei and Gouifla (see Fig 3). This type is based on date palms, especially Deglet Nour and Ghars. It is very adapted to climatological conditions and is characterized by traditional palm tree varieties and a high density of palm trees (150 trees per ha on average). Palm groves are fragmented in very small parcels, which reflects the social process of heritage (Hamamouche et al., 2018).

Pilot Farm and Palm Grove of Agrarian Revolution (RA)

Pilot farm and palm grove is located in Sidi M'hamed Bouragba and Gouifla west. In the early 1970s the government adopted socialist policies. These included the destructive "revolution agraire"/"agricultural revolution" that entailed nationalization of private land and the grouping of peasants into "domaines socialites"/"socialist syndicate" without land title (Bouchakour and Bedrani, 2015). This type of farm is highly discriminated by the variable irrigation. In fact, the water supply is ensured by the capillary rise of the groundwater. The farm size is 1 to 2 ha, specialized in added-value crops, which are assumed to have a higher value than food crops.

Table 1. The agricultural landscape between the ancient palm groves and the new extensions

Landscapes		Area (ha)	Percentage (%)	Average farm size (ha)	Legal status
Old Oasis	Small gardens	8	0.63	>1	Private property
	Palm grove(CAPER*)	317	25.08	from 0.5 to 1	Private property
New extensions outside oasis	Pilot farms (R.A*)	156	12.34	from 1 to 2	Right to enjoyment, AFPA, concession and private property
	Perimeters (APFA*)	323	25.55	from 1 to 2	
	Smallholders	56	4.43	from 1 to 5	
	New perimeters	404	31.96	2	

Source: *Author's work (Field investigation)*

Note: ***CAPER**: Fund for accession to ownership and Rural Exploitation; **RA**: Agrarian Reform; **APFA**: Accession to the agricultural fundamental property

