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# An empirical approach of past and present mobility management in the desert societies of camel breeders in South Eastern Morocco

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ABSTRACT

Nomad, semi-nomad and transhumant used to be the most frequent mobility types of pastoral society. Nowadays, these categories become questionable in regard to the evolution of the pattern life of families in southern Morocco. How do we link past and present mobility? What have been the changes? In this article, we question the relevance of the aforementioned categories of mobility, as defined by the actors of scientific research and development, to analyze and classify pastoral mobility management that condition the way of life and the adaptive capacities of Saharan societies, by mobilizing different corpus such as 'récit de vie' and typology. This study was conducted downstream in the Drâa Valley (Morocco). If the majority of breeders claim to be nomads as soon as they practice a pattern of living in a tent over the course of a year, the typology of mobility pattern reveals intra- and inter-annual fluctuations of its management embedded in their adaptive strategies to climate variability or economic constraints which makes difficult to classify breeders according to the mobility only. In this context, developing climate change mitigation interventions for pastoral societies need to understand and integrate the permanent changing pattern of mobility management in these pastoral societies.

## 1. Introduction

Nomad, semi-nomad, and transhumant livestock systems were once the most powerful and well-identified systems, as described from all over the world, such as in sub-Saharan countries (Boutrais, 1994; Moritz, 2005; Santoir, 1994), North Africa (Bourbouze, 2000; Cole, 1975) and Asia (Bacon, 1954; Fernandez-Gimenez, 2002). This kind of classification allowed differentiating among various types of livestock management based on herd mobility and feeding system throughout the year, which were implied and embedded in a way of life in terms of habitats, social interaction, and organization. Nomad mainly refers to a way of life of a people who move cyclically or periodically; this way of life is characterized by an ephemeral habitat (tent) and associated with pastoralism and caravan activity (CNRTL, 2012; Gagnol, 2011; Larousse, 2017). Semi-nomadic systems, on the other hand, practice seasonal or periodic moves in a similar way, but involve some form of shifting crops. The third system - transhumance - is a type of pastoralism that implies the seasonal movement of people and their herd. This type of mobility is practiced all over the world in mountainous regions or where the pastureland is too cold or too dry such that it can only be used for one season in the year. In mountainous regions, vertical transhumance with seasonal movements, between higher pastures in summer and lower valleys in winter, has frequently been reported (Akasbi et al., 2012; Pardini and Nori, 2011). Generally, this seasonal move for grazing is associated with cycles of females' mating and/or fattening of the young animals. By extension, this type of mobility was also described as semi-transhumant herding, involving cropping alternatively or synchronically with herding, with part of the herd not moving. For the transhumant or semi-transhumant, family economy is based on a combination of crop cultivation and breeding; the herders have a sedentary home where their wives and children live.

In North Africa, nomadism has undergone a major transition induced by the decline of caravan activities and sedentarization policies that began during the colonization era (up to the 1950s) and continued after independence in the latter half of the 20th century (Abaab et al., 2002; Alary and El Mourid, 2005; Nordblom et al., 1997; Sandron, 1998). The primary reasons (formal reasons) of implementing these policies stemmed from the ideas of rural modernization and educating of children, as

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pastoral practices were considered backward (Davies, 2005). However, the undeclared reasons for these policies included the need to control remote regions that could hamper socio-political stability and that practiced uncontrolled trade and smuggling (trading/smuggling weapons, various illicit goods, such as drugs, and even live animals). Furthermore, the transition to sedentarization can be attributed to conflict and insecurity in pastoral zones, which were followed by the dramatic droughts of 1969–1973 and 1983–1984 (Bourgeot, 1994; Gallais, 1977) and the incapacities of herders to defend their mode of land use faced to urban elites or land speculators favoring private property. Moreover, during the first decades after World War II, societies all around the world were marked by the technical modernization of agriculture and the dominant worry over food security and, thus, mobile livestock systems, especially nomadism, came to be considered as 'archaic' and 'ancestral' and a non-productive way of life. At the opposite, as described in Dyson-Hidson and Dyson-Hidson (1980), we can find an ancient and persisting 'romantic' representation of such pastoral societies, in which nomads were viewed as 'brave,' 'independent,' and 'freely moving' in the absence of civilizing living constraints. This anthropologic representation is conveyed and reported by the European travelers all along the 19th century and even before around the myth of the Bedouin (Pouillon, 2017).

A paradigm shift occurred in the 1980s, mainly arising from the perspectives of agronomy and social geography. In agronomy, many authors have highlighted an important level of adaptation of these systems based on herd mobility to manage the inter- and intra-annual climatic variability of feed resources in harsh environments, characterized by extreme temperatures, rugged relief with an irregular supply or absence of water (Balent, 1987; Balent and Gibon, 1992; Gibon et al., 1999; Nardone et al., 2000; Toutain et al., 2012). Local breeds used in these systems also presented a remarkable level of adaptation to a periodic lack of nutrients and water (Hoffman, 2008). Thus, from this perspective, mobility was explained according to herd characteristics (species, herd size), topography (that dictated the physical effort), and spatial heterogeneity with respect to seasonal water availability (which explained the seasonal and inter-annual change of location). From a geography perspective, pastoralism is viewed as a social system that constitutes an original form of exploitation of the environment and occupation of space (Retaillé, 2003, p.88), as demonstrated, for instance, for the Fulbé society (Boutrais, 1994), the Touaregs and Maures (Retaillé, 2003), and the Wodaabé in Niger (Bonfiglioli, 1990).

Since the 2000s, more attention has been given to the diversity of livestock management practiced by pastoralists in harsh environments in relation to their livelihoods and their responses to climate change (Thornton et al., 2009) and, to a lesser extent, to social changes. From this perspective, by enlarging the spatiotemporal dimensions of access to potential resources, mobility is considered to be a flexible and long-term adaptation to climate variability (Turner, 1999; Turner et al., 2014). The majority of these studies have focused on the geographical patterns of herd mobility in relation to the social and economic opportunities and constraints of a pastoral environment (Adriansen, 2008; McCarthy and Di Gregorio, 2007; Thébaud and Batterbury, 2001). In link with the adaptive mechanisms and livelihoods, some researchers have adopted an integrated approach based on the resilience of the pastoral ecosystems due to social and ecological interactions (Berkes and Folke, 1998; Berkes et al., 2003). This has led to more attention being paid to the mechanisms of adaptation of social systems (such as family, tribes, and local institutions) to learn and adapt in response to disturbances (Folke et al., 2005). This can be related to the most ancient research thinking of Ostrom (1990) who has shown how local small-scale management can be more efficient than top-down solutions on common lands. However, such studies fail to combine an analysis of the transformation of these systems with the local perception that condition the existing transformation. Socio-anthropological research provides new insights related to this transformation in terms of identity and culture. For instance, Gagnol (2006) highlighted the cultural and cognitive dimensions in pastoral society and showed how ancient nomadic societies continue to understand themselves as nomadic by analogy and tautology. Notably, he showed how local people can metamorphose the semantic of specific terms related to past practices to fit their present system. This approach allows understanding how nomadism continues to not only fascinate researchers but also the herder society itself. Then, how do the traditional models of mobility remain pertinent for studies on the current adaptive capacity of pastoral society in harsh environments?

