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Social Network Analysis of the Stakeholders Involved in the Dromedary Sector in the Mediterranean Region

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Abstract: Marginal arid zones in the south Mediterranean are faced with the dramatic departure of their labor forces through migration. Interest in the capacity of the dromedary species to enhance desert ecosystems and to be a potential lever of economic development of these marginal zones only started to grow in the last two decades. Based on an empirical survey of 179 stakeholders in four Mediterranean countries, we explored the links of the stakeholders in the dromedary sector in two dimensions: horizontal links with peers and vertical links along the value chain and in resource management. Both descriptive statistics and social network analysis highlight the original organization of the dromedary sector around herders and their social and cultural organization at the territorial level. Therefore, even if milk production and processing start to constitute an opportunity for the young generation who do not necessarily have the financial capacity to invest in a large dromedary herd, this change towards milk valorization can only happen if it is linked with the traditional system based on mobility. Using a systemic approach and working toward multiple valorizations of dromedary products instead of only targeting milk productivity should be explored.

Keywords: dromedary sector; value chain; social relationships; social network analysis; Mediterranean countries

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1. Introduction

Mediterranean agricultural systems have been facing increasing pressure including population growth, urbanization, increasing demand for high-value products like animal

products and vegetables, and high competition for land and water. In this context, pressure on resources results in many challenges and sometimes competition between the trade-offs in the use of resources (land, water, and nutrients) that can affect the sustainable development of such systems. In addition, some marginal inland zones are faced with the dramatic departure of their labor force through migration leading to important social and natural changes. These changes particularly affect the arid and desert lands of southern Mediterranean countries where traditional societies used to explore and exploit vast uncultivated arid lands thanks to livestock systems based on grazing by mixed herds of dromedary camels (*Camelus Dromedarius*) (the dromedary camel is the dominant camel species inhabiting the arid and desertic zones from the Arabia peninsula to the African Saharan Desert. In the paper, we have opted for the term of camel that is commonly used in the region), sheep and goats, and mobility. These mobile systems, also called pastoral and agropastoral systems, were based on kinship links at the tribal level that made it possible to share resources in space and over time over the last centuries, as evidenced in many pastoral societies. Many research works on these mobile systems underlined the interactions between natural resource management and the socio-geopolitical systems, and the main issues of the shrinking frontiers [1–3]. However, until recently, at the national level, particularly concerning national agricultural priorities and policies, camel farming was generally perceived as an asset of secondary significance, and raising dromedaries as poorly productive. On the other hand, some studies underlined camels' ability adapt to arid environments and to make rational use of resources in these areas, along with their numerous functions, making them valuable resources in the current context of climate change and desertification [4–6]. As such, camel farming has an impact on the broad socio-economic and ecological issues in the Mediterranean basin by preserving biodiversity in the large areas of desert rangeland [7], alleviating poverty in marginal desert areas [8], for achieving a sustainable development in link with the food security in fragile systems while limiting rural exodus and migration [9–12]. All these research works point to the need to develop holistic approaches to the system at the multiple scales of space and time.

Interest in the capacity of this animal species to enhance desert ecosystems and to be a potential lever of development of these marginal zones really started to grow in the last two-three decades with increasing research focusing on the therapeutic properties of certain camel products and the increasing demand for products with low environmental impacts [13,14]. One of the oldest initiatives was the installation of a dairy processing unit *Laitière de Mauritanie* in Mauritania in the 1990s, which began to process and pasteurize camel's milk in addition to cow's milk [15]. In Morocco, small-scale dairy plants selling pasteurized camel milk have set up the beginning of a supply chain from Laâyoune to the northern part of the country in the 2000s. In Algeria, an intensive camel farm based at El-Oued recently built a small dairy plant for the local market. However, these chains are far from being regularly supplied, the main explanation being the small quantities produced by each she-camel, that do not exceed five litres per day in a good climatic year. Therefore, although the camel population is 4% of the total TLU (Tropical Livestock Unit) in the region, the share of camel milk in milk consumption is only 0.73% [16]. Most camel milk is self-consumed, given to relatives and neighbors, especially for celebrations, or sold directly to consumers through family or local direct channels with no outside control.

The national consumption of camel meat also remains low and is estimated at around 2.84 kg/inhab/year for the whole region [17,18], while traditional processing, mainly drying of camel meat, known as *loudek* or *tichtar*, is still widespread although several trials using more standard meat processing units have been held in Tunisia, for example [19]. A large private company in Morocco also promotes different camel meat products (sausages, mortadella, ham) for export in the Middle East and Arab peninsula. However, in general, the camel meat supply chain is limited to local butchers, specialized or not [20,21]. Up to now, no camel meat is available in supermarkets at a scale comparable to that of other livestock species, including sheep and goats. Overall, these developments thus remain at the local level with only limited up-scaling and organizational impacts. The most active

channels are still illegal or cross-border smuggling that consists of importing live camels from Sahelian countries for slaughter. The largest importing countries are Libya, Egypt, and, to a lesser extent, Algeria, and Morocco. These channels are based on ancestral social networks (often tribal kinships) with few links with collective actions promoted by the public sector.

However, the different initiatives in the milk and meat sector showed a relatively rapid, although incomplete and disorganized, change in the camel sector, followed by diversification and technological innovation in associated products along the last decades. Among the major drivers of changes in these farming systems are urban growth and changing diets, both of which accelerated the marketing of camel products [4]. Given these recent dynamics, some herders have started to settle on the outskirts of cities and to intensify production to supply products that are better suited to the needs of urban populations. This trend shows that the camel farming system, which is traditionally extensive, could be becoming more intensive. Upstream, the public sector has supported this change through subsidies or by promoting (even imposing) collective associations or organizations, as in Morocco [22,23] or by financing research on the characterization of the genetic diversity in links with economic, ecological, and sociocultural values [24]. However, from a development or political perspective, this change is perceived in southern Mediterranean countries as too embryonic to constitute a fundamental rural development pathway. Moreover, the cultural factor embedded in a living pattern could be difficult to conceal with an efficient value chain.

Researchers involved in the CARAVAN project (https://caravan-project.weebly.com/; https://www.facebook.com/Caravan-project-toward-a-camel-transnational-value-chain-411485666055683/ accessed on 20 October 2021), proposed to address the urgent need for the camel sector to move toward a systemic organization of the breeding and the food chain at national and transnational level, as a tool for the economic development of local communities in disadvantaged desert areas of the Mediterranean where the camel has a triple "animal traction-meat-milk" function. We can note that the function of animal traction previously used for agricultural activities is now mainly dedicated to tourism activity for desert trips. In this perspective, we hypothesize that the dromedary camel is a strategic resource, as it is the best suited and productive livestock species, with a good potential to contribute to the local activities and food security and sovereignty in the arid and desert areas of Northwest Africa. Furthermore, the dromedary camel represents an element of cultural identity and continuity for sedentary nomads, as shown in [25]. As camel rearing is mostly extensive or semi-extensive, it plays a fundamental role in conserving critical and endangered semi-natural habitats of high ecological value and is involved in agriculture, tourism, and transport [6]. The nutritional qualities of camel milk and meat have significant market potential as reported in [26,27], and are also a possible alternative to meet the needs of specific categories of consumers. In this context, one can hypothesize that the lack of professional organization of the camel industry is an obstacle to its development, and, in turn, that sustainable coordination between actors will depend on understanding and integrating existing social links that have proven their value.

