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Economic profitability of livestock systems and futurs prospects at local level : a typological analysis of farms in arid rangelands in southern Tunisia

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Abstract- Livestock is one of the main sectors in Tunisia; it contributes 41% of agricultural production and 4% of the country's GDP. Historically, the feeding of animals is based on rangelands production fodder. Two-thirds of the number of herds are located in arid and semi-arid areas in the center and south of the country. The study was carried out in the arid rangelands of El Ouara in southern Tunisia. It aims to understand the diversity of the existing livestock systems and evaluate these economic results in order to perceive their future. For this purpose, the profitability analysis of the livestock systems was carried out using a database that was collected from 73 breeders in the study area. Using analysis typology, four types of livestock systems have been identified. Despite the disturbance by some socio-economic and climatic factors, these systems continue to provide incomes at an acceptable level in comparison with economic indicators. They are characterized by very rudimentary breeding techniques and their costs (feeding and guarding) are very linked by droughts. However, animal husbandry remains an interesting traditional activity with which development actions could be undertaken to improve the region's future.

Key words: Livestock system, transhumance, economic profitability, Tunisia.

1. Introduction

Globally, drylands extend 6.09 billion hectares and provide the livelihoods of More than 400 million people (35%) in the developing world (Van Ginkel et al. 2013). In Tunisia, arid rangelands constitute more than 2/3 of the total area of rangelands, around 5.5 million ha, of which breeding is the main activity practiced on these vast rangelands (Ben Salem, 2011). Thus, there is a high degree of dependence between farms and the fodder resources available on the rangelands. The scarcity and instability of these feed resources coupled with endogenous factors of breeders (livestock, non-agricultural activities, labor, cash availability, socio-cultural characteristics, etc.) have led to the diversity and heterogeneity of their characteristics (Belhedi, 2018). However, keeping systems rely on a thorough knowledge of their functioning in order to identify weaknesses and propose improvements that will complement their strengths.

As long as it is impossible to develop specialized recommendations for each farmer, the diversity and variability of farming systems can be summarized using a typology of farms while respecting the main characteristics (Perrot and Landais, 1993; Alvarez et al. 2018). In this study, we analyze the different livestock systems developed in arid rangelands, we assess their economic efficiency and we perceive their future in order to analyze the livestock sector sustainability in this arid region.

2. Materials and Methods

The study was carried out in the El Ouara rangelands, which belongs to Southeast of Tunisia (figure 1). The region is characterized by its arid climate with a spatio-temporal irregularity of the precipitations. The average annual rainfall ranges between 50 mm and 180 mm.

The particularity of this region is the spread of livestock grazed on natural rangelands to cover its needs. The extensive breeding allows the development of the available space and the exploitation of these arid environments. With the acceleration of the privatization pace of collective lands, rain-fed arboriculture has been developed increasingly at the expense of rangelands (Ben Salem, 2011). While cereal farming remains episodic and is mainly dependent on precipitation during the autumn and winter periods which determine the sown area on the rangelands.
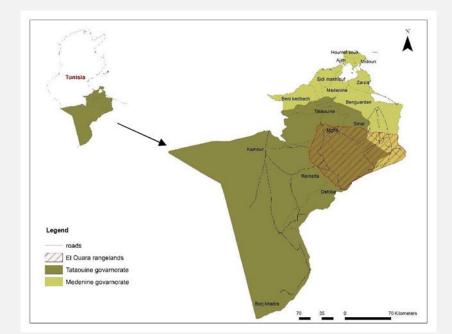
Figure 1. Map of the study area (El Ouara rangelands, southern Tunisia)

The information has been obtained by the survey method recommended by different authors (Capillon, 1985; Dobremez and Bousset, 1996). We interviewed directly the breeders. It involved 32 breeders from the Medenine governorate and 41 breeders from the Tataouine governorate. The survey provided both quantitative and qualitative information related to socio-demographic characteristics of households, breeding structure and practices, the economic results of the production unit and breeders' perspectives, access and use of rangelands as well as grazing management methods and social organizations.