This article aims to address this question by conducting an empirical study in three communes, downstream the Drâa Valley (Morocco), focusing on Saharan societies based on dromedaries,[1] called camels here, which possess several attributes to adapt to desert and arid environments in the southern regions of North Africa (as shown by Faye, 2016). However, whereas the biological attributes have been widely studied, fewer studies have addressed the whole-family farm systems that are based on camel breeding and mobility management (Jenipher Biira Salamula et al., 2017; Sandron, 1998; Watson et al., 2016). Moreover, whereas climate variations have been widely explored in an effort to understand spatial and temporal mobility (Füssel and Klein, 2006), other topics such as global change related to social and societal change have been rarely explored in marginal areas, such as Southern Morocco where tribal power and rules are always active. Thus, in this article, we define mobility patterns as they are practiced and we question the relevance of these categories of mobility, as defined by the actors of scientific research and development, to analyze a pastoral society, as mobility management conditions their future development options. We are also interested in observing how camel breeders define themselves and perceive pastoral livestock systems. For this purpose, we analyze the changes in mobility pathways among two generations of breeders by mobilizing different corpus such as 'recit de vie', typology and their perceptions. This allows us to discuss the terms 'nomad' or 'transhumant' and their pertinence faced to recent social and environmental changes.

## 2. Materials and methods

### 2.1. Study site

Nomadic camel herding was once an important economic activity in the Saharan zone of the Southern High Atlas in Morocco and was entirely associated with the golden age of the oasis in the pre-Saharan southeastern region from the 12th to 14th centuries, based on caravan trade. Indeed, with its capacity to travel long distances without stopping for water, this animal allowed goods to be traded between sub-Saharan African areas to North Africa up to the beginning of the 20th century. During the middle of the 20th century, government policies and desert warfare, conducive for effective political control of cities over the desert, multiple year droughts, and other extenuating factors, such as a decline in the economic values of desert products (especially livestock and caravan trade), caused a large decline in this kind of economy. As a result, palm trees, based on an intercropping system with wheat, barley or alfalfa in association with ruminants (sheep, goats or even cattle), have become the main agricultural resources in the oasis, and camel breeding has been relegated to their harshest fringes where the arid environment as well as limited water for irrigation combined to soil salinity hinder date palm tree cultivation (Faye et al., 2017).

This study was conducted in three communes, downstream the Drâa Valley (Fig. 1), namely M'hamid El Ghizlane, Tagounite, and Ktawa. The populations here mainly survive on agriculture (mainly date palms), camel breeding, and small ruminants (sheep and goats). These three

[1] The dromedary, also called Arabian camel (*Camelus dromedarius*), is one of the dominant camel species inhabiting the arid zones from the Arabia peninsula to North Africa (including Saharan Desert). However, here, we used the terms of camels, as an umbrella term commonly used in the region.

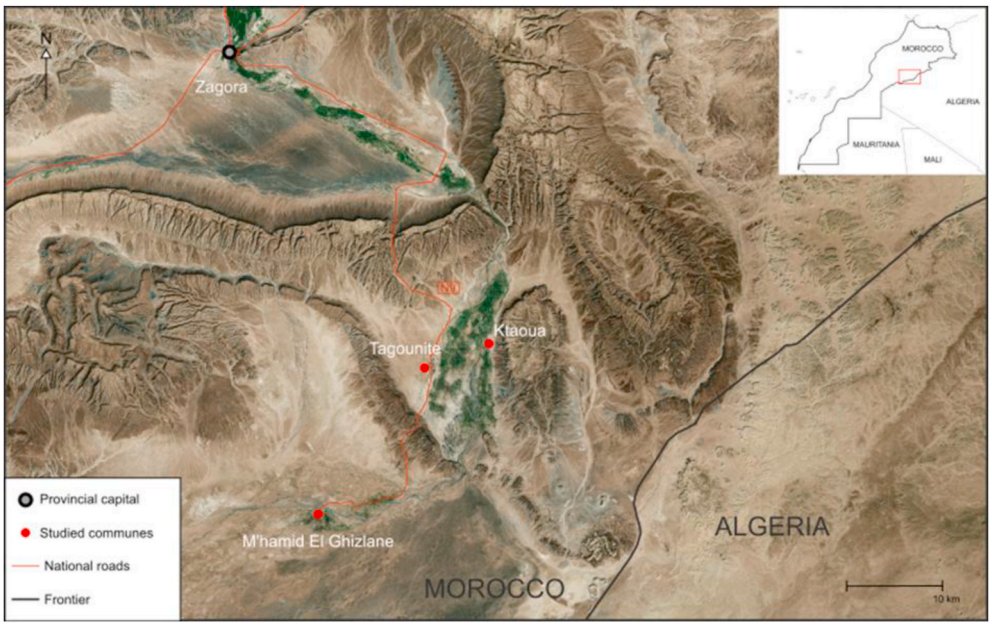


**Fig. 1.** Geographical location of the three studied communes along the Drâa Valley in the South Eastern Morocco.

communes are inhabited by the Draoua, the descendants of sub-Saharan African slaves,[2] as well as Arab and Berber tribes. The main tribes who practice pastoral management of their herds include the Aït Ounzar (means 'people of the rain' when literally translated in Berber), who speak the Tamazight, the local dialect, and are mainly located in Tagounite and Ktawa, and the Aribs who speak Arabic and are mainly located in M'hamid El Guizlane (Casciarri, 2006). The Draoua, comprising mainly cultivators, are present in the whole area and are employed as occasional workers (called '*khammes*', meaning the fifth[3]) by the Arib and Aït Ounzar. These three main major social and ethnic groups have developed various entrustment arrangements for the grazing management of livestock and agricultural lands, as a function of their past status (slaves, land cultivators or nomads), which impact their way of life.

In the studied region, the climatic conditions are mainly arid with an annual average rainfall of less than 150 mm (Fig. 2). Moreover, rainfall in this region is highly irregular, mainly falling from November to March, making agricultural activities highly vulnerable. The temperatures here are extreme, with the mean maximum temperature reaching 43.6 °C in summer and minimum temperatures of approximately 3.3 °C (Zagora station). The vegetation comprises xerophytes and grasses, which are scattered among the stony surfaces of the plateau (*hamada* landscape) and the sandy plains (*erg*) of the desert. In the oases, date palms, associated with staple crops such as cereal grains (barley and soft wheat) and fodder crops (mainly Lucerne -*Medicago sativa*-), are almost the only possible outputs for subsistence purposes. In the study area, the yield of palm trees is very low due to the lack of water and soil salinity. Therefore, the oases' inhabitants have always relied on migration as a vital source of additional incomes, which is important to fulfill the needs of their livelihoods, as they also allow financing new agricultural practices (Rignall, 2016).

Between April and July 2017, in partnership with the local agricultural development agency (the *Office Régional de Mise en Valeur Agricole de Ouarzazate* - ORMVAO -) and technicians from the veterinary administration, a group of camel herders was surveyed to assess the mobility management changes in link with the family farm systems. A total of 41 camel herders were interviewed. Table 1 shows the socio-geographical distribution of the sample.

Additionally, two workshops with a group of herders and representatives were organized in July 2017 to assess the similarities between the observed realities with respect to the perceptions of camel herders regarding the different models of mobility management. These workshops comprised two parts: a general discussion about the categories of mobility management we identified and then about the perception of the future of each mobility pattern in relation to global change, adaptation, and representation based on a shared landscape of the mobility type.