Recognizing the traditional and ongoing collective action at the community and sectoral level, our objective in the present paper is to explore and characterize the links between the main stakeholders in the camel sector that are the premises for the conception of a systemic organization within the CARAVAN Projects. For that, we proposed to characterize the interactions between actors in two dimensions: horizontal links with the peers (intra-relations) and vertical links between the different kinds of stakeholders along the value chain and in resource management (inter-relations). We used a semi-structured questionnaire in four northern and southern Mediterranean countries to identify the roles and relationships of stakeholders along the value chain and the main constraints and opportunities perceived by the actors concerning the organization of the sector. This paper is the first representation of the social network of the dromedary camel sector and is

intended to provide a basis for reflection about a more structured organization of the chain while considering the main existing channels of communications and exchanges.

2. Conceptual Framework for Analysis of the Camel Sector

Based on the literature review, one of the main obstacles to a formal camel sector is hypothesized to be the lack of a structured and recognized network of national or even international actors linked with the movements of camels across the borders. Through a transversal study in the southern and northern Mediterranean countries, we aimed to identify the main relations between the different actors involved in development of the camel sector by distinguishing between horizontal ties based on the relationships with the peers who practice the same activity, and vertical ties between the actors in the upstream and downstream value chain, by referring to the Local Agri-Food System (*Système Agroalimentaire Localisé* SYAL) framework [28].

By using this approach, beyond the value chain, we assume that understanding the camel sector requires an overview of all the stakeholders who interact directly or indirectly in the camel sector at local or national level. Based on the expertise of the transnational research team involved in the CARAVAN project, a conceptual framework of the camel sector (Figure 1) was discussed and validated in a research group meeting. In this approach, the sector is assumed to include all the stakeholders in the upstream and downstream value chain and all the private and public organizations involved in the camel sector. The stakeholders are considered as a category of actors who influence or are influenced by the camel sector in general, and by the camel value chain in particular. In this preliminary research work on the camel sector, we did not include consumers as a group of its own, as the majority of the camel products are consumed by the pastoral societies represented by camel herders. Given the important cultural identity of camel herders throughout the zone, we decided to analyze the relationships among peers considered who exercise the same activity, plus their relationships with other stakeholders who practice another activity.

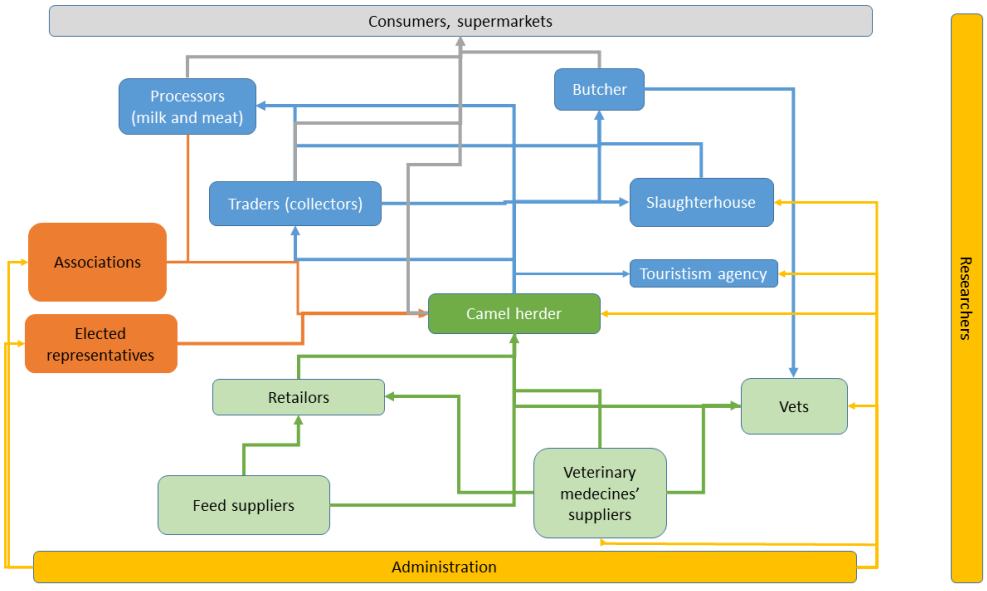


Figure 1. Preliminary representation of the camel sector based on the flows (designed from a meeting between researchers involved in the four countries of the Caravan project).

3. Materials and Methods

Our semi-structured questionnaire (see file S1) resulted from a research group meeting organized in the CARAVAN project. It was structured in three parts (i) the main characteristics of the interviewees, (ii) the nature and intensity of links with their peers; and (iii) the nature and intensity of ties with the other stakeholders in the camel sector. The

main indicators used to qualify a relationship were the type of exchange, the frequency of the exchange, the benefits derived from this relationship in terms of main outcomes and impacts and the degree of trust between the stakeholders. The nature of a relationship refers to the type of links, i.e., with family or friends or only with professionals. In the case of professional connections, we wanted to know if the link involved an oral or written contract. The degree of trust was scored on a scale of 1 to 10. Several qualitative and/or open questions addressed the benefits of the links and their trends in recent years.

The majority of interviews were conducted face-to-face by national research teams and students in each country in the local dialect. In average each interview required around 30–45 min. In Algeria, a digital questionnaire was used to reach some administrative or technical staff in very remote areas. Four countries were investigated: Morocco, Algeria, Tunisia, and Canary Islands (Spain). A total of 179 stakeholders were interviewed, including camel herders, butchers, traders, feed providers, vets, administrative staff, local representatives, slaughterhouse managers and staff, and researchers. Except in Spain where has been realized an exhaustive survey among the stakeholders, the sampling method was based on the snowball sampling approach in each location.

Figure 2 shows the distribution of the final sample according to the type of stakeholder and per country. The distribution highlights the particular configuration of the camel sector in the Canary Islands (Spain), linked with the sector's main orientation at the local level, tourism. In the three North African countries, camel herders and butchers are the main stakeholders in the value chain linked with the local meat market. In Algeria, herders may also be butchers but are considered as herders in our sample, which explains the smaller number of butchers in our sample distribution. Traders are well represented in Algeria and Morocco but are less numerous in Tunisia, where traders are often the herders themselves or fattening specialists. Indeed, in Tunisia, beyond rearing, camel herders are involved in different activities along the camel value chain, which empowers the camel owners at every link of the value chain in obtaining better incomes. In Algeria, the large number of slaughterers can be explained by the fact that most herders are also slaughterers. In Algeria, 20 stakeholders cumulated different functions along the value chain. For our cross-national analysis, we categorized stakeholders according to what they declared to be their main activity. However, the accumulation of different functions along the value chains is an important characteristic of the functioning of the camel sector. Finally, it should be noted that tourism involving the camel sector is well developed in Tunisia, but not in Morocco or Algeria. The fact camel rides are less common is some places, mainly in the southern governorates of Morocco and Algeria, implies a bias in our sample, especially in Morocco, where in some places like in the Ouarzazate or Errachidia governorates, some tourist activities based on the camel sector were observed.