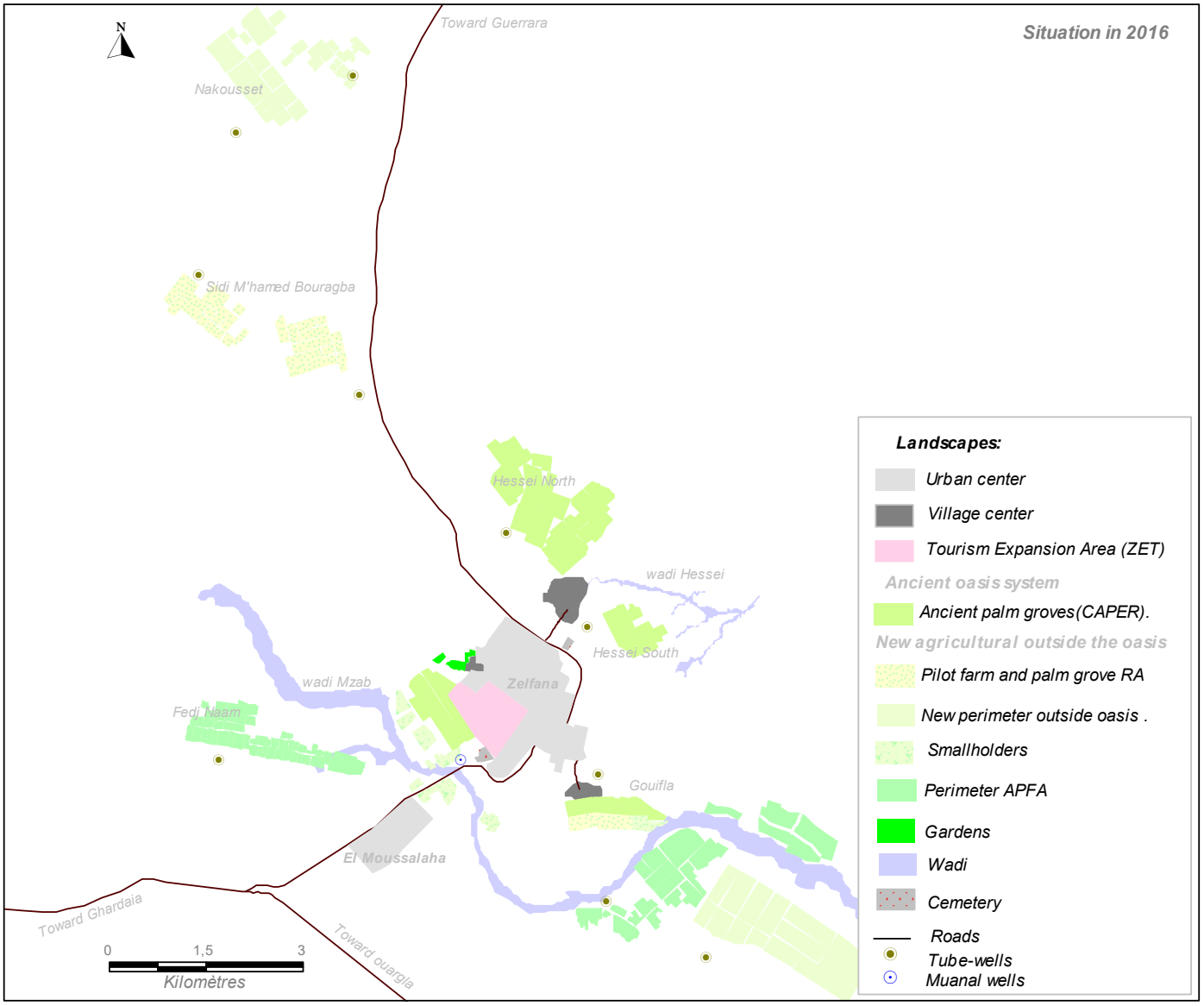

Figure 3. Situation of the agro-system in Zelfana region (Source: Author's work)

Perimeters (APFA)

Since 1983, national policy has been based on the agricultural development of the steppes and the Sahara (Hadeid et al., 2018). This political transition was followed by the launching of the "Accession to the Agricultural Fundamental Property" program (APFA) in1983. This law was hugely successful and sparked a real enthusiasm for this type of activity, which resulted in an expansion of agricultural areas in Saharan regions (Zegait et al., 2021).

Cosequently, thousands of hectares in different regions in the south have been enhanced by creating a new agricultural dynamics. This was translated by the emergence of new farming systems. This type includes small farms created by the Law (APFA) (1983) as a small farm of 1 to 2 ha.It is the first experience of farms outside the oasis and far from Zelfana area centre. These farms (APFA) are located in Fedj Naam and Gouifla. They are characterized by a low density of palm trees (60 trees per ha on average).

Smallholders (Small Farms)

This type includes small farms attributed by Concession (Law on Land Concession1997). They are located near the perimeters (APFA) and are oriented towards market agriculture based on average value crops. The farm size is between1and 5 ha. They are specialized in agricultural products of great consumption such as melon, watermelon, vegetables, pulses and cereals... Most of these products are mainly directed at marketing. Due to these evarious products, the region of Zelfana has become a place of exchange of agricultural products, with local, even regional influence.

New Perimeters (Medium and Large Farms)

The new perimeters include medium farms, large farms and agricultural enterprises. They are very significantly discriminated by the professional identity of the farmer. These contractors, traders, executives and doctors have seized the opportunity of investment in the sector and benefited of the state support.

They are located outside the oasis and are oriented towards market agriculture, based on high-value crops. Driven by the emerging "Algerian Company of Agricultural Engineering" (EAGR), this operation would aim to strengthen the skills of young agricultural concession by appropriating technical training in agricultural training centers.

Agro-System in the Region of Zelfana

In Zelfana region 70% of surveyed farmers are engaged directly or indirectly in agriculture and agriculture-related activities such as crops, livestock, agro-pastoral and palm oases. Moreover, they produce fodder, and grow vegetables and some fruit trees. According to the estimation of 2016 from the Direction of Agricultural Services (DSA, 2016), there are more than 1.500.000 trees of different types, such as variety Deglet Nour and Ghars of date palm.

Socio-Economic Characteristics

The old palm grove in Zelfana was established under the policy "Fund for Accession to Ownership and Rural Exploitation", in the colonial era. The introduction of pumping ensured the creation of new agricultural areas in the Sahara; they primarily focused on the production of dates, high-value variety "Deglet Nour (Saker et al., 2011).

The results show that 15% farmers are primarily engaged in agriculture and the rest (85%) are practicing agriculture as secondary function.

The socio-economic environment directly affected the development of the agro-system in this region because of the interrelated relationships between the different factors that make agriculture socially acceptable and economically fruitful.

Indeed, the socio-economic factors in the region of Zelfana affected the development of the old palm plantations and created the new agricultural perimeters outside the oasis. Consequently, the maintenance of the current situation is becoming even more disturbing.