### 2.2. Methods

The field investigation aimed to provide a database for approaching mobility management changes in camel breeding systems in the three studied communes and to relate these changes to the diversity of family farming systems. Individual interviews were conducted in two parts. Firstly, we achieved an open interview with the head of family who recounted us about the changes in herd mobility from the previous generation to the present. This retrospective approach to the changes in camel herd management between generations and in the activity system was led on the basis of narrative approaches. The only guided questions aimed at addressing the places and roles of each activity over two generations (camel, sheep and goats, land use and off-farm jobs). Secondly, we used a semi-structured questionnaire to collect qualitative and quantitative information on the following: *i*) family composition, land tenure cropping system, and specific composition of the herd; *ii*) herd mobility management over the last year (location, herd composition, who decides, who moves, vegetation type and its appreciation, and changes with regard to the previous years); *iii*) a comprehensive description of feeding and management practices for camel health; and *iv*) the qualitative approach to changes in mobility in relation to various factors, such as the institutional and organizational system, communication factors (mobile phone, motorized transport), means of adding value to livestock activities and products (milk, meat, or renting camels for tourism purposes), and family changes.

The retrospective analysis of the changes made it possible to

[2] They were freed in 1932, the date of abolition of slavery in Morocco (Jacques-Meunié, 1973).

[3] This term refers to the terms of crop sharing that are used as compensation. 'Even the ancient division of wealth of the founding pact (one-fourth to nomads and three-fourths to farmers) is still considered as valid' (Casciarri, 2006, p.403).

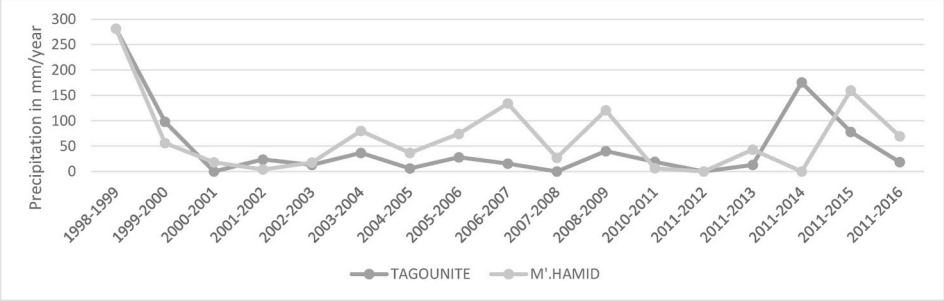


**Fig. 2.** Annual rainfall in the study areas, Tagounite and M'hamid El Guizlane, 1998 to 2016 (source: ORMVAO).

**Table 1**
Sociogeographical distribution of the study sample by commune and social group (faction of the tribe) in the South Eastern Morocco.

| Faction | M'hamid el Ghizlane | Ktawa | Tagounite | Total |
|---|---|---|---|---|
| **Aarib** | 17 | | | 17 |
| **AïtOunzar** | 1 | 5 | 13 | 19 |
| **AïtKhabache** | 2 | | | 2 |
| **AïtIssefoul** | | | 1 | 1 |
| **Aït Atta** | 1 | | | 1 |
| **Lakrazba** | 1 | | | 1 |
| **Total** | 22 | 5 | 14 | 41 |

highlight the main factors of evolutions over the last few decades and discuss the expected trajectories of these systems with the breeders. The cross-analysis of the endowments and systems of activities of the pastoralists with mobility made it possible to characterize the diversity of farming systems in the area. To analyze the diversity of the camel systems, we conducted a multiple correspondence analysis (MCA) using XLSTAT. The MCA is a factorial analysis, which makes it possible to analyze the distances or proximities of individuals (here, family farms) according to a set of qualitative variables (Escofier and Pagès, 1994). This method has already been used in many research fields to get an overall understanding of the diversity of systems (e.g., in Tittonell et al., 2010; Köbrich et al., 2003; Alary et al., 2016). One of the main advantages of this method is that it allows combining a large set of data. Here, we integrated 40 variables related to the following: *i*) the story of the head of the household; *ii*) the family composition and schooled children; *iii*) the herd composition at the start of the activity and today; *iv*) the cultivated land area and the agricultural activities around the palm grove; *v)* the seasonal management of supplementary feed for animals; *vi)* the performance indicators of dromedaries and live animals, as well as milk marketing; and *vii)* other activities. We further added 24 supplemental variables to describe mobility (Table 2). Quantitative variables (such as household size, land and crop areas, number of animals, etc.) were previously coded into classes. On the basis of this factor analysis, we proceeded to conduct a cluster analysis (Ward's method) to identify the different types of family camel systems (Kaufman et al., 2009). This method allowed to group the closest farms into clusters by minimizing intra-cluster variance and maximizing the variance between clusters.

## 3. Results

### 3.1. Retrospective analysis of change

A preliminary descriptive analysis of the factors relating to change shows that breeders highlighted the impact of the annual level of rainfall on the evolution of camel activities (Table 3). This factor explains almost 50% of the evolution of the systems in the study area. Family events, such as weddings, death or the purchase of a house, ranked second and third, while closure of the border with neighboring Algeria was only ranked tenth.

**Table 2**
List of active (from theme i to vii) and supplementary (viii to xiv) variables for the factorial analysis to identify the camel systems in South Morrocco

| Theme | Variables |
|---|---|
| (i) Story of the head of the family | When did you start the camel activities? On what occasion?<br>Since when have you been the head of the family? On what occasion? |
| (ii) Composition of the family | Number of dependents; number of children in school |
| (iii) Herd structure | Camel stock at the start, and in 2017; structure of the camel stock (by physiological stage) in 2017; sheep stock at the start, and in 2017; goat stock at the start, and in 2017 |
| (iv) Land and crops | Area under ownerships (ha); cultivated area (ha); owned palm trees (number); |
| (v) Supplementation | Practices of supplementation, by season |
| (vi) Performance and transactions of camels | Period of lactation (month); dairy production at the peak period (l/day); interval of parturition (months); sale of camels inthe three-year period 2014–2017 (number, reasons); purchase of camels inthe three-years period 2014–2017 (number, reasons) |
| (vii) Other activities | Military; local representative; tourism; camel keeper; trade |
| (viii) Commune and tribal faction | Commune; tribal faction |
| (ix) Distance to pastureland | Radius of herd mobility (maximum and mean) |
| (x) Mobility management | Keeping in turns or renting of a keeper; individual or collective moves; who decides? |
| (xi) Quality of pastureland | Good, medium or poor |
| (xii) Problems of mobility | Theft of animals; authority; breeder/farmer conflicts |
| (xiii) Future | Mobility (yes/no); mobility based on rain (yes/no); mobility by lack of choice (yes/no); mobility of proximity (yes/no); mobility by attachment (yes/no) |
| (xiv) Perception | How do you describe yourself? (nomad; sedentary; other) |

A retrospective analysis of the practices of mobility by the previous generation and in 2017 by the herder in charge of the camel herd clearly indicated a decline in the nomadic way of life (where the household lives all year round under a tent) in the studied area, except in Ktawa (Table 4). This change is most significant in M'hamid El Ghizlane where all breeders live nowadays in a fixed house in the village for most of the time.[4] According to the herders who were interviewed, nearly 15 breeders always live under a tent in the commune with all their family

[4] The possession of a house in the village is not a new phenomenon for the camel pastoralists of M'hamid El Ghizlane and Tagounite, as revealed in the work of Spillmann (1936) who stated that 'even pastors, own a *qsar*, a *tirhremt* or a house [ …].These fixed dwellings served as a "home port" for nomads'(p.63). The main difference lies in the fact that it is now the main habitat for the whole family.

