CULTURE SYSTEM IN NAAMA OASES (SOUTHWESTERN ALGERIA)

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ABSTRACT

The present study contributes to the identification of cropping systems applied to traditional argosystems in Naama region (southwest of Algeria). A series of farm surveys were conducted for 30 oases farmers using a semi-structured questionnaire on aspects related to systemic typology crops practiced in Moghrar and Tiout oases in Naama region. The obtained results showed a diversification of crops grown intensively in these oases. They are characterized by the practice of mixed food crops cultivation in underlying strata, associated with family-type livestock farming. Truly, the presence of 35 different crops: date palm cultivar, 5 forage crops, 16 market gardens and 13 fruit trees has been recorded. This oasis system represents an ancestral oasis heritage built and maintained by the local population owing to a careful management of natural resources.

Introduction

Saharian agriculture has undergone a profound evolution during the different agriculture policies adopted from the independence period to nowadays (Mihi et al., 2019 ; Amichi et al., 2020; Hadeid et al., 2021; Senoussi et Huguenin, 2021). During the period of

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reforms and novelty in agriculture, such as the transfer of agriculture outside the oasis, the use of plastic tunnels of market gardens, new irrigation techniques, and above all the evolution of land tenure, decisive changes have taken place in both agrarian systems and attitudes (Hafiza, 2013; Saidani, 2022; Hamamouche, 2018; Saadi and Djeddi, 2024).

The study of production systems, namely cropping systems in the palm groves of southwestern Algeria allows us to examine the evolution of the oasis cropping system and to try to understand the behavior of the oasis farmers. The characterization of these cropping systems and farming practices adopted by farmers in the oases of southwestern Algeria revealed the richness of the local know-how of the southern people in order to ensure agricultural production and to preserve the sustainability of the systems and the surrounding environment.

The objective of this study consists in :

- Characterization of oasis production systems in southern Naama

- Identification of the degree of oasis farmers structuring and functioning

- Understanding the dynamics of oasis production systems,

- Assessment of the sustainability of oasis agrosystems via an agroecological and socio-economic diagnosis