Thus, after the analysis of the socio-economic features, the results showed that the majority of the farmers were old, married, and had a middle school education. Their ages are between 40 and 60 years. The majority, 38% of farmers are more than 45 years; 28% were 35 years and under, while 31% are between 35 and 45 years old. 85% of farmers have a family size between 5 and 8 members and 15% have a family size of fewer than 4 members. About 50% of households live in extended families (housing for grandparents).

- Concerning the level of education: about 4% of farmers have a university level, 15% of the farmers have a technical education, 15% have a preparatory education and 26% had no education level at all while 40% of them read and write. This all is a criterion that limits the practice of new cropping techniques.
- In addition to the lack of operators on farms: 80% of the respondents have other ancillary activities or are retired; farming serves as a secondary function.
- The geographic origins of some farmers: about 80% are local population, 10 % from different municipalities of Ghardaia, 4% from some southern regions such as Adrar, Ain Saleh and Ouargla and 6% from the north of the country whether they are farm owners or tenants. Moreover, some of them were settled in the south due to the security conditions in the early 2000s and have started working in the agricultural sector as encouragement

Varietal Profile of the Date Palm in the Region of Zelfana

The centuries-old palm groves system is a traditional oasis ecosystem that is witnessing a major degradation today, although the oases have developed their own characteristics: there is a great genetic biodiversity of intra-species (i.e.a variety of palm trees; such as cvs 'Deglet Nour' and 'Ghars' on a regional scale) (Bénédicte Veyrac et al., 2017), very adapted to local conditions (Hamamouche et al., 2018). Such agricultural practice constitutes the diversity of date palms in Algerian oases under climatic change, but also a constant large economy of the biggest region for dates production (Bedjaoui and Benbouza, 2018).

Date Palm Varietal Distribution

The Zelfana region is relatively rich in varietal diversity, due to its central position in relation to the Algerian date production centers where many nomads pass, the high mobility of its inhabitants (traders in most cities Algerian) and also greater use of local varieties.

There are two types of high-value date variety "Ghats and Deglet Nour". The majority of farmers use Deglet Nour plantation at the development perimeters for that market value. The Ghars variety is characterized by its small size of fruits compared to Deglet Nour.

These varieties, whose harvest begins in July, allow having a production that spans almost six months of the year.

Date Palm Age

The age of most palms in the studied farms and surrounding extensions varies, the palm groves (CAPER) are over 60 years old on average, characterized by traditional palm tree varieties, a high density of palm trees (150 trees per ha on average), the average palm trees height is within 6 to10 meters, and a distance of 4 meters between them (Figure 4).

The pilot farm and palm grove (R.A) contain palm trees that are over 45 years old, created in order to track the development of Bayoud (epiphyte date palm). It is the disease that affects dates and a disease that touches at the same time many plants of the same species in any region. However, this practice of mono-varietal culture constitutes not only a genetic erosion on the diversity of date palm in Algerian oases under climatic change but is, a constant threat to the economy of the biggest region for date's production.

The perimeters (APFA) of farms contain palm trees that are over 36 years old. These perimeters are characterized by a low density of palm trees, the average palm trees height is within 2 to 6 meters, with a distance of 4 meters between them (Figure 5).

The new perimeters, medium and large farms, with palms less than 30 years old, represent 20 % of the total studied farms, often located in the palm groves of Nakousset and Gouifla.

Figure 4. Scheme of the farm in palm grove in the ancient oasis (Zelfana El Oued) (Source: Author's work)