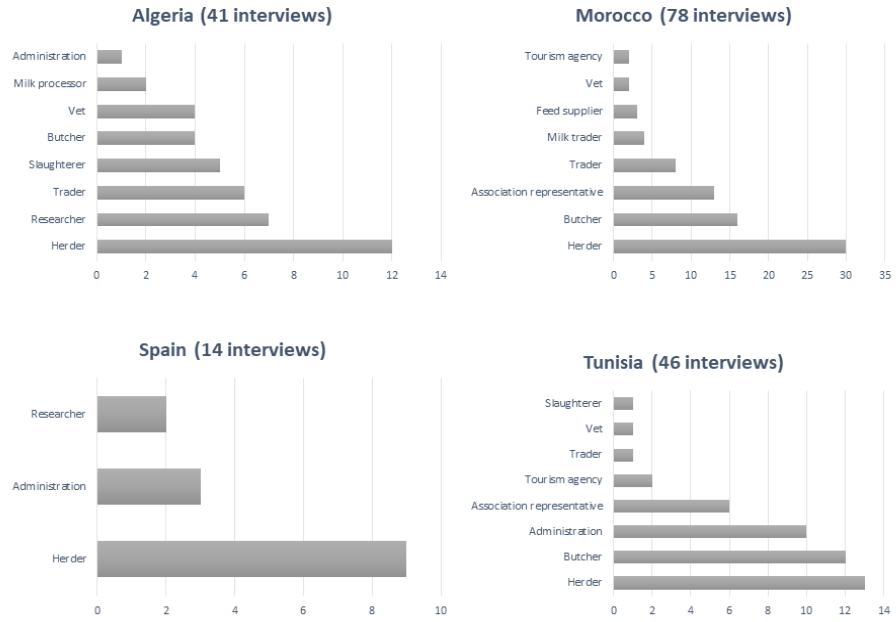


Figure 2. Distribution of the study sample in each country (sample: 179 interviews).

The stakeholders' relations with their peers were analyzed using descriptive statistics related to quantitative and qualitative variables. At the sectoral level, we used a mixed approach to social network analysis (SNA) [29,30] that combined quantitative and qualitative research to better understand the stakeholders' social networks at the local or national level. As a research study, we used the relational data collected in the survey as a guide (a) to map existing formal and informal network structures and (b) to identify central nodes that could play an active role in the conception and future organization of the sector. The qualitative variables qualify the type of relation (between who?) within the camel sector and the nature of the relation (kinship, professional or contractual) for each individual (179 interviews). The quantitative variables are the scores related to the variables that qualify the link in terms of frequency, functionality (good, medium, bad), trust (score from 1 to 10) and its trend over the last 5-year period (deteriorates, maintains, or improves) for each individual and each relationship. These variables are the raw data from the survey.

The SNA was applied using the software GEPHI [31]. GEPHI is an open-source software for visualizing and analyzing networking. GEPHI uses a 3D render engine to display graphs that allow to explore links between the individuals and reveal set of patterns between individuals. To identify the most closely connected or central actors in a network, we applied the widely used centrality measures, based on the number of connections that pass through them [32,33]. Using qualitative information related to the degree of trust attributed by each agent to the other stakeholders with whom they interact could help draw up principles to guide the creation of more extended social networks in the camel sector.

4. Results

4.1. Relationships between the Stakeholders and Their Peers

The descriptive analysis of the relationships between the different stakeholders in the camel sector and their peers revealed the importance of the nature of family or friendly links alone (15%) or linked to professional or contractual interactions (49%) (Figure 3). For the actors downstream or upstream of the production level, some differences in the peer relationships were observed in each country (Figure 4). Kinship relationships mainly concerned camel herders in all four countries. A gradient ranged from only or mostly kinship and friendly relationships to only professional links from Tunisia to Morocco in the case of butchers. The majority of contractual relationships between peers were observed

in Algeria among herders, traders, and vets, where stakeholders managed their activity based on contracts (mainly oral). Most of the relationships between stakeholders in the administration or veterinary services were professional but included no specific contract.

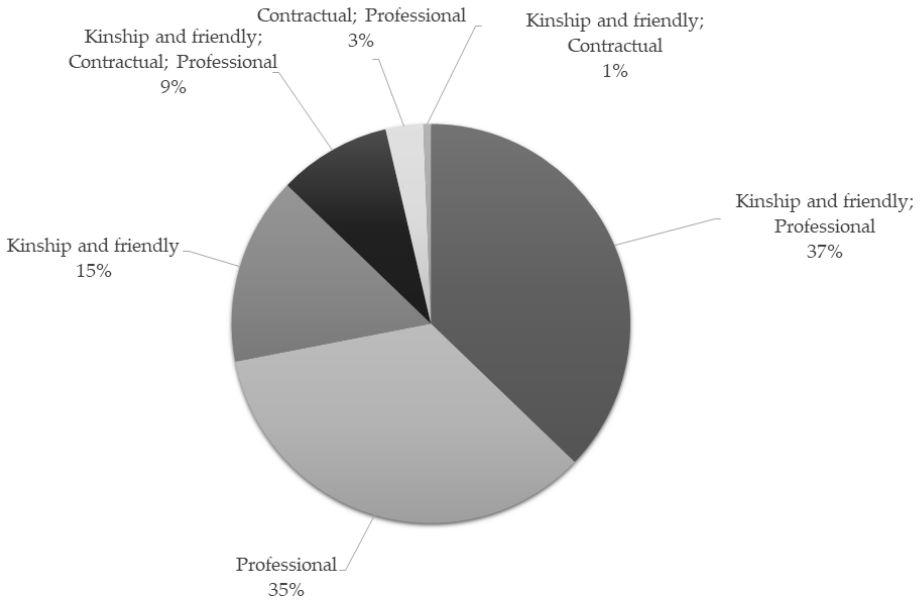


Figure 3. Nature of the relationships between the stakeholders and their peers (sample: 179 interviews).