Materials and methods

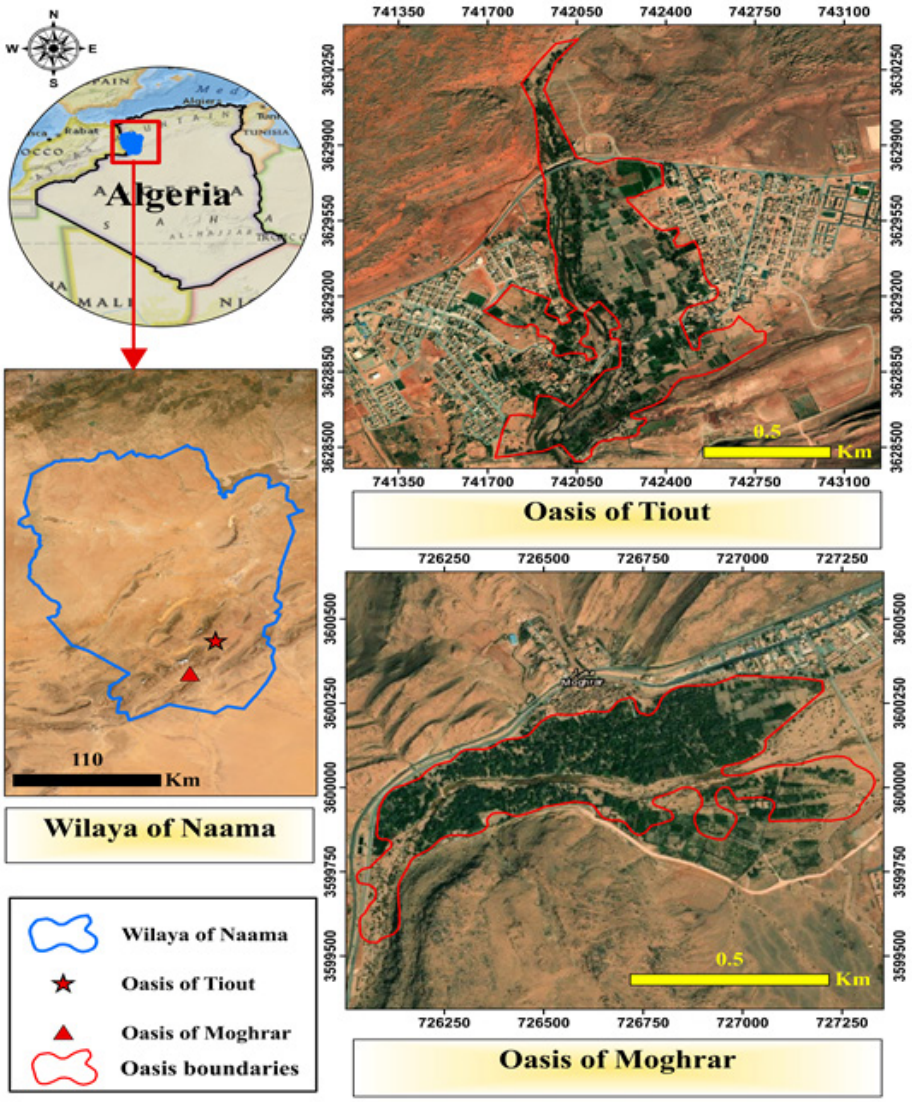
1. Geographical location

Tiout and Moghrar oases are located in an arid zone in Naama province (southwestern Algeria), (Figure 1).

Tiout oasis is located 10 km east of Ain Sefra city, the most important city in the province of Naama, in extension of the National Road No. 47. It is located between the geographical coordinate's 32°47' N altitude and 0°24'W longitude. It rises to an altitude of 1025 m. It is located between Djebel Aissa in the north-west, Djebels Djara and Mekter in the south. It is located in the bed of the Wadi Tiourtelt, which drains the waters of the Djebel Souiga and is part of Tiout municipal, within the daïra of Ain Sefra (Hadidi et al., 2018; Boucherit, 2018; Benaradj et al., 2021; Hadidi, 2019; Ait Saadi and Remini, 2020; Remini, 2019).

Moghrar oasis is located 50 km south of Ain Sefra on National Road 6. It is geographically located between 32° 30' of the North altitude and 0° 35' of longitude and with 937m of altitude. It is bounded to the north by the Djebel Bou Amoud (1.692 m) and the Djebel Cheracher (1.726 m); to the east by the Djebel Boulerhad (1.690 m) and to the south-east by the Djebel (Hadidi et al., 2018; Boucherit, 2018; Remini, 2019; Hadidi, 2019; Benaradj et al., 2021).

Figure 1. Geographical location of study oases



Methodological Approach

Agricultural censuses of agricultural statistical bulletins demonstrate the importance of agricultural production across different agro-ecological regions at local and regional levels (D.B.P.M., 2023). These surveys across a wide range of variables that enable the analysis of both the structuring of agricultural space - including major crops and permanent grasslands - and the structure of farms (FAO, 2018; Junquera et al., 2022; Klebl et al., 2024). These censuses aim to understand the organization of farming and measure its evolution over time: to track the evolution of agricultural production and

the agricultural population. The selection of statistical variables and the analytical approach are crucial for the relevance of the results.

The search for a typology of a production system requires a study focusing on socio-economic and technical aspects. The study of the typology of oasis agro-systems can be designed according to different criteria: cultivation system; agro-climatic situation and production system itself (Zenkhri, 2017; Faci, 2019; Benaradj et al., 2020; Sahli, 2020; Mihi, 2022; Addoun and Hadeid , 2022; Addoun, 2022; Errayhany et al., 2022; Ahrabous et al., 2023; Houssni et al., 2023; Chahid et al., 2024; Amrani, 2024).

The survey was conducted for 30 oases farmers in order to collect information used in the inventory and analysis of agricultural practices applied by farmers in both oases studies (Moghrar and Tiout) during the period of February and June 2018. The number of farms surveyed was not fixed in advance, but it was imposed by our investigation in the field, based on the availability of farmers, the ease of accessibility to the operation and the admissibility of the people visited. The farm visits were carried out with the collaboration with Directorate of Agricultural Services of Naama (DAS) and the representative of farmers from the oases.