**Table 3**
Factors affecting change in camel rearing systems since the 1960s in the M'hamid El Ghizlane and Tagounite communes (survey of 41 breeders; number of events (n = 371) that affected mobility among the interviewees).

| Type of event according to breeder | Before 1975 | 1975 to 1990 | 1990 to 2005 | 2005 to 2017 | Total over the period |
|---|---|---|---|---|---|
| **Total events** | 32 | 50 | 106 | 180 | 371 |
| **Bad climatic year** | 2 | 11 | 27 | 45 | 87 |
| **Good climatic year** | 3 | 15 | 28 | 38 | 84 |
| **Family events (marriage, death)** | 7 | 6 | 12 | 6 | 31 |
| **House purchase** | 0 | 3 | 12 | 11 | 26 |
| **New activity** | 0 | 4 | 11 | 9 | 24 |
| **Loss/theft of dromedaries** | 1 | 2 | 6 | 10 | 19 |
| **Cultivation of collective land** | 0 | 1 | 1 | 14 | 16 |
| **Purchase of camels** | 2 | 1 | 1 | 11 | 15 |
| **Purchase of car** | 0 | 0 | 1 | 12 | 13 |
| **Closure of Algeria–Morocco border** | 11 | 0 | 0 | 0 | 11 |
| **Exceptional events** | 0 | 2 | 1 | 6 | 9 |
| **Dam** | 5 | 1 | 0 | 0 | 6 |
| **Purchase of sheep and goats** | 0 | 1 | 1 | 3 | 5 |
| **Other** | 0 | 1 | 1 | 3 | 5 |
| **Good touristic year** | 0 | 1 | 1 | 3 | 5 |
| **Bad touristic year** | 0 | 0 | 0 | 4 | 4 |
| **Matriculation and departure of children** | 1 | 1 | 0 | 1 | 4 |
| **Abandoning of activity** | 0 | 0 | 1 | 2 | 3 |

**Table 4**
Descriptive analysis of father's and interviewee's mobility practices (in %) (41 breeders).

| By commune | M'hamid El Ghizlane | | Ktawa | | Tagounite | |
|---|---|---|---|---|---|---|
| Sample | 22 | | 5 | | 14 | |
| Who | Father | Son | Father | Son | Father | Son |
| Moves across border | 27 | 0 | 80 | 0 | 62 | 0 |
| Lives under tent | 68 | 0 | 100 | 80 | 85 | 46 |
| Rents a keeper | 36 | 45 | 40 | 0 | 8 | 15 |
| Owns a fixed house | 50 | 100 | 20 | 20 | 38 | 54 |
| Practices 'azib' | 41 | 36 | 100 | 20 | 77 | 31 |

members (wife and children). The practice of *azib* has also witnessed a large decline. This is a type of seasonal mobility where the breeder moves around alone with his herd (without his family) and lives in a temporary shelter in the desert built with wooden branches and denim. In this situation, men in charge of several herds often engage in communal cooking and usually share the burden of keeping the animals.

### 3.2. Farming types and herd mobility management

The diversity of herd mobility management systems in the zone is represented in Fig. 3. The horizontal axis (1) of the factorial plan differentiates systems according to the mode of adding value to camel products, in particular, between the traditional herders, oriented to the sale of live animals to cover the annual or exceptional needs of the family, and the new breeders, oriented towards touristic activities (Type 1). This touristic orientation partly influences the structure and management of the herds. The vertical axis (2) (Fig. 3) differentiates the 'traditional' systems, according to two modes of herd management related to the history of the family. It distinguishes, in particular, the breeders who inherited their flock and practice a nomadic life (under a tent with their family) in the rangelands around the neighborhood of the commune (Type 2) from the breeders who practice seasonal mobility without their family (Types 3 and 4). This vertical axis also differentiates farmers according to their access to cultivated land, especially the land in ownership, called 'Melk', and the number of palm trees they exploit. These first two axes of the MCA explain 43.9% of the variability in the sample. The main variables characterizing mobility patterns by breeder type are reported in Table 5.

The system oriented toward tourism (Type 1) was developed around the small town of M'hamid El Ghizlane, which is surrounded by dunes that have attracted tourists since the early 1980s. This type includes young breeders who received family autonomy in the 1990s and started breeding camels either using a small inheritance or by acquiring few males. The families of such breeders consist of six persons on average, and their herd doesn't exceed 10 camels—all of them males, as no reproduction is needed—but also includes a flock of approximately 70 goats. Furthermore, they possess 4 ha of cultivated area in Melk (privately owned) with a cropping system based on fodder, such as barley and lucerne, for the animals, and a palm plantation with around 40 trees. In this type, herd mobility is limited to the summer season (May to September) under the 'azib' model and within a reasonable radius of the village due to the hot temperatures and reduced natural vegetation. In the touristic period, from October to April, the animals are kept in pens around the fixed residence for tourism purposes.

By contrast, the three remaining systems (Types 2, 3, and 4) are oriented toward live animal sales to cover the needs of the breeder's family. Type 2 essentially comprised breeders from the Aït Ounzar tribe, belonging to the Tagounite and Ktawa communes. These breeders started possessing camels at the end of the 1970s with their fathers, gaining their autonomy in the early 1980s, usually after the death of the father. Starting with a herd with an average of 16 camels and more than 135 small ruminants, they possess currently around 17 camels and 110 to 115 small ruminants (either sheep or goats, but with a majority of goats, as this species is more adapted to harsh conditions). This indicates a relative stability in herd size over the last four decades. These herders cultivate less than 1.8 ha of land and possess almost 50 palm trees, on average, not necessarily on their own land. The main characteristic of this system is its pattern of living that entails staying 'under a tent' with the entire family although herd mobility is restricted around this tent, which remains fixed all year long. Almost 83% of the herders in type 2 declared they have access to good pastureland and, thus, wished to maintain this system, and 75% of them consider themselves to be 'nomads', even when their tent remains at a fixed location.

The third type brings together the largest number of breeders in our sample. These breeders belonged to both the M'hamid El Ghizlane and Tagounite communes. They started their own activities in the early 1990s following an inheritance or a donation, often in connection with marriage. The herd comprised around 41 camels and 30 goats at the beginning. In 2017, their flocks nearly had 54 camels and 52 small ruminants. They own nearly 6 ha of cultivated land in Melk and possess an average of 130 palm trees. The dairy performance was approximately 3.5 liters per day per she-camel during peak production; this value was the highest in the study sample although milk remains used for home-consumption purposes. The sale and purchase of camels amounted to around two to three per year over the past three years (2014–2016). These herders practice different types of mobility: short (50 km radius), medium (between 50 and 200 km), and long (more than 1000 km from the dwelling place). Mobility distance depends on rainfall levels, covering an average of 370 km a year; however, 75% of the herders who practice long-distance (more than 300 km) mobility belong to this type. More than two-thirds of the breeders follow their herds in transhumance, which is led collectively with relatives (son, brother, cousin) or by a hired shepherd, but without the family, i.e. wives and children. The main declared problem of this type is the theft of animals. It should be noted 81% of them wanted to maintain mobility due to the lack of alternatives, and 25% of them underlined their attachment to this lifestyle. Even if their mobility is more seasonal, 69% consider themselves