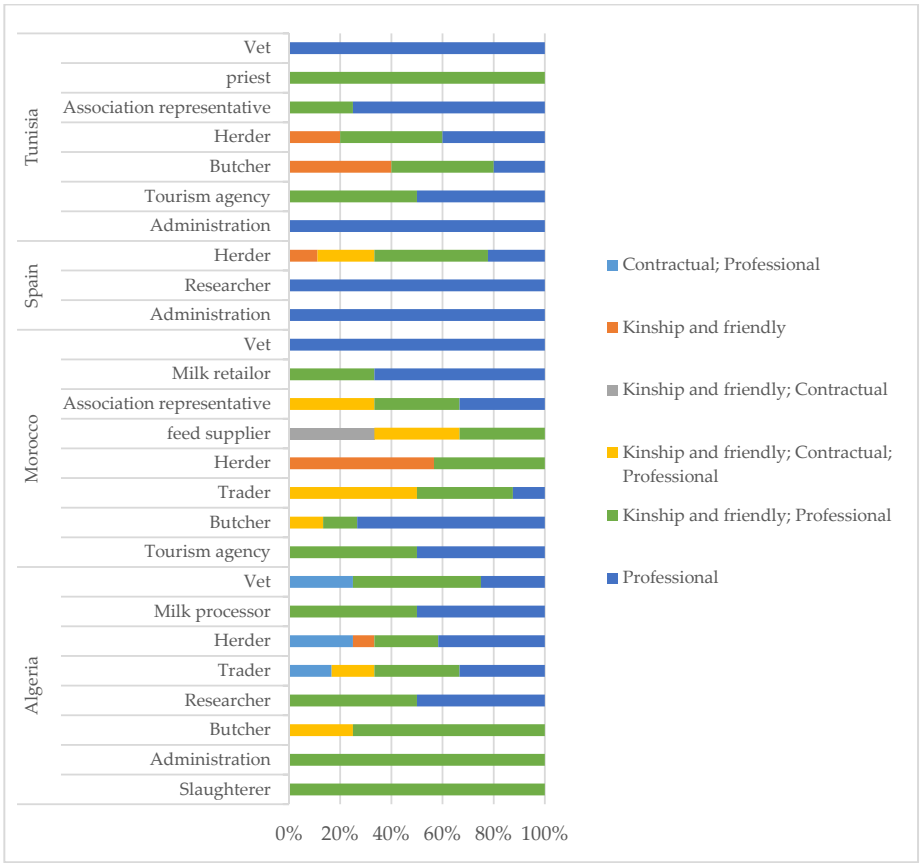


Figure 4. Nature of the relationships between the stakeholders and their peers (sample: 179 interviews).

The main nature of exchanges (both given and received) between peers concerned the transfer of information and knowledge (35% of the exchanges) and, to a lesser extent, the exchange of services (labor) and of animals (Figure 5). Figure 5 reveals contrasting types of interactions between peers in each country. For instance, in Tunisia, the majority of the exchanges were limited to the exchange of information and experience with a few exchanges of goods and services, whereas in Morocco and Algeria, exchanges of animals or services (mainly labor) were common between peers, especially between camel herders. Trade in animals or inputs and services are also common between herders in Spain, where camel herders want to improve their breeding program.

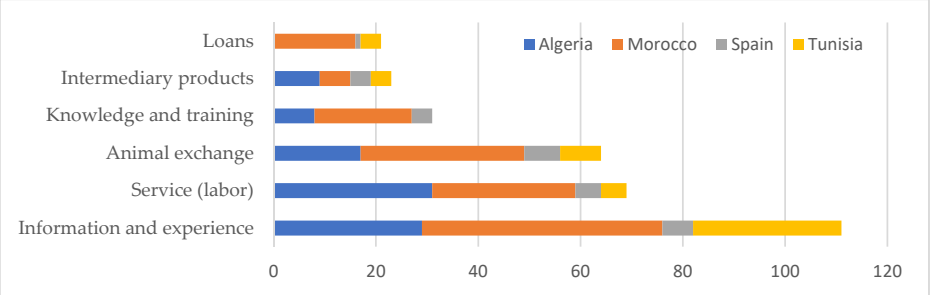


Figure 5. Nature of the exchanges between peers (319 recorded exchanges between peers).

Figure 6 shows that almost half of the interactions between the camel associations or butchers focused on the exchange of knowledge and experience. Exchanges concerning loans were the most common in the butcher category and also through the associations. However, while the profiles of the exchanges were similar, the main benefits obtained from the relationships between peers were contrasted (Figure 7). In our sample, the benefits were the most diversified in Tunisia, where the different actors obtained facilities regarding access to animals, inputs, or services.

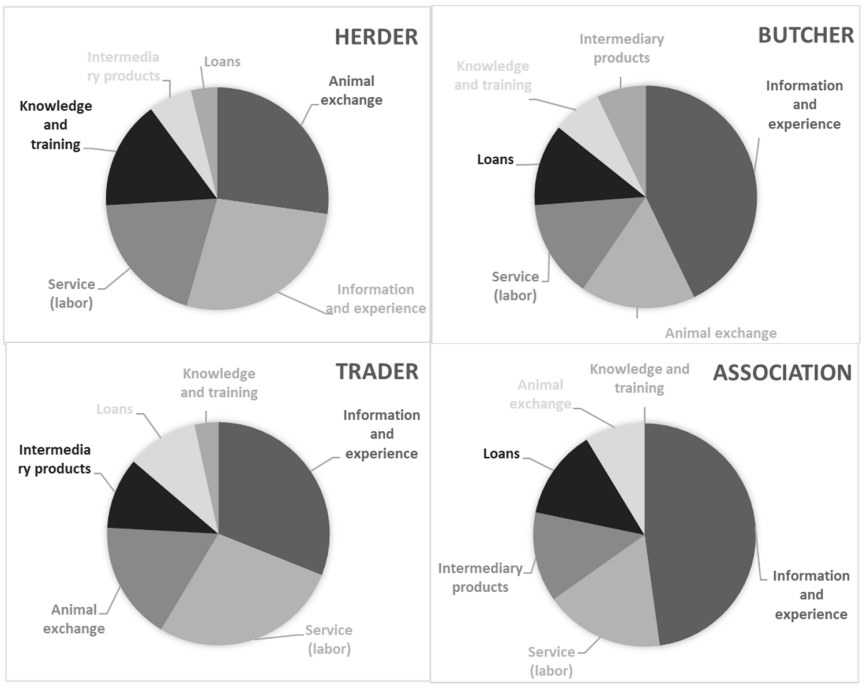


Figure 6. Nature of the given and received exchanges between peers for four main stakeholders (158 exchanges between herders, 42 between butchers, 29 between traders and 23 between association' leaders).

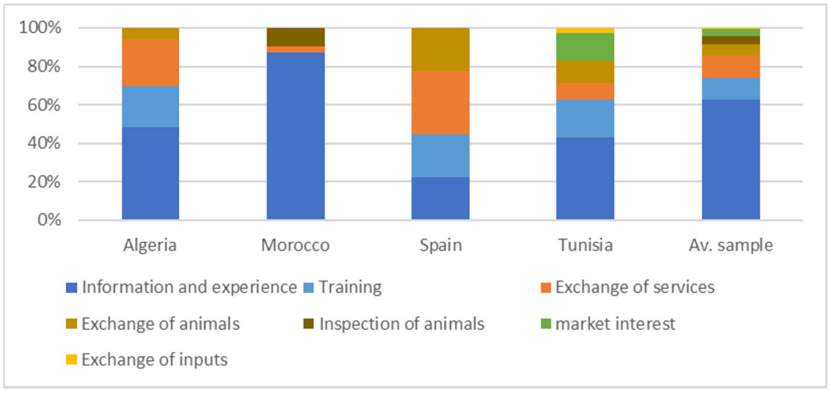


Figure 7. Main benefits obtained from exchanges with peers according to the country (139 answers).