The approach followed for developing the typology is based on the following steps:

- Presentation of the study area as a unit of analysis led by key informants and supported by specific documentation.

-Prospecting of study oases and inventory of plant species (date palms, fruit trees, market gardening and fodder crops). It will allow the characterization of the different production factors (surface area of farms, types of farms) and the parameters for measuring plant agrodiversity (specific richness, varietal richness).

- Semi-directed informal exploratory surveys carried out with oasis farmers in traditional agroecosystems and using a participatory approach. The oasis prospecting survey aims to evaluate and identify cultural diversity (phoenicicultural, fruit and herbaceous), describe the different production factors based on socio-economic and agricultural descriptors. These respondents were interviewed by farmers with visual observations of farms to obtain answers regarding the traditional knowledge, which was the subject of our study.

The survey conducted for farmers is structured by a questionnaire, which guides the interviews administered as a quantitative research tool to collect information on aspects relating to the typology of agricultural holdings (Identification relating to the holding: size, method of asserting, structural means, mode of production and management: irrigation, fertilization, crops grown, cultural stratification, plant species cultivated: phoenicicole, fruit and herbaceous) in connection with socio-economic aspects (Identification of the operator: Age, sex, academic level) .

- Development of the thematic survey guide for farms and formal surveys of farms and creation of a typology of farms to better understand the different types of cultivation practiced by the oases

- Data analysis makes it possible to inventory the cultures in a synthetic manner at the level of the two studied oases. Descriptive analysis was used to calculate percentages and frequencies of variables. The graphs and tables were extracted using Excel software based on data from surveys and visual observation of the oases.

Results and Discussion

1. Analysis of biophysical data from the study area (oases)

1.2. Socio-economic framework of oases

The oasis of Tiout has a population of 7,231 inhabitants, spread across an area of 789.5 km² at a density of 6.6 inhabitants / km². Indeed, the oasis of Moghrar, which has a population of 4,707 inhabitants spread across an area of 1,792.5 km² at a density of 1.97 inhabitants per km² (*Table 1*.).

Table 1. Evolution of population (number of inhabitants) in the study oases

Years	O. Tiout	O. Moghrar	Total/ inhabitants
1998	5,014	3,275	8,289
2008	6,532	4,348	10,880
2018	7,231	4,707	11,938
2020	7,296	4,791	12,087

Source: D.B.P.M. Naama, 2021

According to *Table 1*, we have observed an evolution in the population over the last two decades; it increased from 8,289 to 12,087 between 1998 and 2020.

1.2. Climatic characteristics of agro-systems

The region is characterized by a dry and very continental Saharan climate, with cold and humid winter and warm and dry summer. The wet period lasts only three months, and the dry period spreads over the rest of the year; indicating a water deficit. The average annual rainfall is 213 mm. The average annual temperature is 15.9 °C, with a maximum of 36°C in the warmest month and a minimum of -0.5°C, in the coldest month. The average annual relative humidity is 43.33% with the average daily amplitude of 2.14% in November, December and January. White frost occurs on average to 24 days per year, extending over the colder months from December to February. The winds blow most frequently from southwest to northeast (Boucherit, 2018; Benaradj et al., 2021).

1.3. Geological characteristics

The Tiout region is geologically characterized by a flat-bottomed syncline, which locally exposes the Barrémien, Aptian, and Albian lithostratigraphic subdivisions. As to Moghrar region, it is characterized by the presence of Upper Jurassic dolomitic limestones and sandstone with interbedded clay layers (Benaradj, 2017; Boucherit, 2018; Hadidi, 2019).

1.4. Soil characteristics

In Naama region, soils are generally shallow with low organic matter content and they occupy the accumulation zones, including the spreading zones, offer the best potential for agricultural development. The different types of soils are distributed according to geomorphological characteristics and mainly consist of materials produced by the weathering of the abundant sandstone bedrock or limestones from the surrounding massifs (Boucherit, 2018).

1.5. Hydrological characteristics

The particular hydrography is characterized by the conditions of surface water concentration, which is almost planar, and by the existence of groundwater ressources. The oases needs in water are provided by the rational use of the foggaras system. The water sources are springs and wells that tap the groundwater, which, by accumulating, replenish the reserves of vast deep and shallow aquifers. Groundwater is an important part of the water resource. They have the advantage of their regularity, their low mobilization costs, and their good spatial distribution (Derdour et al., 2022). Deep aquifers are exploited by boreholes and shallow wells, the depth of which generally varies between 4 and 30 meters (Benaradj et al., 2015).