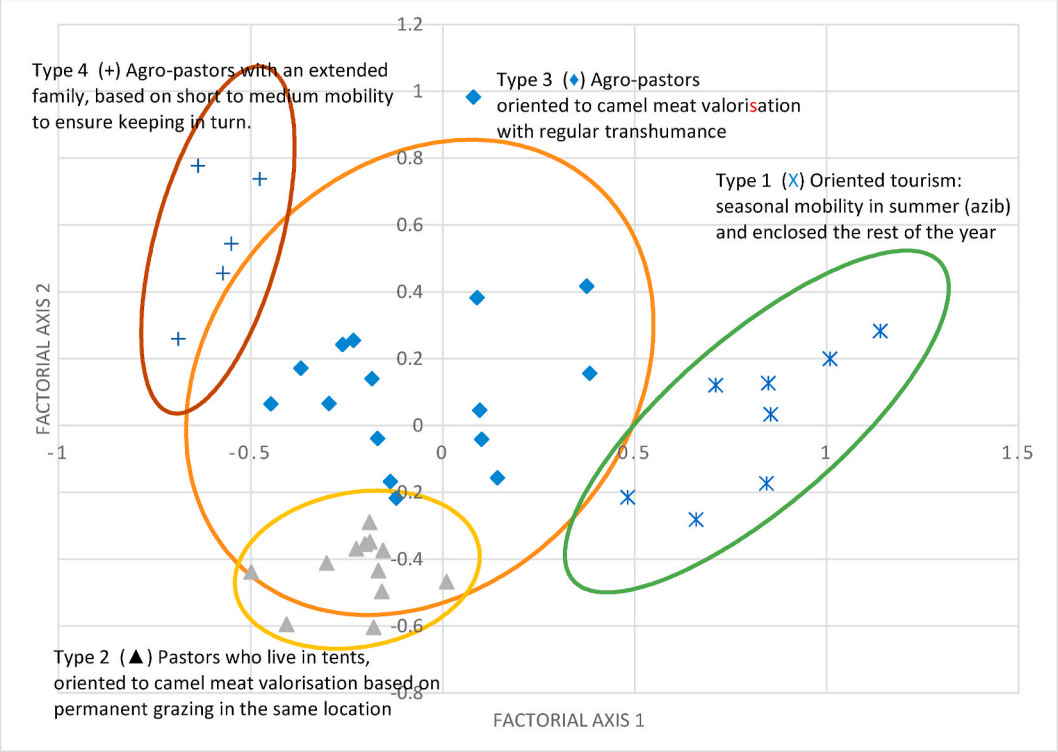


**Fig. 3.** Cluster analysis and representation of four types of camel breeders (n = 41 breeders) in the South Eastern Morocco.

**Table 5**
Descriptive data of the farm types (average/type)in the South Eastern Morocco (with an intra-class variability of 23.5%).

| Classe_4 | Type 2 | Type 3 | Type 4 | Type 1 |
|---|---|---|---|---|
| **Commune** | Tagounite/Ktawa | Mhamid El Ghizlane/Tagounite | M'hamid El Ghizlane/ Tagounite | M'hamid El Ghizlane |
| **Tribe** | Ait Ounzar | Aarib/Ait Ounzar | Aarib/Ait Ounzar | Aarib |
| **Type** | Camel system under tent | Transhumant camel system oriented to meat | Dependant camel system | Camel system oriented to tourism |
| No./class | 12 | 16 | 5 | 8 |
| Date of leadership of the farm | 1981 | 1990 | – | 1994 |
| Event linked to the start of farm management | Death of the father | Death or separation of the father | Father too old | Death or separation of the father |
| Ownerships of camels | Inheritance | Inheritance//Donation | Dependant/donations | Purchase |
| Date of starting of the camel activity | 1978 | 1992 | 2007 | 1990 |
| Family size (no. members) | 9 | 7 | 10 | 6 |
| Schooled children (No.) | 2 | 2 | 3 | 1 |
| No. camel at the starting date | 16 | 41 | 44 | 13 |
| No. sheep and goat at the starting date | 122 | 27 | 92 | 25 |
| Adult camels 2017 (heads) | 13 | 43 | 37 | 7 |
| Young camels 2017 (heads) | 4 | 11 | 15 | 1 |
| Goat 2017 (heads) | 97 | 46 | 19 | 70 |
| Sheep 2017 (heads) | 15 | 6 | 12 | 2 |
| Melk area (ha) | 1.8 | 6.0 | 6.0[a] | 4.0 |
| Cultivated area (ha) | 1.5 | 2.4 | 1.8[a] | 5.0 |
| Palms (no. trees) | 51 | 133 | 72[a] | 41 |
| Lactation duration (months) | 8.4 | 9.5 | 9.3 | |
| Maximum milk yield (liter/sh-camel/day) | 2.8 | 3.5 | 3.4 | |
| Interval parturition (months) | 1.4 | 1.8 | 1.9 | |
| No. of sold camels 2014–2017 | 4 | 7 | 13 | 2 |
| No. of purchased camels 2014–2017 | 1 | 6 | 2 | 2 |
| Feed complementation | | | | |
| Dates (kg/day) | 1.2 | 0.7 | 0.7 | 1.7 |
| Barley grain (kg/day) | 1.3 | 0.5 | 0.5 | 0.8 |
| Lucerne(kg/day) | 0.0 | 0.1 | 0.0 | 0.8 |

[a] Excluded one breeder who owned more than one thousand palm trees on 28 ha of land in Melk.

to be nomads due to the structural component of mobility in camel management. However, according to the common categorization of mobility management, this type corresponds better to the 'transhumant' model.

The last type (Type 4) can be considered as a subgroup of Type 3. In this group, the majority of interviewees manage their fathers' herds; a

few received camels as donations, but these remain in the fathers' herds. With an average of 44 camels and 92 goats between 2005 and 2010, the herds had around 52 camels and 41 small ruminants in 2017. In the past, mobility involved women and children, where the women kept sheep and goats on the rangelands. Flock reduction resulted from the installation of women and children in the village for schooling purposes with limited opportunities to access the rangelands. These farms cover an average of 6 ha of land (1.8 ha of which were cultivated for 80% of farmers in this type). They also possess around 72 palm trees, apart from one farmer who owns 28 ha in Melk and more than 1000 palms. The performances of their camel herd are comparable to that of Type 3, with 9.3 months of lactation and peak production of 3–4 L/day. It should be noted that 80% of these breeders practice short and medium mobility, mainly to reduce the cost of shepherd. A significant difference between types 3 and 4 is noted with regard to the renewal of the herd, at a time where Type 4 sells an average of four animals per one purchased per year, Type 3 registers a higher number of purchases per sold animals.

Therefore, classifying the camel systems reveals intrinsic links between the system itself and the practice of mobility (as described in Table 6). In summary, types 1and 2 are defined by their mode of mobility management: Type 2 with limited mobility, but a permanent way of life under a tent in the zones of Tagounite and Ktawa, and Type 1 with limited (in time) mobility (3–4 months) on nearby pasturelands and 'bivouac' for touristic activities. In fact, bivouac could correspond to the modern version of the way of living in a tent with 'standardized' comfort (access to water and electricity), stimulated by leisure or touristic activities and not the research of natural resources for the herd. Type 4, with large families composed of the father and his adult sons or several brothers and their families, is oriented toward short-to medium-distance mobility from the village of residence. This can be explained by the fact that mobility is costly and, in this type, herd-keeping is provided by family members (brothers, sons, grandchildren) who alternatively keep the camels. If we pay attention to the various practices related to mobility management in this type (with/without keeper, individual or collective decisions, etc.), we find that all of them consider mobility to be a way of reducing camel feeding costs. Finally, Type 3 comprises the majority of farmers who practice long mobility (75% of long mobility is represented by this group); however, this long mobility is practiced by only 38% of this type, with the rest of the herders practicing various types of mobility at short and medium distances in relation to family constraints and/or the weather conditions of the year. In fact, one recurrent reason regarding the mobility management -that emerged from the interviews-is strong pressure from women and children to stay in the village, which profoundly affected the family lifestyle that characterized these systems up to the 1990s. Decisions related to the path of mobility depend on two main parameters - marketable valorization of live animals, especially in Guelmin or Tan-Tan (far by almost 1000 km in the South West of the country) -, or weather conditions that lead farmers to adapt and change their mobility every year. Moreover, distant mobility is expensive, and this further influences the final decision.