Concerning trust, on a scale of 1 to 10, herders received the highest score, followed by butchers, and then associations and administration (Figure 8). The average score for trust in the private or public agents in charge of services such as vets, traders, slaughters, or researchers was between 7 and 8. The lowest score was obtained by milk retailers and milk processors where the geographical radius of action is often reduced, and competition is consequently very high. This may be also linked to the limited supply of camel milk (which is a high-value product) in all four countries.

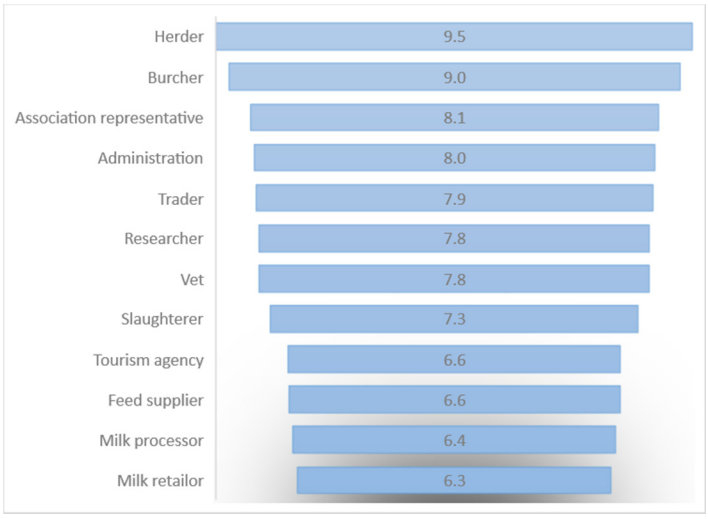


Figure 8. Degree of trust between peers along the camel value chain (average of scores from 1 to 10) (163 answers).

4.2. Relationships among Different Staleholders in the Camel Sector

In a total of 179 interviews, 629 relationships with different stakeholders were recorded, meaning that one stakeholder was in contact with 3–4 people who had different functions in the camel sector. Figure 9 summarizes the camel milk sector network in the four countries. The main links were between three main stakeholders, herders, vets, and feed suppliers. The other actors, the administration, butchers, slaughterhouses, and researchers, came second in the overall social network. The marginal role of the elected representatives, meat processors, and transporters also stands out.

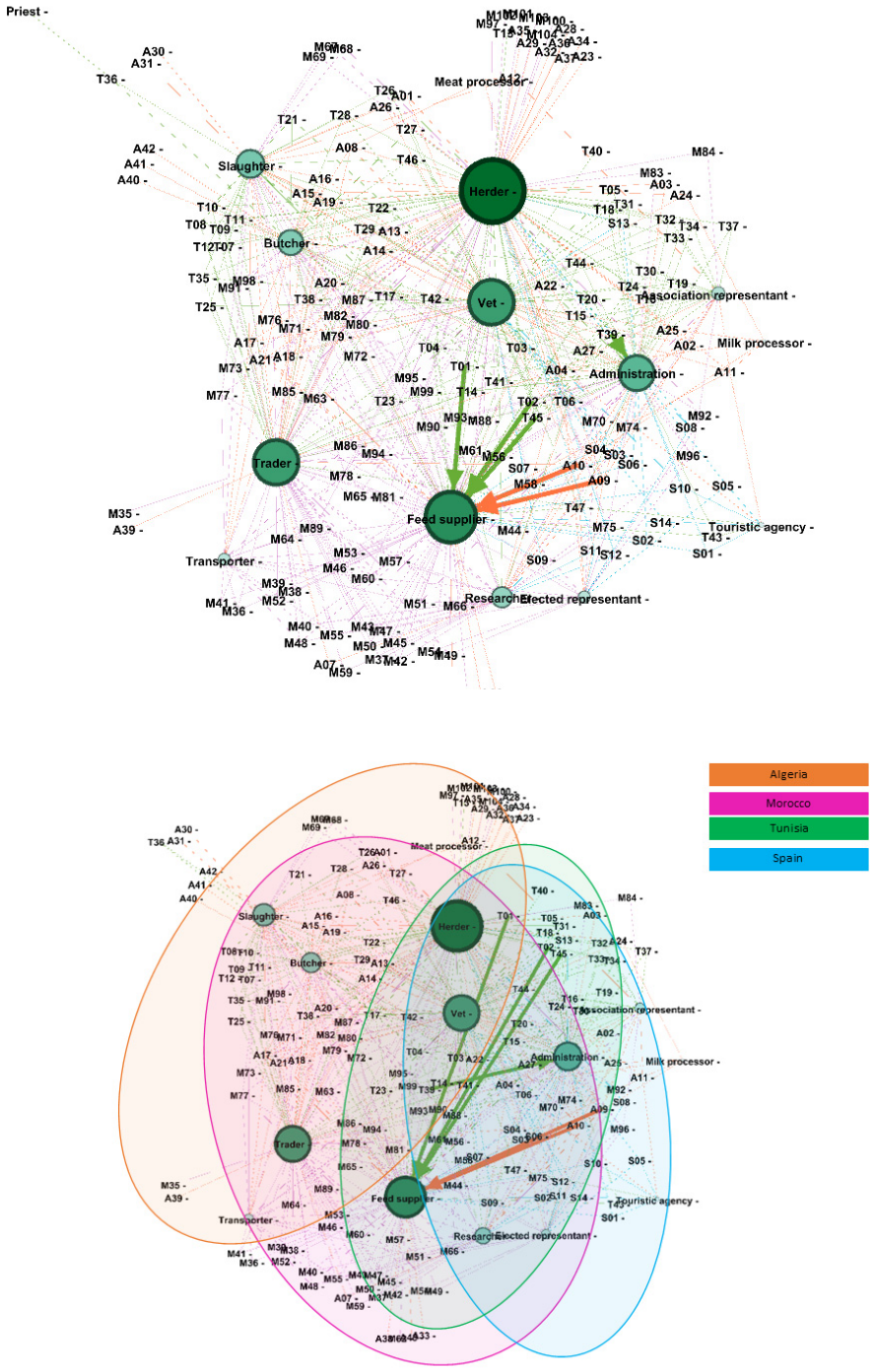


Figure 9. Overview of camel-milk networks in the four countries (legend: Morocco (pink), Tunisia (green), Algeria (orange) and Spain (blue)).

The color of the outline of each ellipse reflects the dominant network in each country. Notably, the vets' strategic cluster, feed suppliers, and traders dominate in Morocco (*in pink*). Contacts between vets, feed suppliers, and the administration dominate in Tunisia (*in green*). A particular link was observed between vets and milk processors in Algeria in connection with the expanding milk sector (*in orange*). In the Canary Islands (Spain), there was a different configuration centered on the administration and researchers. Appendix A gives a specific representation for each country.

