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Email: hammamioumayma93@gmail.com

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Impact of the regression of rangelands on the evolution of breeding systems in Northwest Tunisia

Oumayma HAMMAMI[a,*], Mustpha MANSOURI[b], Moncef KHTIRI[b], Ali FERCHICHI[a]

[a] *University of Carthage, Institut National Agronomique de Tunisie (INAT), 43, Avenue Charles Nicole 1082, Tunis, Tunisia.*
[b] *North West Forestry and Pastoral Development Office (ODESYPANO), Avenue Environnement 9000 Beja, Tunisia.*

Abstract

The pastures of northwestern Tunisia have undergone several changes over the last decades. The main results are the decrease in rangelands, the increase in the total animal load, the increase in the cultivated land, the increase in the production costs particularly the purchase of concentrated feeds, and the low subsidies from the state. All these factors are changing the livestock system, mainly dairy cows. The present study, therefore, sought to characterize farm household systems that seem to be currently adapted in the Sejnane plain using a typology. We focus on understanding the variables that contribute to raising farmers' choice of breeding system in the study area. We interviewed 44 farmers. Furthermore, we analyzed their responses using descriptive statistics, ascending hierarchical classification AMP and principal components analysis PCA. The results show that four types of livestock systems could be characterized, depending on pasture and production. Moreover, they suggest that landless pastoralists are more vulnerable than agro-pastoralists.

Keywords: Agro-pastoralists; Livestock system; Northwestern Tunisia; Rangelands; Vulnerability.

1. Introduction

In Tunisia, the rangeland area is continuously decreasing. As a result of population growth and climate change, pasture areas decreased by 20% between 1980 and 2000 [1]. The high animal load, the regulation absence of cultivation in the pastoral area, and the constraints on the collective areas' management have been decisive in pastoral resources management in both quantitative and qualitative terms [2].

From 1970 to the 2000s, livestock systems began to diversify. It's initially extensive. Since this period, the rangelands' contribution has been made decreased and currently represents only 10 to 20% of the total feed of animals in the northern Tunisia regions [3, 4]. Grazing in this region accounts for only 16% of total production [5].

Indeed, most farmers use feed additives, especially concentrated feed, during grass shortages. More than 75% of the Sejnane plain population is engaged in breeding as the main family income. However, the production system is blocked by the indivision constraint and the collective land use (88.7%) inappropriately [6]. Reference [7] showed that agropastoral settings represent a context-specific adaptation to global change. In addition, Reference [8] asserted that current livestock systems are integrated into agricultural systems.

However, production systems differ in terms of available pasture resources, production objectives, management, and natural resources use [9]. Reference [10] reported that assessing the impact of livestock grazing to find the right management strategy is essential in degraded rangelands.

Therefore, the present study sought to determine the evolution degree of rangeland in the Sejnane plain and to characterize the diversity of farm household systems. Our focus is on understanding the variables that contribute to farmer choice in the breeding system. We wanted to assess the farming system in a selected agroecological area.

2. Materials and methods

2.1. Presentation of the study area

The surveys were conducted in the Sejnane plain, located in Northwest Tunisia (Bizerte governorate, Latitude. 37°03' 38" N, Longitude. 9° 14' 18" E) (Figure 1).