2. Typology of the oasis agro-ecosystems

The two oases; Moghrar and Tiout are characterized by an oasis-type system which, since antiquity, has been an association of three vegetation cover strata: palm trees, fruit trees, and annual crops (cereals, forage and market gardening). This oasis agro-system is essentially located in the form of oases along the wadis, in the vicinity of water sources, and in places where groundwater levels are shallow.

The farming system features an intensive and diversified cultivation approach based on the natural use of water, and is practiced by the inhabitants of Ksour, in gardens established near water sources, captured by Foggaras system.

Agricultural production in the oasis is an important source of food and income for its inhabitants, and for many it is the primary or second means of ensuring their livelihood. The majority of the oasis's agricultural production is destined for the self-consumption of families, and due to the quantity produced and its quality, it ensures their families' food security (Boumadda, 2019; Benaradj et al., 2020).

Table 2. Distribution of agricultural strata (Ha) in Oases study

Cultures	O. Tiout	O. Moghrar	Total
Number of Date Palm Trees	3,800	31,800	35,600
Arboriculture (Ha)	368	179	547
Herbaceous crops (Ha)	711	100	811

Source: D.B.P.M. Naama, 2021

According to the *table 2*, the number of date palms is increased in Moghrar oasis (with 31,800 palms) by addition in Tiout oasis. On the other hand, the area reserved

for arboriculture is significant in the oasis of Tiout compared to Moghrar oasis. This development is due to the rise in land ownership costs and the promotion of investment in the sector.

The production and irrigation systems of the oases, as well as the crops practiced, vary according to the location of the oases, in relation to their environment.

The oasis system is based on the integrated association of vegetables, fruit trees, and date palms in combination with small livestock. This system is sustainable and adapted to the constraints of the arid climate. Water management is optimized. This cultivation system is practiced with two or three strata depending on the availability of irrigation water, and can be reduced to two types of cropping system: extensive and intensive.

2. Typology of oases production systems

2.1. Socio-demographics of respondents and analyses of agricultural features

Table 3. General profile of surveyed

Parameters		Number	Percentage (%)
Age (years)	20-40	2	6,67
	41-60	12	40
	Over 60 years old	15	50
	Total	30	100%
Sex	Woman	2	6,67
	Man	28	93,33
	Total	30	100%
School level	Illiterate	20	66,67
	Primary	6	20,00
	Medium	3	10,00
	Secondary	1	3,33
	Academics	0	0%
	Total	30	100%

Source: Survey study

2.1.1. Age of respondents

In the sample studied, the age of the farmers surveyed varies between 20 years (minimum age) and 85 years (maximum age). So, we found that 57.5% of elderly farmers were between 40 and 60 years old and predominated in the region with the largest proportion , 32.5% of farmers under 40 years old and 10% for the category of old farmers over 60 years old and young people whose age is between 20 and 40 years old. The majority of operators in the region belong to elderly people who have popular know-how. For older people, this sector has become an integral part of their lives. Furthermore, for young people this reflects the disinterest of young people in this activity which appears too difficult to them and they turn towards other less difficult and more remunerative activities, which pose the problem of the future of these oasis farms.

1.2.2. Level of education of respondents

In terms of educational level, the majority of respondents are illiterate; i.e. 20 farmers, the rest have acquired a modest level (primary or medium), the know-how inherited from their parents constitutes the main reservoir of agricultural practices in this oasis agro-system of the study region.