To achieve our study goals, our analyses were performed using three steps, following a progressive approach: In a first step, we carried out multivariate analysis to define and analyze the different livestock systems practiced in the area studied. These include technical criteria (agriculture-livestock integration, etc.), economic (importance of farming system income in total household income), and those relating to the organization and practices of farms (mobility, supplementation, intensification) (Gibon et al. 1999). The main objective of multidimensional statistical analyzes is to define livestock systems groups within which these are as similar as possible on the variables which were used to construct the clusters. In a second step, to analyze the economic situation of livestock systems, we calculate Animal Gross Marginal (GM; calculated as the sum of the incomes obtained from animal activity minus variable costs), Animal Net Marginal (NM; calculated as the sum of the incomes obtained from animal activity minus variable and fixed costs) and the Agricultural Income (calculated as the sum of the incomes obtained from farm activity) to assess the overall profitability of farms. Finally, in order to investigate the future of each type of farms that are maintained and developed and those that are blocked and that could disappear, we compared the average monthly agricultural income, with monthly reference thresholds (poverty line (PL), the minimum guaranteed interprofessional wage (GIMW) and the average income per capita)..

3. Results and discuss
3.1. Livestock systems and characterization of actors
3.1.1. Movement modalities of breeders : new ways of managing the herds

In this unstable context that is characterized by a strong climatic variation and socioeconomic changes, breeders develop many practices according to their available means. Indeed, the identification of the different movement modality of herds informs us about the main modes of livestock conduct. The analysis shows three modes of conduct: the sedentary (breeders reside in the same rangeland area for all year), the transhumant (breeders move on the large rangelands depending on the availability of fodder), and the semi-urban ones (breeders bring their herds to the rangelands just in the rainy periods). The instability of herds then continues to characterize livestock systems in the rangelands in southern Tunisia. Table 1 shows that 75.4% of farms in movement while only 24.6% of them are fixed for all year in the same rangeland area.

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Table 1. Movement modalities for breeders and herd size (Own survey, 2019)

	Number of breeders	% of the sample	Average of small ruminants size	Average of camels size
Transhumant	41	56.2	338	25
Sedentary	18	24.6	333	9
Semi-urban	14	19.2	72	1

The search for good grazing areas is the main drive of mobility during the rainy years, while in the dry years, breeders move around looking for water. Therefore, the mobility decision is essentially linked to the two factors : water and feed. We note that the large numbers of camels are owned by breeders practicing transhumance.

In order to cope with the long period of drought, some breeders living in the city developed a new modality of conduct; it is the semi-urban livestock system. We noted that 19.2% of breeders return herds to the house in the urban area in order to reduce livestock costs. These individuals have the smallest herd size, an almost total absence of camels, and the size of small ruminants is limited to 72 heads on average. From this last practice appeared, we confirm the development of bipolar systems, which are closely attached to the city. Therefore, new practices emerged and some other breeding habits were changed.

Nowadays, with the large trends of urbanization, the breeders are increasingly faced with difficulties in finding and recruiting shepherds. A new transhumance mode over short distances appears that represents 56.2% of the studied sample. In the past, transhumance was organized either in a family way depending on the availability of fodder without being aware of either the regional limits or the borders of the country ; the family moves with herd therefore breeder does not need salaried labor. As reported by Ammar et al. (2011), the breeding that has traditionally been based on the use of rangelands in southern Tunisia has undergone a set of modifications such as the disappearance of transhumance to the neighboring countries (Libya, Algeria) and even towards the center of the country.

For all farms, the herd size fluctuates rapidly depending on the climatic conditions and the owner's financial situation.

3.1.2. Farms' characterization according to the owner status

The livestock sector in the El Ouara area remains very attractive because of the benefits that can be generated by this activity. Especially, it offers the necessary herds number for wedding parties and for the Muslim festival "*Aid lekbir*", as was in line with other studies carried out in Tunisia such as of Elloumi et al. (2006). The analysis of both various feeds conducts and spatial management of the systems makes it possible to differentiate two breeders' categories having specific practices and strategies: "breeder-owner" and "breeder-herder-owner" with respectively 87.7% and 12.3% of the sample. For the breeder-owner, there are two types, either the breeding is the main activity for the owner and it presents the fundamental source of the family income, either the owner inherited the herd from his father or in some cases he is passionate about breeding and he practices it as a secondary activity (Table 2).