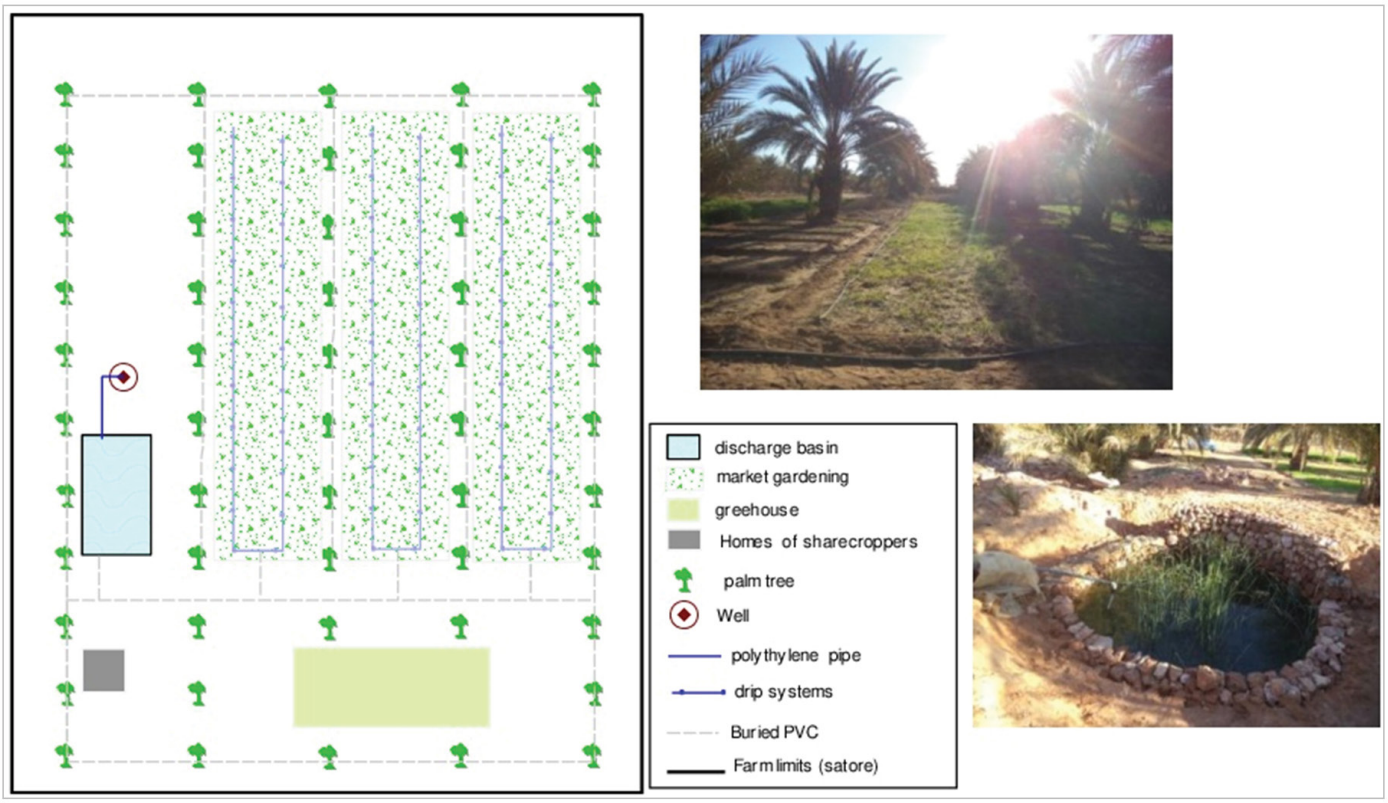

Figure 5. Scheme of the perimeter (APFA) in new extensions outside oasis (Farm Kamari Miloud in Gouifla). (Source: Author's work)

We noted that the most age-advanced palm trees are recorded in Zelfana El Oued and El Hessei. We did find farms in Nakousset and around Gouifla which are less than 30 years old due to the presence of Sebkha constraining the exploitation of new land.

Dynamics in Date Palms Producing and Their Evolution.

The date palm produce and its evolution, how it is structured in different oases, are essential for its dynamic conservation and sustainability. In the Zelfana region, we notice agricultural attraction in space, in terms of presence of the number of palm trees and the date production of palm groves; about 1501840 trees and the 550935 Q per year (DPSB, 2016), meaning the average yield of each palm tree is about 0.51 kg of dates per palm per year.

The following table (Table 2) combines the date palm production of the area of Zelfana between (2001-2016). This period witnesses the emergence of new agricultural plantations in the outside oasis of Zelfana and the introduction of new production techniques through the Law 18/83 on the Accession to the Agricultural Fundamental Property and the Improvement (PNDA). Based on the results (Table 2) we observe the growth of palm trees in production. The fourth column of the table provides changes in real crop output between consecutive years, starting from 2001-2016 about fifteen years. The remaining columns provide the number of palm trees in production to total date palm cultivars.

The production value of the palm trees during the period 2001-2016 increased and was recorded at about 38686 quintals. That varies between a minimum value of about 15900 quintals in the year 2001, and a maximum of about 54 586 quintals in 2016, so the production has doubled twice in 10 years. This agricultural transformation is explained by the extensive investment that has been granted in recent years outside the oasis and which affected the yield of the ancient oasis.

Irrigation System in the Zehfana Region

Irrigation systems are often thought of as being organized around a single water source, usually surface water (Bouarfa et al., 2020). The alternative resource is often fresh groundwater, even in existing surface water irrigation systems (Shah , 2010), Generally in the ancient oasis of Zelfana the dozens of old palm groves use the traditional irrigation system which was dug by local people, where the water reaches the old palm groves by channels buried underground. The majority of the palm grove farms have small basins (madjen; clay basin) or catchments that are currently intended for irrigation.