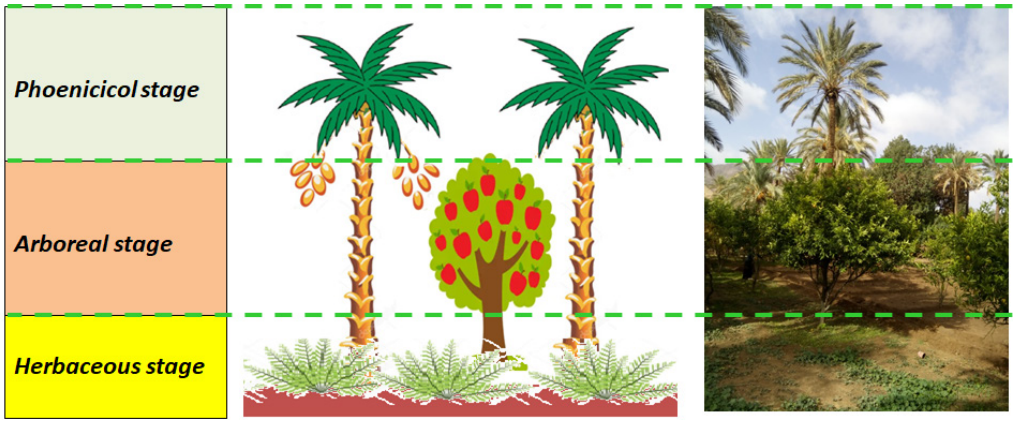
1.2.3. Area of farms

The size or surface area of farms is between 0.5 and 5 ha. The surface areas of the farms surveyed in the study oases are small; 75% of farms have an area of 0.5 ha or less. The surface area of each plot rarely exceeds 0.5 ha; the palm trees are planted on the very surface of the water table. Also, the results showed that only 25% of farms had a size greater than 1 ha. The results highlight the predominance of the surface area of less than 1 hectare, which is qualified as a small farm. Which indicates fragmentation is very important in the study oases. Indeed, the problem of fragmentation is much accentuated, this largely explained by the impossibility of extending farms and the rules of inheritance. According to this fragmentation of production units (0.5 to 1 ha/farmer), the family nature of land exploitation, agricultural intensification remains very modest. The small size of farms hinders the development of agricultural production which will be oriented mainly towards self-consumption; this is "subsistence agriculture". Similar results are noted like Algerian oases and the oases of North Africa (Otmane and Bendjelid , 2018, Ben Khalfallah, 2019; Otmane , 2019, Boumadda, 2019; Adair et al, 2022; FAO , 2021; Benaradj et al, 2020; Gharbi et Elloumi , 2023; Amrani and Senoussi, 2023) .

2.2. Cultivation system

In these studied oases, the cultivation system practiced has three stages:

Figure 2. Cultivation system in oases



2.2.1. First stratum with "phoenicicol" system (date palm)

The date palm (*Phoenix dactylifera*) is the main component of the oasis production systems. It is an intensive system that plays a role of sheltering the oases from desert influences and creating a microclimate favorable for the development of neighboring crops.

The primary activity in the oases is date palm cultivation (phoeniculture). The date palm grove consists of numerous varieties, each with varying economic importance (e.g., Feggous and Aghrass).

The date palms constitute a woody canipy that shade the underlying crops.

Efforts have been made to support small-scale farmers in the oases study, the through date palms planting programs. As a result, the potential date palm area has reached around 527 ha. This has led to a modest but significant date production of close to 7,130 quintals in 2020 (D.B.P.M., 2021).

2.2.2. Second stratum to Fruit Tree System

Fruit tree cultivation is practiced on a very small scale as an intensive system, mainly for home consumption. The fruit orchard includes a variety of species, such as almond (*Prunus dulcis*), lemon (*Citrus limon*), orange tree (*Citrus sinensis*), grape vine (*Vitis vinifera*), quince tree (*Cydonia oblonga*), fig (*Ficus carica*), orange (*Citrus sinensis*), pomegranate (*Punica granatum*), apricot (*Prunus armeniaca*) and olive (*Olea europaea*). These fruit trees are adapted to the local pedoclimatic conditions and are scattered among the date palms at a low density of around four trees per hectare.

Figure 2. Fruit trees under date palms (a. *Vitis vinifera*, b. *Citrus sinensis* , c. *Cydonia oblonga*)

2.2.3. Third Stratum to Herbaceous System

The favorable microclimate created by the date palm canopy supports a polyculture of food crops, including vegetables, fodder, and cereals, as well as livestock, primarily goats and sheep, in a traditional family-based system.

Herbaceous crops in the study oases are characterized by a diversification of species, with 447 ha of Market gardening, 251 Ha of winter cereals and 325 Ha of artificial fodder (D.B.P.M., 2021).