### 3.3. Functional links between family and mobility management systems

From the intrinsic links between family farm systems and mobility management, several questions emerge. Understanding the current dynamics required obtaining the view and perceptions of camel herders about their system and their future. For that, two participatory workshops were organized in the study area: one in Tagounite (with breeders from Ktawa) and the second in M'hamid El Ghizlane. These workshops were held in a two-stage process: a presentation and discussion around the types of camel husbandry systems and the expected future for different systems to define the new characteristics of mobility.

#### 3.3.1. Perceptions and future of the different camel systems

In the commune of Tagounite, the camel herders considered that Type 2 -called 'khayma' (meaning, under a tent with the whole family)- practices a system that resembles the ancient nomadic way of life due to the presence of family (i.e., women and children). The main advantage of this system is that it allows the division of labor between the men and women, requiring them to respectively keep the camels and small

**Table 6**
Description of mobility characteristics and management by camel breeder type (means by type; in bold the more significant variables).

| Theme | Variable | Type 2 | Type 3 | Type 4 | Type 1 | Av. sample |
|---|---|---|---|---|---|---|
| | Breeder type | Pastoral | Agro-pastoral | Agro-pastoral (extendedfamily) | Oriented to tourism | |
| | Sample | 12 | 16 | 5 | 8 | 41 |
| Characteristics of mobility | Large mobility (>300 km) | 17% | **38%** | 0% | 0% | 20% |
| | Short or medium mobility (<300 km) | 17% | **56%** | **80%** | 25% | 41% |
| | Seasonal mobility (azib) | 0% | 0% | 0% | **63%** | 12% |
| | Living under tent | **67%** | 6% | 20% | 0% | 24% |
| | No mobility | 0% | 0% | 0% | 13% | 2% |
| | Mean distance of mobility (km) | 231 | **369** | 45 | 22 | 222 |
| | Maximum distance of mobility (km) | 1000 | 1074 | 63 | 55 | 1074 |
| Mobility management (%) | Keeper in turn within the family | 0 | 31 | **60** | 13 | 22 |
| | Rents a keeper | 17 | **38** | **40** | **38** | 32 |
| | Keeper moves with camels | 50 | **69** | **80** | 38 | 59 |
| | Individual mobility | 33 | 31 | 20 | **88** | 41 |
| | Collective mobility | 25 | **63** | 40 | 0 | 37 |
| Quality of pasture (%) | Good pastureland | **83** | **81** | 60 | 13 | 66 |
| | Medium pastureland | 42 | 50 | 40 | 63 | 49 |
| | Poor pastureland | 8 | 13 | **20** | 13 | 12 |
| Prob-lems related to mobility (%) | Problems of theft | 17 | 50 | **60** | 25 | 37 |
| | Problems with authorities | 0 | 6 | **60** | 0 | 10 |
| | Problems with crop cultivators | 8 | 6 | 0 | 13 | 7 |
| How you see mobility in the future? (%) | Wants to continue the mobility (yes/no) | **83** | **81** | **100** | 63 | 80 |
| | Mobility according to seasons | 50 | 31 | 20 | 13 | 32 |
| | Mobility by lack of alternative | 17 | **31** | 0 | 13 | 20 |
| | Mobility of proximity | 8 | 0 | 0 | **25** | 7 |
| | Mobility by tradition and attachment | 17 | 25 | 0 | 13 | 17 |
| How do you define your-self? (%) | Sedentary | 25 | 31 | 20 | 38 | 29 |
| | Nomad | **75** | **69** | **80** | 38 | 66 |
| | Backpacker | 0 | 0 | 0 | **25** | 5 |

ruminants. Mainly based on rangeland resources, this system is more efficient during drought, as it reduces feed purchases. However, according to the breeders, this model will likely disappear in the future because of the schooling of children, the health risks associated with distance from health care centers, and generational changes in lifestyle (especially the absence of kitchens for women). Another major factor that could lead to its downfall is the harsh environment, notably sandstorms. Moreover, this model is more at risk today because of the deployment of military authorities in the area in connection with border control with neighboring Algeria, which has led to the imposition of more administrative procedures, such as needing a pass and local permission. However, if this model appears as the closest to nomadic life due to the life of the entire family under a tent, then mobility is reduced to neighboring pastures. Regarding seasonal transhumant types, Type 4 will also likely disappear with family separation, induced by the departure of youngsters due to a decrease in land property and livestock. Therefore, the more stable system would be Type 3, which is oriented toward live animal marketing. However, according to the breeders, this system has several constraints, such as increasing bureaucratic procedures for mobility, with the need for regular authorizations for moving animals from the Cheikh (tribal representative to the government authorities), the veterinary service and, more recently, the Caïd (the local representative of the Ministry of Domestic Affairs). The watering of animals has also become critical in some areas because of military deployment on pastureland where breeders used to go for watering. Other development options such as dairy cooperatives are also encouraged by the administration. However, in the M'hamid El Ghizlane commune, the recent development of a camel milk collection cooperative to increase its monetary value (the milk of the cooperative is sold 1.5 euros a liter) did not appear to be promising for the breeders due to a lack of organization and limited market opportunities at local or regional level. Indeed, the milk is not stored, pasteurized or packaged, which are essential criteria for large-scale marketing. In addition, there are internal governance problems within the cooperative, resulting in conflicts between different members, often from the same family. Finally, Type 1, where mobility is driven by touristic activities, is likely to remain embedded in the commune of M'hamid El Ghizlane. This model, based on bivouac, is viewed by people as the recent model derived from the past nomadic style.

Overall, these two workshops confirmed the robustness of our results, as no other mobility patterns were distinguished, and no sound alternative to the existing systems in the zone was found. The participants of this study also insisted that Type 3 would be the most flexible system in terms of coping with the current climate change and socio-economic evolution.

#### 3.3.2. From the perception on the mobility way of life to a characterization of the mobility

From the breeders' viewpoint, mobility management results from a compromise between family expectations (generally due to the children) and the annual climatic variability. Generally, the abandonment of the *khayma* model follows the wishes of the women who prefer living in the village due to material conditions (electricity, water access, etc.) and ensuring the education of their children. This occurs when the children reach primary school age. Breeders also manage mobility according to the precipitation and available natural vegetation as well as with respect to the marketing of live animals in the region. As distance is a function of income, with longer mobility duration being expensive (when including all costs of transportation, feeding, and keeping), the mode of keeping can change every year according to the financial capacity.

Regarding their perception of the nomadic way of life, the breeders consider people who live in tents – the '*khayma*' model – to be the 'true' camel herders; the others are qualified as 'civilized' or 'modern'. For them, the drastic reduction in the *khayma* model dated from the closure of the Algeria–Morocco border in 1975. Indeed, this event has resulted in a significant reduction of pastoral territory (many of the people used to take their herds to the Algerian pastures) as well as the dislocation of the family unit, young men being enlisted in the army. For breeders in M'hamid El Ghizlane, the system closest to the *khayma* model is the touristic model comprising the traditional bivouac. However, this model would suffer the ups and downs of the geopolitical context in the Arab world as mentioned by one breeder of Type 1.