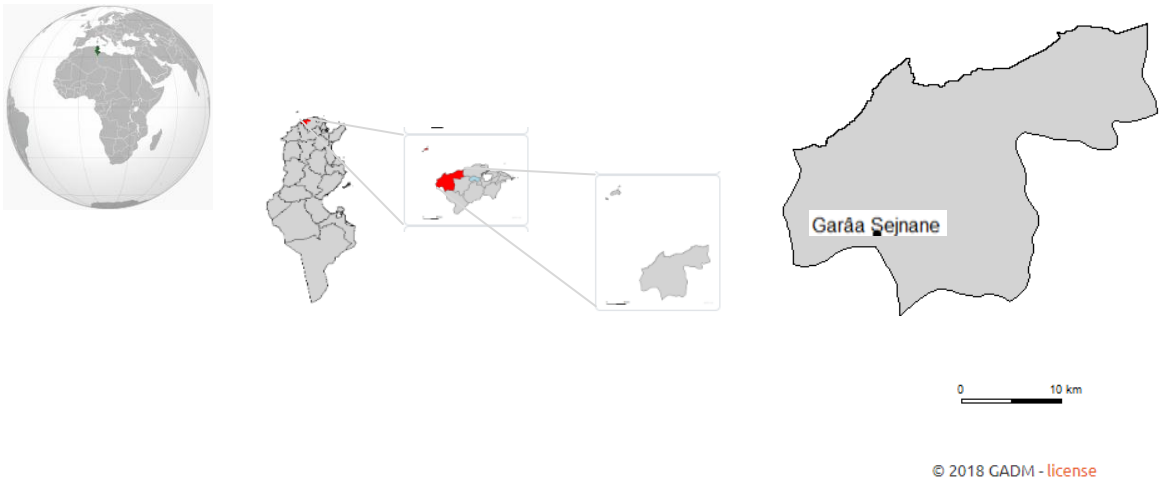

Figure 1 Location of Sejnane plain northwestern Tunisia

Our study area belongs to the subhumid bioclimatic zone. The annual precipitation is on average 932 millimeters can exceptionally exceed 1400 millimeters. The majority part (73%) falls in winter, when marshes form, occupying a third of the total [6].

The water body shrinks in spring until it is completely dry in summer and it's used for grazing by the local communities. Nevertheless, it suffers from a four-month drought, following the rangelands drying up and losing a significant part of their nutritional value.

This sublittoral plain covers 4,322 hectares an area, which is spread over seven administrative sectors. It concentrates more than 88% of the Sejnane delegation's total population which houses 6574 households.

2.2. Méthodology

Data collection on the Sejnane rangeland and field observations to estimate the ecosystem regression.

Socio-economic surveys in the study area were conducted in Mai 2022, to assess grazing role and to develop farming systems typology.

The questionnaire makes it possible to collect a maximum of information on livestock farming and the natural pastoral resources exploitation in the Sejnane plain. Its main aspects are:

- The social aspect, which includes all information concerning the herder.
- The technical aspect includes the total agricultural area distribution, the existing livestock (sheep, goats, and cattle), the breeding system practiced, the grazing duration, etc...
- The economic aspect, such as farm income, and production costs.

Assuming that the concentrates purchase for dairy cows is the only production cost, with equal quantities for the agro-pastoral households surveyed. The concentrates supply at grazing time in equal quantities for all cows induces responses that do not vary with the animal characteristics. This original result supports the idea that the majority of cows with a production level which more than 20 liters per day do not manage to satisfy all their energy requirements at grazing and that grass intake is a limiting factor that concerns all cows [11].

2.3. Statistical analysis

The total number of households in the sample is 44. The selection was made on the lists basis of pastoralists using the rangeland, obtained from the North West Forestry and Pastoral Development Office[1], and according to the availability of reliable information.

[1] ODESYPANO : Office du Développement Sylvo-Pastoral du Nord-Ouest (agrinet.tn)

15 variables (Table 1) were selected for the typological classification of the farms studied. The choice was made for variables that have a strong discriminating power to highlight the differences between farms. Two multivariate statistical techniques were used to establish a typology of agropastoral systems: Principal Component Analysis (PCA) [12], to present in graphical form the maximum amount of information contained in a table of data composed of individuals and quantitative variables, and Hierarchical Ascending Classification (HAC) [13] is used to group and arrange individuals into classes according to Cluster Method « Between groups Links » and « Squared Eudidean distance » interval between them. It is complemented by the number of axes considered interesting in the principal component analysis.

Once the distinct types of agropastoral systems were established, the impact of livestock decisions on the vulnerability or sustainability of the system in terms of intensification, productivity, natural resource use efficiency and farm consumption were analyzed.