2.2.3.1. Market gardening crops

This system is based on two systems of culture:

- Crops grown under greenhouses between October and March include tomato (*Solanum lycopersicum*), pumpkin (*Cucurbita pepo*), potato (*Solanum tuberosum*), beet (*Beta vulgaris*), turnip (*Brassica rapa*), bell peppers (*Capsicum annuum*), and other crops. These tunnel plots are located in palm groves and belong to local growers.

- Winter field crops mainly consist of feva bean (*Vicia Faba*), onion (*Allium cepa*) and garlic (*Allium sativum*). The winter and spring seasons are followed by summer crops, promarily melon (*Cucumis melo*) and watermelon (*Citrullus lanatus*).

Figure 3. Market garden crops under date palms *(*a. *Vicia Faba,* b. *Cucurbita pepo ,* c. *Allium cepa,* d. *Capsicum annuum)*

2.2.3.2. The Forage Crops System

Forage crops grown under palm trees, although still poorly controlled and subject to multiple constraints, are still practiced. They include alfalfa (*Medicago sativa*), barley (*Hordeum vulgare*) and maize (*Zea mays*). These forage crop can improve the soil ferility via the addition of organic matter and nitrogen fixation by the legumes.

Figure 4. Forage crops under date palms (a. *Avena sativa*, b. *Zea mays*, c. *Medicago sativa*)

These forage crops occupy small patches between palm trees and sometimes even occur around palm trees, dispersed here and there in the form of bouquets (Benaradj et al., 2020; Boucherit et al., 2020).Therefore, forage crops are of great interest in oasis farming systems. The role of forage crops is largely linked to the role of livestock farming (Sraïri et al., 2019, Laribi et al., 2023).

The results of the study showed that in the oases cultivate more than 35 plant species are cultivated: several date palm cultivars (Feggous, Aghras, Takerboucht, Tafghola, Tighazrin…), 13 fruit species, 5 forage species (cereals and alfalfa) and 16 species market gardening species. This diversity in cultivation and production systems has ensured the sustainability of the oasis agro-ecosystem for several centuries.

According to Benaradj et al., 2020, the oasis agrosystem also offers a favorable environment for carrying out polyculture of food crops in underlying strata, associated with family-type livestock farming. The oasis agrosystem presents a high performance of the cultivation systems practiced which can be the key to ensuring food self-sufficiency for the local population (Mihi et al., 2019).

In North Africa, oasis agriculture is essentially based on the association of the date palm with other crops such as fruit growing, market gardening and forage crops. This ensemble forms a three-story oasis agro-ecosystem which is characterized by its specific crops not only through their cultivation methods but also by their genetic potential (Faci , 2019; Salhi , 2020; Houssni et al., 2020; Aljane et al., 2020 ; Loumerem et al., 2020; Benmoussa et al., 2022 ; Amrani, 2023 ; Afify et al., 2023 ; Loucif, 2023).

The results allowed us to refine our work hypotheses and to start studying the ancient oasis system, which represents an agro-ecosystem developed and maintained by local population of Ksar, based on the efficient management of natural resources. This organization is predicated on the effective use of drainage water and the diversification of cropping systems, associated with date palm cultivation with herbaceous crops and small livestock.

Conclusions

The typology carried out at the pre-saharian oases level of southern Naama shows that the dominant production system is a mountain oasis agro-system practiced for centuries. This intensive three-stage cultivation system: phoeniciculture, fruit growing and generalization of market gardening and fodder systems.

Saharian agriculture in Naama oases is diverse and multilayered. The date palm dominates the tree layer as the primary crop, accompanied by fruit trees in the shrub layer, and numerous annual herbaceous crops in the ground layer, resulting in a highly diversified system.

This oasis system represents an arid agro-ecosystem which has been constructed and maintained by local population through a careful management of natural resources. It contributes to the soil fertility enhancement by means of incorporation of compost and crop residues, and legumes-based crop rotations.

In conclusion, the production system in the study area is traditional and based on polyculture, with different cultivation methods adapted to local conditions. The aim of this system overarching logic is producing for subsistence.

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Conflict of interests

The authors declare no conflict of interest.

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