When only the categories (and not the individuals) were considered, camel herders, located at the center of the network, represented the main point of contact for all the other

actors. Consequently, they play a structural role in the organization of the camel sector (Figure 10). The herders' closest relations were with the feed and medicine suppliers and vets downstream in the value chain and with the butchers and traders upstream in the value chain. However, the main direction of the links downstream in the camel value chain is directed away from the stakeholders in charge of valorization of the camel products to the producers, i.e., herders, and not inversely.

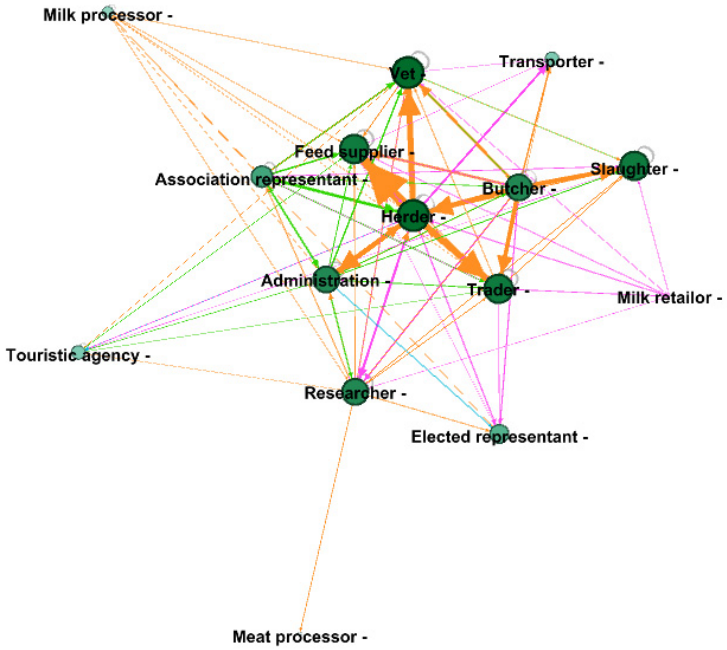


Figure 10. Overview of the social network between the stakeholders (Algeria in orange; Morocco in pink, Tunisia in green; Spain in light blue).

Researchers were the main intermediaries between the camel herders and the administration or associations and meat or milk processors, implying that the processing of camel products is still in the early stages of development and needs innovation and accompanying processes. The butchers occupy a second cluster and represent the link between the transporters (haulers), the slaughterhouses, traders, and herders. However, the existing relations between the herders and butchers also reveal meaningful social exchanges between all the stakeholders that are most consolidated in Algeria where some interviewees cumulated different functions e.g., animal trade and transport, slaughter, and sale of camel meat.

Figure 10 also underlines differences in the social networks between the four countries. Notably, whether the central cluster is oriented toward or away from the herders. In Algeria, social networks are more common along the value chain. In Morocco (and, at a lesser degree, in Spain), the camel sector appears to be more organized around a territory with more interactions between the representatives of the association, the elected representatives, or the administration.

Figure 11 highlights the high degree of trust declared by the herders in their vets and feed suppliers. The degree of confidence between the herders and the butchers (*in green*) is mitigated. Degrees of trust between the herders the milk processor are contrasted (and even opposing). Researchers and vets have excellent trust in milk processers compared to their trust in the administration, whereas the associations and the traders have little trust in the milk processing units.

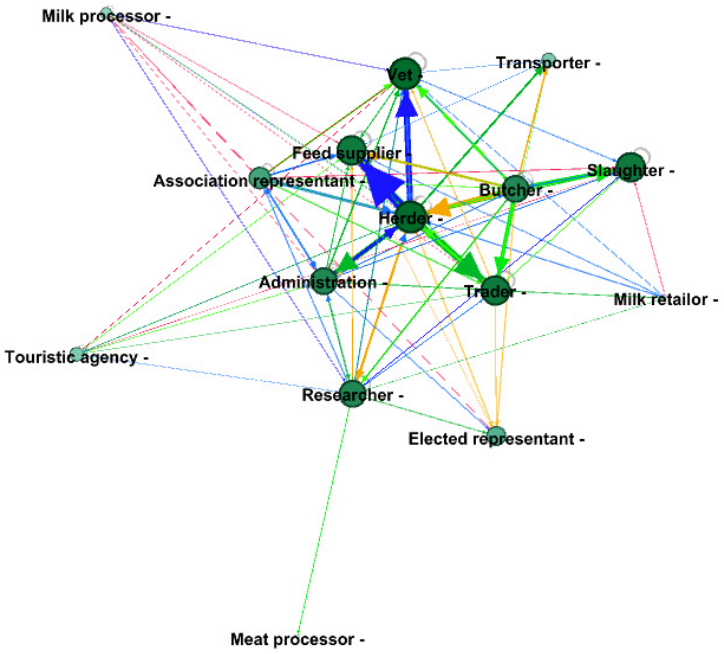


Figure 11. Degree of trust between stakeholders (no or limited trust in red (score 0 to 3), limited or medium trust in orange (score 4 to 5), medium trust in green (score 6 to 7), and good trust in blue (from 9 to 10)).

5. Discussion

5.1. Overall Characteristization of the Social Network in Camel Herders' Society

The present analysis of the social network in the camel sector based on a rapid appraisal survey highlights its original organization around the herders rather than along the value chain or focused on intermediaries, which is the case in the majority of the economic sectors in agriculture. This structure is rooted in the geographical and social context of camel systems in desert and arid environments. One of the significant adaptive capacities of this desert community is its mobility depending on rainfall opportunities [25]. This mobility forged close and strong links between herders and their families located around their encampment to secure access to natural resources, plus much more distant links with support and development structures. Linked with the recent settlement of herders and their families, either a reduction in the distance travelled during transhumance or part of the camel flock kept in the family encampment, can be observed. In the two cases, two stakeholders, vets, and feed suppliers, become strategic for the herders and their families. Not only do these two stakeholders ensure the health of the camels (one of the main physical assets in the zone), but feed suppliers have become one of the main sources of credit in the face of shocks.

The second strategic network includes slaughterhouses, butchers, and traders. These actors are the main connection between the herders and the consumers. The nature of exchanges concerns live animals, but this represents the main hub where loans and credits based on the camel assets as guarantee circulate. This connection mainly takes place at the local level, although a few links have developed at the regional or national level. As shown in Section 4.2, the main directions of the links downstream in the camel value chain are from the stakeholders in charge of valorization of the camel products to the producers, i.e., herders, and not inversely, meaning that these actors are demanders of service rather than providers of services for the herders. One characteristic trait of this network in Tunisia and Algeria is that one person often cumulates all three activities. Some stakeholders may even cumulate four activities in the same family, i.e., camel keeping (owners), trading, slaughtering, and butchering. In this context, the trader (but also sometimes the butcher) is someone who belongs to the same family lineage as the herder in whom he trusts.