Table 1
Variables used to identify distinct household types

Variables	Data source
1. Total agricultural area (ha)	- Primary survey data
2. Fodder area in relation to total area (%)	- Calculated from primary survey data, according to this system: 1 cattle = 5 sheep [14].
3. Dry fodder area in relation to fodder area (%)	- Calculated from the primary survey data.
4. Irrigated fodder area in relation to fodder area	- The concentrate price for dairy cows is estimated at 1.36 TND per kilogram, and it for sheep is about 0.83 TND [15].
5. Fallow area in relation to total agricultural area (%)	- The liter milk price in 2022 is 1.14 TND.
6. Number of dairy cattle (head)	- The kilogram meat sheep or goat reference price in july 2022 is estimated at 14 TND for weights of around 45 kg [16].
7. Number of sheep (head)	
8. Number of goats (head)	
9. Grazing time (hour/head/day)	
10. Total grazing load (sheep head equivalent)	
11. Supplementation with concentrates (kg/year)	
12. Milk production per holding (l/year)	
13. Meat production per holding (kg/year)	
14. Concentrate costs (TND /year)	
15. Farm income per farm (TND/ year)	

TND : Dinar Tunisien (1 TND = 0,295828 EUR au 29/06/2023)

3. Results and discussion

3.1. Rangelands evolution

The following table shows the variation in the surface area of these lands between 2010 and 2020.

Table 2
Evolution of rangeland area (ha) in Sejnane [17]

Year	Rangeland area (ha)
2010	12628
2020	11500

An estimated 1128 hectares of rangeland have been lost in the Sejnane delegation in ten years. The reason for this is the importance of agriculture in this delegation. Reference [18] showed that the most critical factor in rangeland degradation is changing the land use of rangelands to civil and agricultural uses, proper land use planning is essential to decrease degradation in the rangelands. It affects breeding systems, especially small ruminants. In particular, many communal lands have become increasingly vulnerable to degradation, as they show signs of desertification, due to high grazing pressure and poor proactive grazing strategies [9]. Reference [19] said that the decline of this ecosystem in northwest Tunisia has been around 1% per year over the past thirty years, leading to a rise in animal load per hectare.

In this context, the following table shows the trend in livestock numbers:

Table 3
Evolution of existing livestock in the Sejnane delegation [17]

Year	Cattle (Head)	Sheep (Head)	Goat (Head)
2007	7500	24000	15000
2020	15000	25000	10000

Cattle numbers doubled between 2010 and 2020. The sheep numbers have increased. However, the goats' number has decreased. The behavioral constraints can explain this result. Goats consume ligneous plants as they are more abundant in forest rangelands. This is down to the "browser" behavior of these animals [20].

Whilst livestock numbers remain high, climate change impacts are growing the ecosystem's vulnerability. Recurrent droughts impacts are all the more harmful as grazed ecosystems are more fragile due to recent anthropogenic disturbances [21].

3.2. Characterization of agropastoral systems in the Sejnane plain

The majority of those interviewed have private access to the land. The overall agricultural area of the holdings an average of 3 ha with a maximum of 9 ha. Farmers with an agricultural area of less than 5 ha make up 74% of our samples. Fodder crops are a priority in the agricultural activity of the holdings studied, with an average fodder area of 95% of the total agricultural area. The remaining land is left fallow to pasture.

The area under forage is dominated by annual crops, which represent an average of 59% of the useful area. Various forage crops are cultivated in the study area, mostly rain-fed (96%). Irrigation is used by certain farmers in the area, mainly to grow bersim, which does not exceed 1 ha. Farmers in the area build up their stock of hay and silage to feed their livestock during periods of grass shortage, at lower cost.

The farms surveyed have a sheep population of 9 ± 8 head, a maximum of 30 head. Goats are generally kept in association with sheep. Their average number does not exceed 10 per farm, with an average of 2 ± 2 goats. Both types of livestock are oriented towards meat production, which is mainly based on grazing with stored feed resources (hay, silage), without concentrates. They are sold at an average live weight of 45 kg for sheep and 25 kg for goats during the month of Ramadan and during the Aid El Adha (sacrifice festival). They are sold mainly in livestock markets.

There is variability among holdings in the total number of cattle. There are on average 3 head, which may exceed 18 cows in production in the study area. Some farms are seeking to increase milk production by feeding concentrated foods during lactation. There were large differences in farm income among different households.

3.3. Typology of farm households

Projecting households onto the space of the first two axes of PCA, followed by AMP, four distinct groups could be distinguished based on structure, herd size, production potential and concentrated feed intake (Figure 2, Table 4).