Table 2. Breeders' status according to movement modalities in percentage (Own survey, 2019)

	Breeder-owner		Breeder-herder-owner	Total
	Secondary activity	Principal activity		
Transhumant	20.6	30.1	6.8	56.1
Sedentary	8.2	11	5.5	24.7
Semi urban	9.6	8.2	0	19.2
Total	38.3	49.3	12.3	100

3.2. Statistical classification of the studied farms

The typology was built based on the variables characterizing the choices followed by each breeder according to capital available (cereal area, small ruminant size, camel size, tree land area, tractor ownership, number

of herders, family workforce) and the spatial and food management methods (supplementation, transhumance, association type, exploitation of the rangelands of other tribes).

The results of the PCA application indicated that the first five axes accumulate 76.3% of the total inertia. Moreover, the analysis of the projection and the correlation circle of variables gave a clear representation of the breeders' distribution and the descriptive parameters (Figure 2). Axis 1 concentrates 24.4% of the variance. It separates farms with a high number of camels and a strong agricultural base from those of weak agricultural base and limited camel heads. Axis 2 preserves 17% of the total inertia by expressing the movement modality of breeders. Thus, it differentiates between breeders that practice transhumance

from the other ones. Axis 3 contributes 14.9% of the variance. It discriminates between breeders according to their employment of salaried workforce. We have the systems based on the hired labor to the right of the axis and in opposition ; one finds systems whose hired labor is rather weak. Axis 4 concentrates 12% of the variance. It differentiates between the large herd size where sheep represent the largest share of the herd (to the right of the axis) and the small herd size (to the left of the axis). Axis 5 expresses 8% of total inertia. It distinguishes breeders depending on the breeding practice followed. On the one hand, determines the breeders who adopted the association practice "*cherka*". On the other hand, there are farms applying a mixed cereal crop-livestock system.
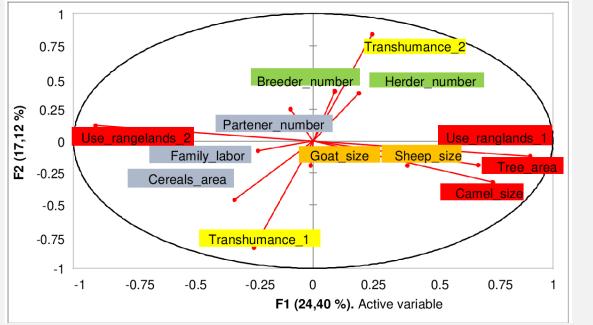

Figure 2. Graphical representation of correlation circle of variables

The results of the hierarchical classification allowed us to distinguish four types of livestock systems described below :

Group n° 1 : agropastoral system
This group includes 24.6% of the sample who are located in total in the Medenine governorate. It is constituted by large farms, both in terms of area and in number of heads. The agricultural area under ownership average
about 20 ha, who is mainly devoted to olive trees with 17 ha area. They plant 1.5 ha of cereals in order to benefit from straws and cereals for the herd. Regarding the livestock size, it is around 469 heads mixed of small ruminants and camels, which composed of 371 sheep heads, 43 goat heads and 55 heads for camels. This system type resides in rangelands even in drought periods in resorting to supplementation. Furthermore, the possession of transport means helps them to move and graze far rangeland areas. Indeed, they have all a van or a car and 44% of them have a tractor. Ben Saad and Bourbouze (2010) found also that the increase in the degree of mechanization facilitated in the majority of cases the spread of supplementation on the rangeland area.

Group n° 2 : sedentary breeders
This group comprises 20.4% of the sample and is spread over the two localities with a main concentration in the Medenine governorate (87%). They have a herd size of 267 heads who is dominated by sheep species (83%), while the camel size limited to 12 heads. The individuals of this group are sedentary breeders, 25% of them consider breeding as their main activity and the only source of income. Further, they do not use much labor and external employees are not frequent. Just during reproduction and supplementation period, 28% of the group recruit a hired workforce. In this system, herd feeding is based mostly on grassland. Indeed, using their expertise, breeders have developed an association practice with other ownerships by carrying out surveillance and sharing the feeding cost. These new ways of arrangements such as agricultural collaborations and work sharing between breeders have emerged in order to maintain interest in activity.