Finally, a third network exists composed of members of the administrative, associations, elected representatives and researchers. While staff belonging to the administration and association benefit from substantial trust on the part of the herders, trust in researchers and elected representatives is more mitigated, but probably not for the same reasons. The elected representatives are often camel herders themselves who have privileged access to subsidies compared to other herders which explains the mistrust between them. In a different way, the researchers are mainly involved via the administration and often promote interactions with the milk and meat processors, which is not a priority for most camel herders.

Our results also highlight different social networks in the four countries. Notably, in Algeria the main cluster is oriented towards or away from the herders, with specific connections with milk and meat processors. In Tunisia, the social networks are more developed upstream and include vets, feed suppliers, associations, the administration, and researchers. In Morocco, the camel sector appears to be more organized around a territory with horizontal relationships between the herders and representatives of the association, elected representatives, or the administration, and vertical relations with butchers, traders, and milk retailors. In Spain, the territorial structure, including herders, administration, researchers are linked with the contribution of the camel activity to tourism in the Canary Islands. The different configuration of the camel sector in the four countries reveals different development pathways depending on different economic, social, and political factors.

5.2. Lessons in Terms of Collective Action

In the three North African countries, the social network approach confirmed that the camel dairy sector is still in its beginnings, with short circuits, few actors other than the camel herders and a few small-scale dairy plants. These dairy plants cannot maintain uninterrupted activity due to the frequent shortage of milk linked with camel mobility and the limited volume of milk collected. The meat sector, which is often based on the extended live animal chain, is more complex. This sector includes a large number of actors, breeders, fatteners, traders, dealers, feeders, slaughterers, butchers and the circuits can be very long and may cross national borders if the supply of live animals is included. For instance, in Algeria, the importance of cross-border trade in live animals with Niger and Mali is widely recognized [34,35]. These cross-border trading activities are often in the hands of dominant tribes. A second specificity of the live animal chain is the sacrifice of camels during the religious festival of Aïd el Kebir in the pre-Saharan desert societies and the gift of live animals, which rhythms the majority of community or family events, such as marriage and births. The exchange and sacrifice of animals take place at the community level and are traditional gestures of solidarity and recognition at the core of these societies.

Concerning the demand for upstream services, our results corroborate the herders' recurrent complaints regarding the administration, particularly linked with the veterinary services for health support. This service is still struggling to meet very dispersed demand (due to herd the mobility over great distances and demand in remote areas) but is not very dense (meaning the cost of intervention per animal is very high). Although camel herders have extensive local knowledge of traditional medicine (ethno-practices) that cover a wide range of the most common disease or accidents [36], there is a great demand for vets to intervene in major urgency in addition to the vaccination.

Whether milk or meat, camel products remain closely linked to desert societies in the southern parts of Algeria, Morocco, and Tunisia. In this regard, the failure of the marketing of processed meat products from desert areas to the main regional or national cities, which are often located in the northern coastal zones, is due both to the poor price/quality ratio, but also the distance in terms of cultural identity. Our results also underline the importance of kinship along the camel value chain, that excludes external actors. Efforts to structure the chain at the national level give the impression of a somewhat top-down approach. However, some recent trends were observed concerning the arrival of educated

young people who originate from the zone and, in parallel, the involvement of tribal representatives in the local community management (elected representatives). This trend could lead to new dynamics in the camel sector but could also perpetuate internal (inter-tribal) inequalities already observed in desert society [37]. A camel-owners network on resourcing and negotiating is really needed in the region. At the national level, inclusive funding and investment in a variety of activities across camel value chains should be planned through each country' specific national livestock strategy.

However, innovative organizations are emerging. For instance, in Tunisia, a national strategy for the promotion of the camel sector was part of the 2016–2020 development plan aimed enhancing camel owners' knowledge and capacities to access inclusive financing and to strengthen their readiness to invest, but also build their capacity for engagement in and advocacy for market access and trade policies. Several operators are involved in this national policy including the Tunisian Union of Industry, Trade and Handicrafts (UTICA), Tunisian Union of Agriculture and Fisheries (UTAP), Livestock and Pasture Agency (OEP) and Agency for the Promotion of Agricultural Investment (APIA). In fact, subsidies are granted by the OEP and the APIA for fattening, management of young she-camels and investment in the camel sector (Letayef and Bedhiaf-Romdhani, 2018). Furthermore, in the Tunisian National Agricultural Investment Plan (NAIP), several measures were taken following the identification of policy gaps to create enabling environments for camel producers in agri-business. This strategy intends to spearhead activities that will increase their access to markets, credit services, inputs, and enable them to benefit from economies of scale and comparative advantages as well as the development of crowd sourcing platforms to promote access to markets and products. As a result, in the last decade, dairy camel farms have been established in the governorates of Medenine, Tataouine, Tozeur, Kebili and Gabes. Raw camel milk is produced and sold through different marketing channels [38], based on milk pasteurization to guarantee a better-quality product. The government has also suggested promotion of the transformation of camel sector in parallel to the development of agri-business along the livestock value chain to facilitate added value and to link farmers to input and output markets.

In the Canary Islands (Spain), the survival of dromedary camels (*Canarian* camels) is apparently relegated to tourism although travel agencies do not appear to include camel-based leisure activities in their tour proposals [39]. These authors highlight the urgent need to take practical measures to guarantee the long-term viability of this endangered breed and conducted a socio-cultural analysis of the camel-based local tourism sector. The results are intended to provide the theoretical background to raise the awareness of stakeholders in the quality attributes or consumer expectations that influence the satisfaction and loyalty of target customers. Customized services should be provided, in which case business value will increase, local economies may benefit and potential for camel conservation will be reached. More generally, in Europe, recent interest in camels and camel products offers interesting and novel socio-economic perspectives.

5.3. Methodological Insights

Although our sample has the advantage of covering different locations in four countries, it can only give a partial and fragmentary vision of the camel sector due to the immense diversity of situations linked with the desert territory that covers more than 50% of the national territory in Algeria, Morocco, and Tunisia. Moreover, the current intra-lineage functioning of the herders especially in the live animal chains question the value of analysis of links along the value chain. For instance, in our study areas in Algeria, herders may also be butchers but in our sample, were considered as herders. Most herders also practice slaughter, especially linked with family or religious events. This cumulation of activities along the value chain questions any approach based on links. Finally, the principle of rapid appraisal of social networks did not allow us to consider the inter or intra tribal links between peers and within the sector. Although our analysis allowed us to highlight the importance of links with family and friends, we were unable to reveal

the tribal nature of these links, which involve traditional rules and social mechanisms in interaction with the socio-ecosystem and its seasonal rhythm.

Our analysis based on descriptive statistics and using a social network approach allowed us to represent the overall links in the sector and to better understand the frequent failures of organizational initiatives based on a traditional value chain in this sector. Notably, we confirm the pivotal role of herders at the horizontal (through exchanges of live animals that constitute the principal economic value of this activity) and at the vertical level (due to the cumulation of functions along the chain in the same family). However, this analysis remains relatively static and does not capture the drivers and dynamics of these relationships within the local communities, i.e., the tribal organizations.