From this, we can identify three systems of mobility (provided in Table 7) in the study area. The first, the *Khayma model*, is based on short-distance mobility practiced by breeders who live in tents with their families. In this model, the tent remains fixed for many years. During the day, the breeder follows his herd on foot or motorbike which grazes a few kilometers from the tent. At night, he and/or his son gather them near the tent to avoid theft, an issue frequently reported by the breeders. Often, breeders reported moving part of the camp to find grass when the pastures near the tent became overgrazed. In this case, the main tent remains on site and the breeder, usually accompanied by a son or any other relative, builds a shelter where they settle (practice of azib) for a short period (one month maximum). The second model of mobility called *azib* corresponds to a mobility of more or less long distance (from 5 to more than 1000 km according to our sample) practiced by breeders who move alone (without their family who remain in the village). This mobility is most often managed collectively with relatives (uncle, cousin) of the same tribe in search of good rangelands. Finally, there is the no-mobility model practiced by breeders settled in the villages who let their camels wandering around the village.

## 4. Discussion

### 4.1. Permanent attachment to the nomadic model

To better understand the recent dynamics and assess how they could influence the adaptive capacity in the study area, we proposed a cross analysis between the perceptions derived from development agencies or researchers based on the definitions of the nomadic way of life and transhumance and the perceptions of the camel breeders in our study sample (derived from individual interviews and participatory workshops). It led us to produce a typology of the Drâa Valley's camel farming systems. It seems interesting here to discuss the choice we've made to use a typology in order to describe pastoral livestock systems. It may seem paradoxical to use this classification method, especially because our starting point was based on the idea that categorizing these systems leads to freezing them while their flexibility is widely

**Table 7**
Current mobility management of camels in the desert society of South Eastern Morocco.

| Models | Khayma | Azib | | No-mobility |
|---|---|---|---|---|
| Mobility | No herd mobility | Seasonal or regular mobility | Conjectural mobility | Wandering |
| Way of life | Under fixed tent with whole family | In fixed shelter (can be a tent), alone | In mobile shelter or tent | Family in village |
| Cooking | Family | Breeder | Breeder | – |
| Distance for grazing | Short | Short/ medium | Short to long distances, depends on year | Very short |
| Keeping | Family | Family breeder[a]/ keeper | Keeper/family breeder | Breeder (supervision once a day) |
| Period | All year | Seasonal (3–4 months) | Seasonal (up to 8–9 months) | All year |
| Organization | Family | Individual | Collective | Individual |

[a] In family breeder, we include reciprocation between males in the family (between father and sons or between brothers).

recognized as a key-factor of adaptation to social, environmental, economic and politic changes. Our choice is justified by the fact that creating categories of farming systems allows to make intelligible and to have a first overview of camel breeding systems and their mobility practices. But it is important to have in mind that this classification is not fixed and changes over time, depending on breeders' strategies to adapt to changes. In order to have a typology that takes into account this flexibility, we choose several variables describing mobilities, which highlights the fact that mobility strategies of camel breeders are based on several factors and this combination of factors can change from year to year, as Blanco (2015, p.116) demonstrated in his thesis: "*breeders adapt their mobility to different factors, ecological, economic, but also social or human [ …]. The weight of these different factors varies greatly from one individual to another*". It is also important to emphasize that if a breeder can change the type of mobility from one year to another depending on external (climatic conditions) and internal (financial needs, family events) factors, the three types of mobility identified in the Drâa Valley (khayma model, azib model and no-mobility model) are relatively stable insofar as they have been observed in other Saharan pastoral areas of Morocco (Blanco, op.cit).

In order to avoid falling back into nomadic/transhumant/sedentary categories to describe mobility practices, we paid particular attention to refer to the different forms of mobility as named by the breeders (*kheyma* and *azib*) and to validate with them that these forms, as we had understood and analyzed them, made sense according to their points of view. However, if the traditional categories do not seem any more operational to characterize a breeding system and its mode of management, we were surprised to see that breeders have appropriated them, in particular the nomadic category. That's how almost all breeders we've met defined themselves as "nomad", even those who live in the village throughout the year. This led to the use of interesting expressions during the interviews such as "nomad of the city" or "sedentary nomad". It is thus advisable to be more nuanced in terms of use of these categories as they make sense for people who have appropriated them. This appropriation can be interpreted as a strong attachment to the nomadic way of life (live under the tent, feeling of freedom in the desert, community living), which is a vector of identity for these societies that know deep social changes, with the modernization of living conditions (children's schooling, development of new means of transportation (4x4) and communication by mobile-phone, family separation during the war between Morocco and Algeria and the enlistment of young men in the army, disinterest of young people in camel breeding, migrations). Furthermore, we've observed during our field work that some elements of the nomadic life were brought back to the village as eating practices (consumption of camel milk, tea ceremony, barley soup), clothing practices (women continue to dress with the traditional *melhfa* while men wear the *darâa* during tribal ceremonies and the traditional turban in daily life) and social practices as weddings organized under tents set up in front of the houses. This highlights a strong attachment of breeders to the nomadic identity. In this line, it would have been interesting to conduct interviews with pastoralist women as well as children in order to capture how these changes and the attachment to nomadism and the way of life it implies are perceived.

### 4.2. Which future for the mobile breeding systems?

Interviews with herders have led us to observe that pastoral farming systems encounter a certain number of obstacles that raise the question of their future within the Draa Valley. First of all, pastoral space is shrinking. Besides, Casciarri (op.cit) who has made a study on the pastoral breeders Aït Ounzar in the same study area talks about "shrinking spaces". This process can be explained by the closure of the borders between Morocco and Algeria in 1975, which, according to the breeders, has marked the start of a difficult period for the practice of their breeding, in particular because they no longer have access to the Algerian pastures that they used to frequent for long periods. The closure of the border has also meant that the herd must be kept more closely. Indeed, the border being only about 20 km away from the grazing pastures, camels can easily cross it. When this happens, the breeder finds himself unable to recover them. This is how one of the interviewed breeders claimed to have lost around 38 heads between 1975 and 1978 on the other side of the border. Faced with the current tensions that cross all the Maghreb countries, Morocco is strengthening the control of its border areas. The Moroccan authorities have thus dug a trench before the border and added military posts. The territory under military control, referred as the "military belt" by local authorities, has an increasing spatial hold according to the breeders' perception. In their opinion, access to the pastures within this belt is subject to strict regulations: they are required to have a pass obtained from the commander of the military barracks in Tagounite village and to present their identity card once on the routes. Access to certain wells within the belt is prohibited. The territory under military control has thus expanded at the expense of the resources accessible to farmers, which is not without being a source of disagreement between the local authorities and military and breeders. In addition to this, the pastoral space is marked by the increasing spatial encroachment of agricultural land. Indeed, since 2008 and the implementation of the Green Morocco Plan (GMP), a very rapid development of agricultural areas dedicated to the cultivation of watermelon or melon has been witnessed, which is encouraged by the subsidies granted (between 80 and 100%) for drip irrigation (FAO, 2017). Then, between the agricultural campaign 2011/12 and 2015/16, the cultivated area of watermelon and melon has increased from 775 to 3200 ha (HCP, 2016). Faced with the increasing spatial hold of the military belt on the one hand and land for agricultural use on the other, breeders find themselves somehow immobilized, like one of the breeders we met who is obliged to stay on a pastoral area since 2014 because of these limits.