The first two factorial axes accounted for 59% of the total variability (Table 5). Axis 1 (38%) is related on the one hand to intensification of production through the use of concentrates and on the other hand to farmers owning agricultural land. Axis 2 (21%) is associated with extensive agriculture or traditional systems that do not rely o concentrates.

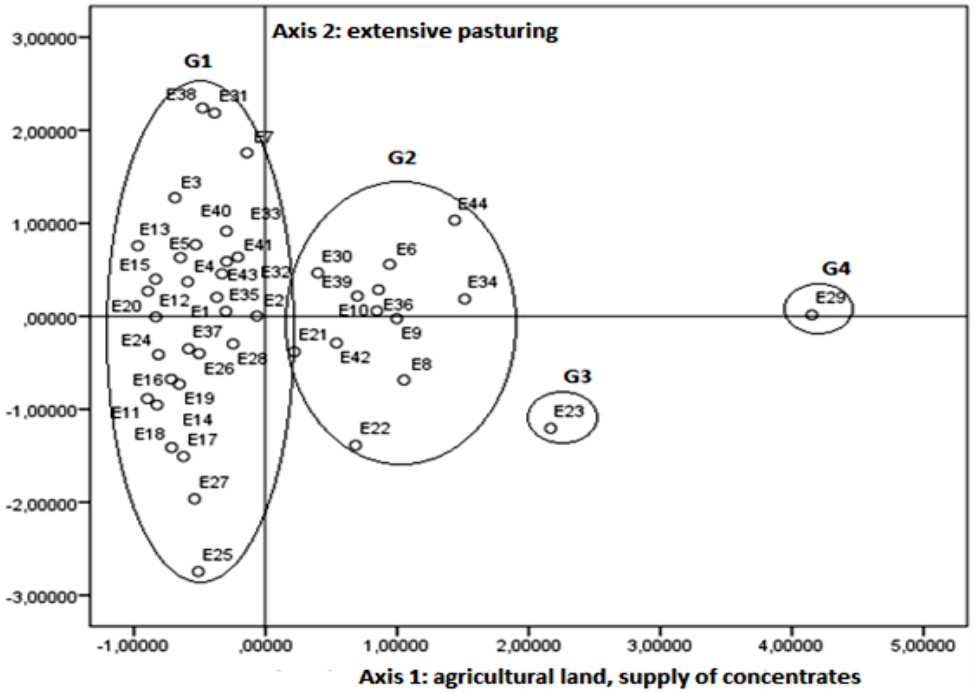

Figure 2 households' projection on the planes formed by the first two axes of the PCA

- **Group 1, Small-scale extensive livestock farmers:** These farms are based on mixed goat-sheep farming, extensive without the use of concentrated feed. This breeding type is oriented toward meat production. Dairy cow farming is negligible, with no more than one cow on average. Moreover, this group is composed of 30 farms with an agricultural area down to 5 hectares for fodder crops, mainly rain-fed, but some farmers use irrigation. Fodder stock is self-consumed by the livestock in winter when the plain is flooded. In addition, herd feeding is based mainly on grazing throughout the year.
- **Group 2, Medium agro-pastoralists:** This group contains 12 farms. The herd is the same order of magnitude as for group 1, with 12 small ruminants on average per household, but with more cattle on average 5 cows. These farms have 5 hectares on average, mainly used for fodder crops. Livestock is based mainly on grazing throughout the year. However, feed supplementation, particularly with concentrates, is more common during the winter period. They are medium producers.
- **Group 3, Exclusively milk producers:** There is only one farm in this group that raises cattle exclusively, with 10 cows in production on average. The animals' feed is based as usual on the natural pastoral resources. However, concentrate feeding is compulsory during the lactation period, to intensify production for marketing. It has 9 hectares of agricultural land for fodder crops. This household has good fodder security. They are milk producers.
- **Group 4, Large agro-pastoralist:** This group contains one farm. It is characterized by diversified livestock production, including 16 small ruminants and 18 cows in production. It has good food security, as fodder crops are grown on the entire agricultural area, the 9 hectares under rain-fed conditions. In addition, the cost of production remains high due to the use of concentrated feeds while seeking to improve productivity. Grazing remains the strategy of all the breeders in the study area to feed their animals. It is the large-scale herder who is the richest in the households studied.