On the other hand, this approach allowed us to confirm that most of the innovations in camel milk processing do originate from research institutions and laboratories. Researchers appear to be the main intermediaries between the camel herders and the administration or association, and the meat or milk processors. Milk production and processing may be an attractive activity for the young generation who do not necessarily have the means to invest in a large camel herd. However, this development can only take place if it remains linked to the traditional system based on herd mobility. Working on a systemic approach and multiple valorization of camel products instead of aiming only at milk productivity is one option. This calls for more integrative transformative pathways at regional level. Further, this study showed that if the actors, including the administration, butchers, slaughterers, and researchers, are at the core of the institutional proposals/schemes for enhancing this activity in the southern regions, except in Spain, they only play a marginal role in the overall social network of the herders. This calls for more collaboration with the herders to develop sustainable value chains.

6. Conclusions

This paper identified the main drivers of the camel sector, i.e., that most actors have kin relationships with their peers, and this link represents the main source of information, and the main weakness, i.e., the lack of trust and agreement along the downstream value chain that impedes coordination, especially with milk or meat processors. The networking analysis of the camel sector underlines also the original organization around the herders rather than along the value chain. The intensity of links is higher upstream than downstream the sector. This configuration explains the difficulties to boost the sector with organizations mainly based on stakeholders downstream the sector.

Based on complementary interviews with herders, one major explanation for the lack of trust downstream the camel sector would be the system of determining the sales price, especially with the butchers, that is apparently not transparent. Another persistent problem is the availability of sufficient feed and veterinary services at the territorial level that constitute the starting point for a more regular milk supply. These two major problems could be the basis for reasoning common actions at regional or national levels. Based on the configuration of the existing social networks in each country, the first coordination cell of this group of reflection could be composed of the herders, the administration (including researchers), feed suppliers, vets, and butchers.

Moreover, this study shows that the processing of camel milk products is still in its beginnings and needs innovation and accompanying processes involving young camel herders who expressed the most interest in this development. This study also revealed that there are currently very few close links between camel herders and milk and meat processors. This calls for more involvement of camel herders in investing in milk plants. The reasons for the limited interest of herders in developing the camel milk sector should be searched for in the camel-based farming system based on a hybrid mobile-sedentary system in the knowledge that mobility management involves considerable seasonal and annual variability.

Finally, the present analysis of the social network in the camel sector based on a rap-id appraisal survey also highlights the interest of the networking approach to under-stand the

main drivers and gaps of a food system' organization based on the stakeholders' perception of their link in the social system. This graphic approach is original and could also be used in focus groups to re-veal and discuss the strengths and weakness of links between actors to reinforce a systemic and operational organization.

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Appendix A

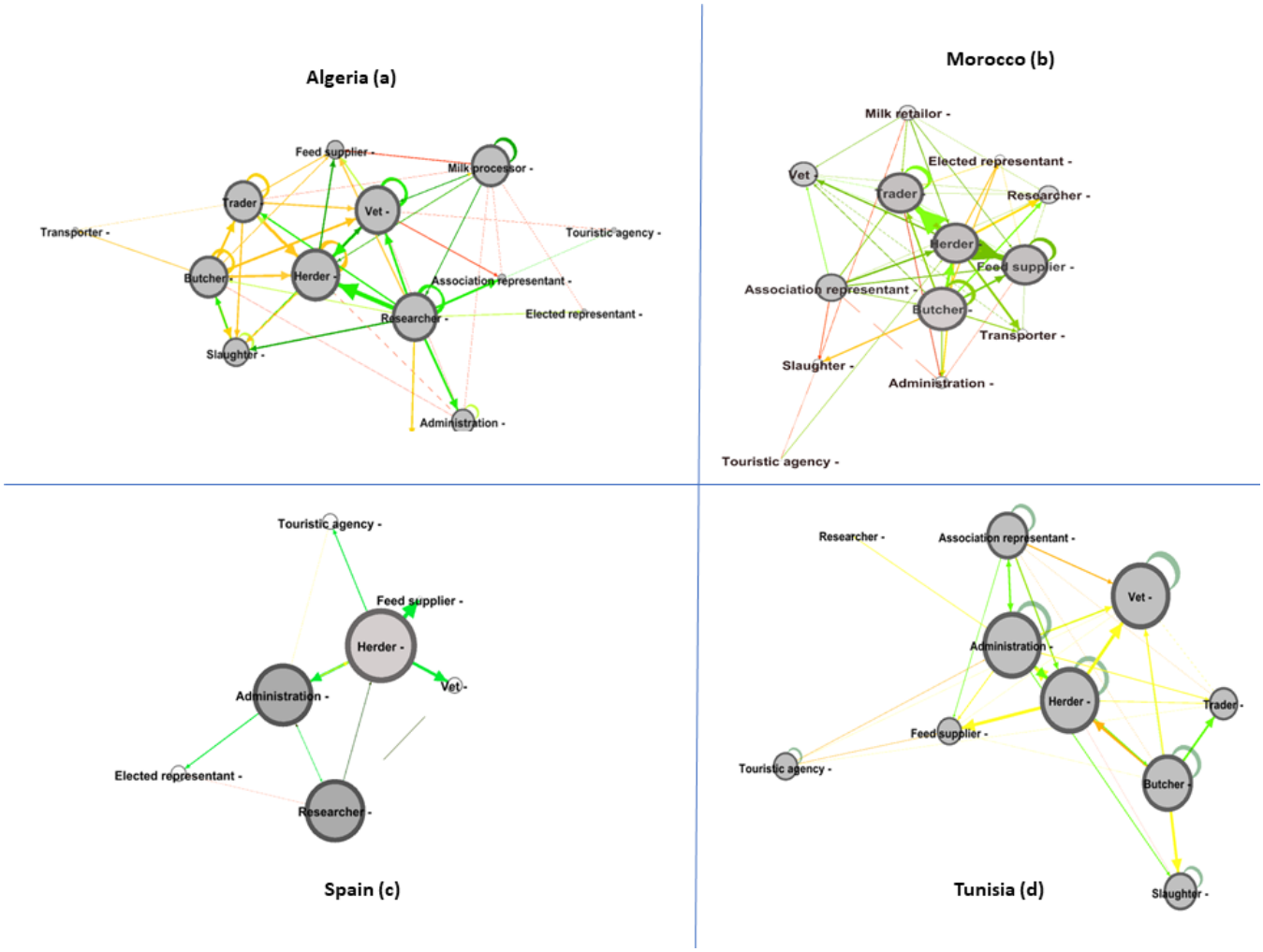


Figure A1. Overview of the camel milk sector networks in Algeria (**a**), Morocco (**b**), Spain (**c**), Tunisia (**d**). The color of the links are along a gradient of trust from the lower trust (in red), medium trust (yellow) to high trust (green).

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