Secondly, the schooling of children also raises the question of the future of camel breeding in the fringes of the Drâa valley. In fact, the children's entry to school is put forward by many breeders as the cause of the sale of part or even all the herd. By the time the children are old enough to start school, the herder and his family have to move to the village and buy a house. This means selling part or all the herd, first to have a certain amount of money to be able to finance the purchase of a house, but also because the herder is no longer able to take care of his herd alone. Indeed, once the children are in school, the division of labor that prevailed when the family lived in tents ends: sons are no longer able to help the father with camel breeding while daughters no longer look after goats. The wife is forced to stay at home to care for the family members. The breeder is then unable to assume all the tasks related to camel breeding (keeping, milking, veterinary care) and finds himself in the obligation to employ a shepherd. However, due to the loss of a certain know-how (according to the herders) and the existence of new income-generating activities that are more attractive to young people in the area, as touristic activities, the herd keepers are becoming increasingly rare. Those who continue to do so take advantage of a situation that is favorable to them (increase in demand, decrease in supply) by receiving a relatively high wage (between 90 and 270 euros per month). Some breeders, unable to pay such an amount, are obliged to sell their entire herd within a few years. So, faced with the schooling of children, a question arises: what is the future of camel farming if the sons of breeders turn away from this activity? Indeed, it seems unlikely that a child who continues his schooling by going to higher education (which systematically implies a departure to the big Moroccan cities) will return to M'hamid El Ghizlane or Tagounite to take over his father's livestock farming. Camel breeding is no longer seen as an inheritance to be passed on to children, but rather as a financial capital that enables children to continue their education and eventually to enter non-agricultural occupations.

Thirdly, the attempts at diversification made by breeders through the development of tourist breeding or the marketing of camel milk seem limited. Given the social and political events that have induced instability in the Arabic countries over the last decade, tourism is declining in

Morocco, and the ongoing COVID 19 pandemic is just confirming such a trend. It is also worth noting that incomes are really limited since reproduction failures are common in camels, as well as mortality (Julien et al., 2020). Concerning the marketing of camel milk through co-operatives, it appears limited for the moment, due to a lack of means made available to breeders, a lack of knowledge of the cooperative model and of this market by breeders, who until now only considered milk as something to give and not to sell.

Finally, mobile breeding systems are perceived by the Moroccan state as archaic, responsible for the "increasingly serious degradation of rangelands" (Ministry of Agriculture and Marine Fisheries of Morocco, 2015, p.1) and a source of social conflict. This vision of mobile pastoral livestock farming has led to the implementation of a new pastoral law aimed at regulating the practice of pastoral mobility. The risk of this law is to make the practice of mobility more and more restrictive due to the implementation of procedures for breeders who wish to move their flocks to another province. In order to obtain a "pastoral transhumance authorization", they will have to give information to the regional rangeland committee such as the identity of the breeder and/or the shepherd, the overall number and by species of the animals making up the herd, the place of origin of the herd, the route followed and the place of destination (article 24). And this authorization will be valid only for 12 months. Taking into account all these elements, we can likely say that camel systems are threatened and are expected to experience a sharp reduction in arid and semi-arid zones such as the desert fringes of the Drâa valley.

### 4.3. How to go further?

However, if this first assessment about the future of the camel systems based on the mobility reveals the high vulnerability of these systems in the studied area, it appears also that understanding the development of this area requires a more integrated approach to the territory, combining some ecosystemic approaches (in terms of multi-functionalities of the natural system) with the capabilities of the people (in terms of expected goals). Méral (2012) and Pelenc (2014) proposed a territorial framework that integrates the notions of ecosystems and natural services along with the well-being of people, in terms of capabilities. In this situation, the desert ecosystem, with camels, can provide multiple services as the provider of feed and food, the preservation of biomass and biodiversity through grazing, and cultural services regarding the attachment to this patrimony most commonly mentioned by breeders. Furthermore, regarding capabilities, as defined by Sen (1999) and formalized by Nussbaum (2003), the preservation of camel activities in this zone could favor capabilities related to emotion and imagination (with respect to the attachment of people to the desert life that is a source of imagination and creativity that can be observed in the current development of music or traditional festivals) and affiliation (social life related to different patterns of mobility), commonly mentioned by interviewees. Presently, some herders in M'hamid El Ghizlane as well as in the Guelmim region in the South west of Morocco practice summer Azib with their grand-children coming from large cities such as Rabat or Casablanca. Therefore, mobility procures non-economic achievements in terms of leisure while contributing to their physical health with regard to camel products and the environment that also need to be considered.

So, thinking around sustainable development needs to consider the complexity of the ecosystem and the need to satisfy the multiple capabilities of people beyond their material conditions. Without considering their attachment to this environment and the multiple functions of the mobility as defined and agreed on by people, the development of options will comprise short-term solutions for survival only. Moreover, focusing actions on the dimension of control on their environment appears to be a primal condition. This process will benefit to the other stakeholders, such as the army and administration, by reducing social conflict, both intra or inter-territorially. Generally, following the perspective of strengthening adaptive capacity to facilitate adaptation, mobility is always a key factor in social and economic sustainability (Moritz, 2010, 2012), as it maintains the social link with the desert communities facing dry years (see Smit and Wandel, 2006; Marshall and Smajgl, 2013) as well as adds value to scarce resources and generates sources of incomes and jobs in areas where poverty is already high.

## 5. Conclusion

These first analyses highlight the changes in the herd mobility management in Saharan camel societies with respect to external factors (e.g. closure of the border with Algeria, the deployment of military in the region and the consequent control on movement, and the duration of drought events) and internal factors such as social changes (schooling of children, development of fixed residences, departure of youngsters). A cross analysis of mobility patterns widely described in the literature and anchored in the approach to development in the area with the existing mobility practices revealed both similarities and divergences for each model. In this study, we observed a permanent adjustment of the mobility considering the social and weather condition change as well as family constraints and needs that impedes the qualification of a particular camel system by its mobility' models. Breeders were seen to combine numerous models of mobility such as nomadic, semi-nomadic, transhumant, and even "sedentary nomadic". Therefore, for research or development, should a new model be thought to describe and to characterize the patterns of mobility? This article shows that we cannot define a camel system by a single type of mobility or a family by a single way of living. The proposed typology based on family farm systems with a panel of mobility could be more functional to identify the paths of development in the changing context. Moreover, we observe a significant shift of mobility organization in the time and space scales with the recent socio-ecological and political changes. Using fixed categories will give rise to ambiguities for research and development actions.

Furthermore, scholars should consider whether we need a change in our assessment of the environment and society in order to integrate new dimensions such as expectations in terms of attachment to the mobility. We also need to consider whether this will be sufficient regarding the economic viability of the system. Apparently, the economic viability is supported by other family and tribal bounds and mechanisms, which escape the scholarly analyses based only on activities and the derived income from the camels. Therefore, the analysis in terms of capabilities could introduce new insights for understanding and integrating the primary goals of herders and their families for the future in the zone.

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## CRediT authorship contribution statement

**Lina Amsidder:** Conceptualization, Methodology, Formal analysis, Investigation, resources, data curation, writing. **Véronique Alary:** Methodology, Software, Formal analysis, Writing – original draft, with, Methodology, results, Funding acquisition. **Taher Mohamed Sraïri:** Supervision, Validation, Writing – review & editing, Project administration.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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