Group n° 3: multi-active breeders

It represents the smallest share of the sample (8%) of which 83% of these breeders are located in the Tataouine governorate. Moreover, half of the individuals in this group practice a main activity other than animal husbandry such as public service, trade… The main distinctive characteristic of this group is the absence of an agricultural area even if it exists with a negligible area unexploited. Moreover, all members' group has only a herd of small ruminants, which is dominated by sheep breed (an average of 198 heads), while goats' size does not exceed 35 heads. The family's participation in the breeding activity is very limited ; they employ at least one herder, or even two in large herd size. The frequent use of hired workers is explained by extra-agricultural financing. In addition to the supplementation practice on the rangelands, 50% of the group move to look out for feed. This result concise with previous studies in southern Tunisia that shows mobility is an ancient practice, which plays a fundamental role in livestock feeding (Frija et al. 2016).

Group n° 4: mixed cereal-livestock system

This group accounts for 47% of the farms of which totally were concentrated in the Tataouine governorate. Breeders develop a mixed cereal-livestock system, with a cereals area of 3.7 ha and a mean number of small ruminants. Thus, they have 168 heads of sheep and 61 heads of goats. As long as they use the family workforce (79.41%), they recruit salaried labor only in emergency cases.

Thus, breeders benefit from the help of their sons, who interrupted their education. This system is generally practiced by breeders living in the near villages close to rangelands whose strategy is to take advantage of cereals stubble in summer and move to rangelands in winter during the good seasons. Thus, it is a new way of mobility that has been developed where breeder move between the rangelands and the village area.

Generally, pastoralism and extensive breeding are in regression. Agro-pastoralism and expansion of agriculture were observed in southern Tunisia (Gaddour et al. 2013). The typological analysis confirms these results by identifying an agropastoral system (group 1) and a mixed cereal-livestock system (group 4), which presented 72% of the sample. Thus, breeding increasingly depend on feed concentrates, agro-industrial by-products and crop residues (Ibidhi and Ben Salem, 2018).

3.3. Economic efficiency of different livestock systems
3.3.1. Financial situation per group

The animal gross margin differs according to the strategy followed by the breeder. Further, it can constitute the main source of family income or its role is limited to an additional income. It varies widely between groups. Thus, the first group has the highest gross animal margin of 7023 TD, which provide a high agricultural income of 6663 TD (Figure 3). In this case, the breeding activity enormously contributes to constituting the family income. Moreover, individuals in this group also benefited from the olive oil gross margin during the rainy years. Concerning the two groups 2 and 3, exhibit almost equal agricultural incomes of 4003 TD and 4076 TD respectively. At this level, the results show that group 3 of multi-active breeders even with reduced herd size, presents a high income. This is explained by their multi-source income. In fact, individuals of the group practice a main activity other than breeding which is a secondary activity for them. These resources constitute security for the domestic treasury against climatic disturbances and help them to take this risk.

The group 4 has the lowest gross margin of 3574 TD. Breeders try to rise it by the recipes of caring for animals of other individuals. In a dry period, the breeder sells even the female heads at unfavorable prices in order to finance the expenses. Nonetheless, they reconstruct their livestock in the rainy year. In addition, this group includes 57% of semi-urban breeders, which are characterized by small herd size. Therefore, breeding offers them a kind of cash that can be easily mobilized when needed. Lastly, all investigated have an agricultural income below the net animal margin, which shows that they use husbandry yield to preserve crop speculations mainly the olive tree (Figure 3).
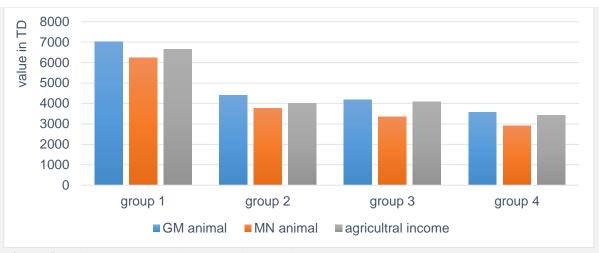
Figure 3. Animal gross margins and agricultural incomes
TD: Tunisian dinar ((local currency) (+- 0.31£: December 2020))

3.3.2. Comparison of agricultural incomes with economic indicators

We compared agricultural income per month with the poverty line (PL = 82 TD / month), the minimum wage (GIMW: 403 TD / month) and the average income per capita (avr_incom / cap: 798 TD / month) in Tunisia (INS, 2018

The calculation of agricultural income per month shows that all groups generate an income above the poverty line. Nevertheless, none group has managed to reach the average income per capita (Figure 4). Group 1 of the agropastoral system presented the only income, which is higher than the minimum wage. This result proves the importance of the transhumance and the added value of camel breeding to the system profitability. Thus, for group 2 of sedentary breeders where the size camel is small and does not exceed 13 heads, their average agricultural income is quite reduced compared to group1. As shown above in the analysis of agricultural income, group 3 having an income fairly close to group 2. Hence, the importance of extra-agricultural income to ensure the profitability of the system.