Table 4
Characteristics of the 4 groups of agropastoral households

Variable	Small extensive livestock farmers	Medium agro-pastoralists	Exclusively milk producers	Large agro-pastoralist
Households number	30	12	1	1
total agricultural area (ha)	4 ± 1	5 ± 1	9	9
fodder area (%)	94 ± 6.43	95 ± 6.63	94	100
dry fodder area (%)	94.72 ± 8.20	98.12 ± 4.58	94.11	100
irrigated fodder area (%)	5.27 ± 8.20	1.88 ± 4.58	5.88	0
fallow land (%)	6 ± 6.43	5.11 ± 4.58	5.55	0
number of dairy cattle (head)	1 ± 0	5 ± 0	10	18
number of sheep (Head)	8 ±7	8 ±7	0	10
number of goats (Head)	2 ± 2	1 ± 2	0	6
grazing time (h/head/d)	4 ±1	4 ± 0	3	5
total grazing load (in sheep head equivalent)	20 ± 10	35 ± 10	50	106
supplemental concentrate (kg/year)	0	11039 ± 2113	15250	18900
milk production (L/year)	7563 ± 4936	40845 ± 8181	91500	153720
meat production (kg/year)	420 ± 356	402 ± 356	0	555
concentrate costs (dt/year)	0	14820 ± 2855	20740	25704
farm income (dt/year)	14498 ± 8276	37372 ± 7872	83570	157307

Table 5
Result of the principal component analysis (PCA)

	Proportion	Cumulative
Axis 1	0.38	0.38
Axis 2	0.21	0.59
Axis 3	0.11	0.70
Axis 4	0.11	0.81
Axis 5	0.06	0.87

Household types G1 and G2 included farms that produced milk and meat with low input intensity. Livestock feeding is mainly based on the natural pastoral resources on the plain, with a long grazing period. Supplementation with stored fodder and concentrates is a strategy to safeguard the animals. Grass consumed by dairy cows is sufficient to produce milk at a lower cost [11]. Nevertheless, the majority of farmers are obliged to provide food supplements for the animals, particularly concentrates [3]. Despite many constraints, livestock farming seems to allow the farmers to achieve their objective of self-sufficiency in Dairy and meat products. Indeed, these farmers adapt to changes in biophysical and socioeconomic situations [22].

Households G3 and G4 were a rarity in our study area, with good food security. Their strategy for feeding their herds is to exploit natural resources with feed supplements, fodder stock, and concentrates especially, during the lactation period. This has an impact on animal performance; they are the main milk producers. Grazing alone does not cover all the food for animals with high production potential, so adding concentrates can be interesting [11]. Milk production is increasingly dependent on international market prices for concentrated feed and raw materials [8]. Furthermore, Reference [23] showed that the intensification of livestock systems (through supplementation) has completely changed the behavior of livestock farmers toward rangelands Farmers with arable land appear to be more adaptable to global change than landless pastoralists, who are more vulnerable [24].

Livestock and rangelands in the natural ecosystem are constantly interacting with each other [10]. Despite adaptation strategies to many changes, the status quo in the livestock sector remains fragile. However, new vulnerabilities related to feed availability and concentrate supply persist [4]. In this context, Reference [25] showed that grassland regeneration, soil conservation, and livestock production improvement can be ensured by controlled grazing. Moreover, Reference [26] stated that social resources contributed

less than natural resources in reducing the vulnerability of pastoralists.

4. Conclusion

This paper set out to understand the farming systems and the dynamics of the use of pastoral resources in the Sejnane plain, which has its climatic particularities. While its rangeland has great importance in the feeding of the animals. The population exercises their right to use the natural pastoral resources and may be tempted to under-report the numbers. Their zootechnical and natural actions tend to specialize Sejnane in cattle breeding by using four distinct systems with a high total pastoral load. Human activity can be a vulnerability factor for grassland areas in the case of poor pasture management. Both strategies for safeguarding herds in grassless; Agro-pastoralism and feed supplements, in particular concentrates. Currently, livestock policy strategies tend to seek a balance between sectors and increase milk production at a lower cost.

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