Table 2. Evolution of the producing of date palms at the Oasis Zelfana (2001-2016)

Zelfana	Total number of palm trees	Number of palm trees in producing	Date production (Q per year)
2001	80102	50969	15900
2002	82896	52010	16030
2003	83525	53168	16700
2004	83525	54925	18275
2005	88786	57609	30340
2006	93481	61698	25686
2007	97490	68165	30035
2008	98950	71455	32275
2009	99075	79076	34965
2010	99957	83060	37924
2011	99957	84827	42137
2012	100307	99982	45068
2013	101007	100282	48986
2014	103562	101987	50948
2015	96 955	94 510	51 080
2016	92265	91002	54586

Source: DPSB, 2016

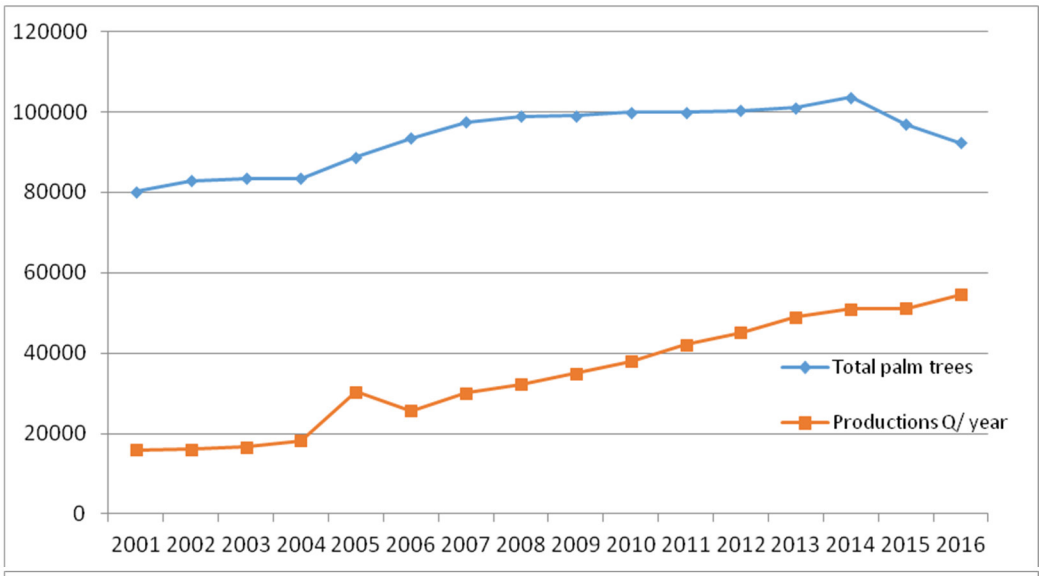

Figure 6. Evolution of the producing of date palm at the Oasis Zelfana (2001-2016)

Water is pumped to a discharge basin which is built at the highest point to ensure gravity flow to each part of irrigated area on the farm via channels buried in PVC.

Today the irrigation system in new extensions outside the oasis is embodied in several forms in each: irrigation by drop, irrigation by drip and spraying irrigation system(Fig. 5).

So, the majority of the new perimeters and the farms outside the oasis use irrigation by drop also known under the name "drop by drop", which is the best technique of irrigation used in most Sahara regions, There is a great type of irrigation drip, known as the 'irrigation by pivot'. It is a system of watering which consists of distributing water in the form of rains on ground; this technique has revolutionized the agriculture of the Sahara especially in recent years, through increased investment and it is limited to use in large agricultural areas.

Conclusion

The dynamics of the study area is complex for the management and development actors. This is explained by the complexity of the strategies that must be put in place by those responsible for enforcing the decrees relating to agriculture and the organization of the facilities. The dynamics should be based on consultation between the project manager and the operators to remove all the constraints which weigh on the improvement of the conditions of production of the farmer. In fact, the biggest challenge in this region is the agriculture production, which is the basis of food, and requires the development of local agriculture which has the largest deficits. The evolution of territorial dynamics of the study area requires the development of local agriculture for better coverage of needs for this thermal region.

Since the second half of the 20th century, we have been witnessing a radical change in the Saharan rural and agricultural sector. This is explained by the fact that the owners of these farms are older (more than 70 years old), which leaves us wondering about their future. Only then can government interventions be included in sustainability.

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