3.4. Future's perception of livestock systems

The typology analysis provided an interesting characterization of the livestock systems in addition to the analysis of the economic efficiency of different groups allowed us to build future perspectives of the livestock systems identified in this arid area.

Group 1 (agropastoral system) brings together the largest farms that have developed both an agricultural base and breeding activity. In fact, they have many means to adapt to variations such as price fluctuations following the opening up to international markets and the development of taxation for the agricultural sector. This group can then be the precursor of a new mode of flexible farm to the rangelands. Nevertheless, the family income is still based on pluriactivity.
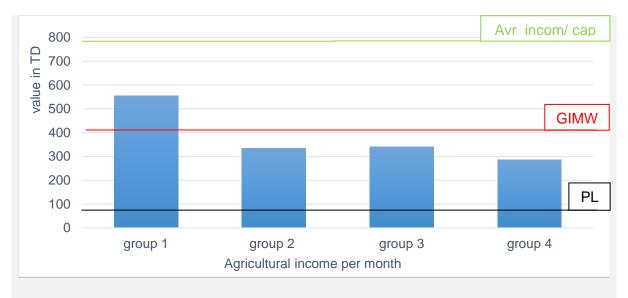

Figure 4. Comparison of agricultural income per month with avr_incom / cap, GIMW and PL
TD: Tunisian dinar ((local currency) (+- 0.31£: December 2020))

Group 2 (sedentary breeders) has a decent income which allows them to easily maintain the breeding activity. These breeders associate with each other as a means of adaptation to the existing constraints. They are thus able to adjust and evolve along the lines dictated by markets and agricultural policies. They present an interesting target group with which development approaches could be implemented. This group would likely have the ability to grow according to their actual situation.

The breeders of Group 3 (multi-active breeders) are possibly the most secure in the medium term. Thanks to the income diversification, they continue to exercise their breeding activities. Thus, it allows them to maintain the system against climatic disturbances. The objective is to occupy both a spatially and socially place in the long term because they do not have local power and do not know well the land structure of the rangelands. Therefore, land dynamics have confirmed inequalities playing against them. Consequently, in an uninviting context, the resumption of operations is sometimes compromised. However, in the short term, this system should persist thanks to its efficiency, despite its small production means.

Finally, group 4 (mixed cereal-livestock system) is a very interesting example in the study area as long as it is more widespread. This system generally practiced by breeders living in the nearest cities to the rangelands, benefiting from cereal crop by the exploitation of stubble in summer. During rainfall seasons, they migrate to rangelands. Then, they oscillate between the habitat area in the village, and the rangeland area to minimize their costs in order to sustain their herds. We must therefore consider that heads held by this production system will be probably increasing. Ounalli et al. (2019) have also proven the importance of the cereals system as a means of subsistence in these arid regions.

The cross-sectional analysis confirmed the profitability of the livestock activity on these rangelands and proving its role in rural sustainability, although it remains a traditional activity in a natural context characterized by climatic disturbances.

4. Conclusion

Livestock activity is regarded as a store of wealth easily mobilized for rural population in rangeland areas of southern Tunisia, where we identified four types of livestock systems. Indeed, the sedentary system persists on the rangelands. While the mixed cereal-livestock system is the most widespread followed by agropastoral system, which explains the extension of olive tree on rangeland areas. Thus, the breeders oscillate between breeding, agriculture and other economic sectors. The study also reveals the development of bipolar systems, strongly linked to the city. Thus, semi-urban breeders leave the rangelands during the hardest periods to reside in the city. Certainly, the most agile breeders are more profitable. If many breeders success to keep their farming system at short-term, it would be necessary to assess their long-term viability. It is therefore necessary to identify and assess the main factors of the strategies adopted by the breeder in order to consolidate their adaptive capacity and avoid the disillusionment of tracing models that have proven themselves in different environments.

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