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Full Research Article

Non-livestock value chains. Lateral thinking for the securing of the Sahelian livestock economies

Abdrahmane Wane[1,*], Ibra Touré[2], Aliou Diouf Mballo[3], Cheikh Ibrahima Nokho[4], Aminata Konaté Ndiaye[5]

[1] Research Economist - CIRAD-SELMET Research Unit-PPZS - Joint Appointment Position at ILRI-PIL programme, ILRI Campus, Mara House Building, PO BOX 30709, Nairobi, Kenya
[2] Research Geographer - CIRAD-SELMET Research Unit-PPZS – Hosted at CILSS – 03 BP 7049, Ouagadougou, Burkina Faso
[3] Statistician Economist, FAO Rome, Italy, Viale del Terme di Caracalla, 00153 Rome, Italy (previously trainee engineer at CIRAD-PPZS, Dakar, Senegal)
[4] Statistician Economist, currently being recruited by the World Bank Washington DC, USA (previously trainee engineer at CIRAD-PPZS, Dakar, Senegal)
[5] Rural Economist, currently being recruited by the USAID – Feed the Future Senegal "Naatal Mbay" program (previously trainee economist at CIRAD-PPZS, Dakar, Senegal)

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Abstract. In a rapid rural appraisal conducted in 2012 in the Senegalese Sahel, agropastoralists of Thiel expressed their need for technical and scientific support in peanut value chain development. Value chain analysis assessed the performance of the stakeholders. Multiple correspondence analysis clarified power relationships among them. Social network analysis facilitated the understanding of social and technical relationships inside the particular node of agropastoralists. Results show that the peanut crop is both a source of cash flow (marketing) and a pillar of food (basic consumption) and feed (by-products) security. This paper also highlights a lack of convenient economic environments, mutual assistance, capacity transfer and knowledge sharing on the best agricultural practices among agropastoralists, despite their weak production performance. Agropastoralists have no influence in the peanut value chain and are dependent on decisions from other actors. Technical support and knowledge sharing appear to be key for agropastoralists to control and adopt agricultural innovations.

Keywords. Diversification, value-chain, social network, Sahel.

JEL codes. D12, D13, Q02.

*Corresponding author: awane@cirad.fr

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1. Introduction

In the Sub-Saharan agricultural sector, diversification consists of a gradual movement away from subsistence food crops toward additional market-oriented crops (Parthasarathy *et al.*, 2008). It has long been accepted that rural producers adopt diversification economic activities in situations with high levels of uncertainty and in the absence of contingency markets (Berhanu *et al.*, 1996) to manage both predictable and unpredictable flows of income (Robinson and Barry, 1987) and to secure rural livelihood systems (Niehof, 2004; Wane *et al.*, 2009a). Farmer motivations to diversify are also specifically addressed through research activities on diversification, risk and income (Bezu *et al.*, 2012; Baird and Gray, 2014); food insecurity mitigation (Michler and Josephson, 2015); climate change coping strategies (Di Falco and Veronesi, 2013a; 2013b; Phillipo et al., 2015); and/or violent conflicts (Paul *et al.*, 2015). Similarly, Sahelian agropastoralists must diversify their economic activities as they encounter global challenges—including climate change—as well as economic, social and political crises (Ickowicz *et al.*, 2012).

Annually, Sahelian pastoral households also deal with extreme seasonal variability, leading to spatiotemporal and asymmetrical distributions of resources. They mainly use various forms of mobility recognised as sustainable strategies of herd management. Due to the threat of acute damage to pastoral productive assets, the environment and individual livelihoods by the aforementioned constraints, Sahelian households use livestock markets to balance short-term consumption needs and long-term herd building strategies to meet future consumption needs (Wane *et al.*, 2009a; Fadiga, 2013). Thus, they primarily attempt to secure their livestock production systems (Tran, 2011), as well as their socioeconomic and cultural heritage. In addition, diversification of income and food sources remains a prevalent *ex-ante* uncertainty-reduced management strategy to secure the living conditions of Sahelian agropastoralists. On the other hand, *ex-post* alternative mechanisms are used to smooth consumption, but they remain random, like the mechanisms of most peasant households in developing countries (Valvidia *et al.*, 1996).

However, in the Sahel, diversification strategies in the crop sector continue to be treated as secondary modes of production. In addition, gap-efficiency analysis along commodity value chains remains very weak. The diversification of agropastoral product value chains in the Sahel is similar to the notion of the A-System, which was initially highlighted by Ruben *et al.*, (2007). The A-System is characterised by traditional production systems with multiple small producers and intermediaries, local value chains, weak market information systems, longer transportation distance and time and complex distribution networks.

Accordingly, based on the concept of productivity measured as the economic output of a combination of production factors – including labour, capital and other factors – this paper emphasises the importance of the term "other factors" in the Sahelian contexts by analysing their complex relationships and the induced incentives that exist in agropastoral value chains. The main objective of this paper is to better describe this complexity, identify bottlenecks and highlight alternative interventions that significantly impact the position of agropastoralists in non-livestock value chains. By doing this, we also address the risk and uncertainty management decisions of the Sahelian agropastoralists by using social network and multiple correspondence analysis approaches in an unprecedented way. An

unexpected finding is the predominance of strong social relationships, with a tiny technical knowledge network among actors.

This paper begins with an overview of value chain analysis. Section 1 focuses on the methodological challenge of quantitatively assessing the performance of different stakeholders. It then provides a justification for the use of social network analysis to better understand relationships between agropastoralists and to explore new ways to improve the agropastoralists' position in non-livestock value chains. Section 2 describes a case study in Senegalese agropastoral areas, where producers clearly expressed the desire to be technically and scientifically supported in peanut value chain improvement. Section 3 develops a discussion on the main findings and shows how groups of individuals differ based on influential and non-influential factors. Finally, a conclusion outlines alternative interventions that could support agropastoralists in adopting innovations and best practices.

2. Area of study, conceptual framework, method description and sampling strategy

After a presentation of the area of study, the peanut value chain is mapped, followed by a description of the conceptual framework, the methodological approach and the household sampling strategy for primary data collection.

2.1 Area of study

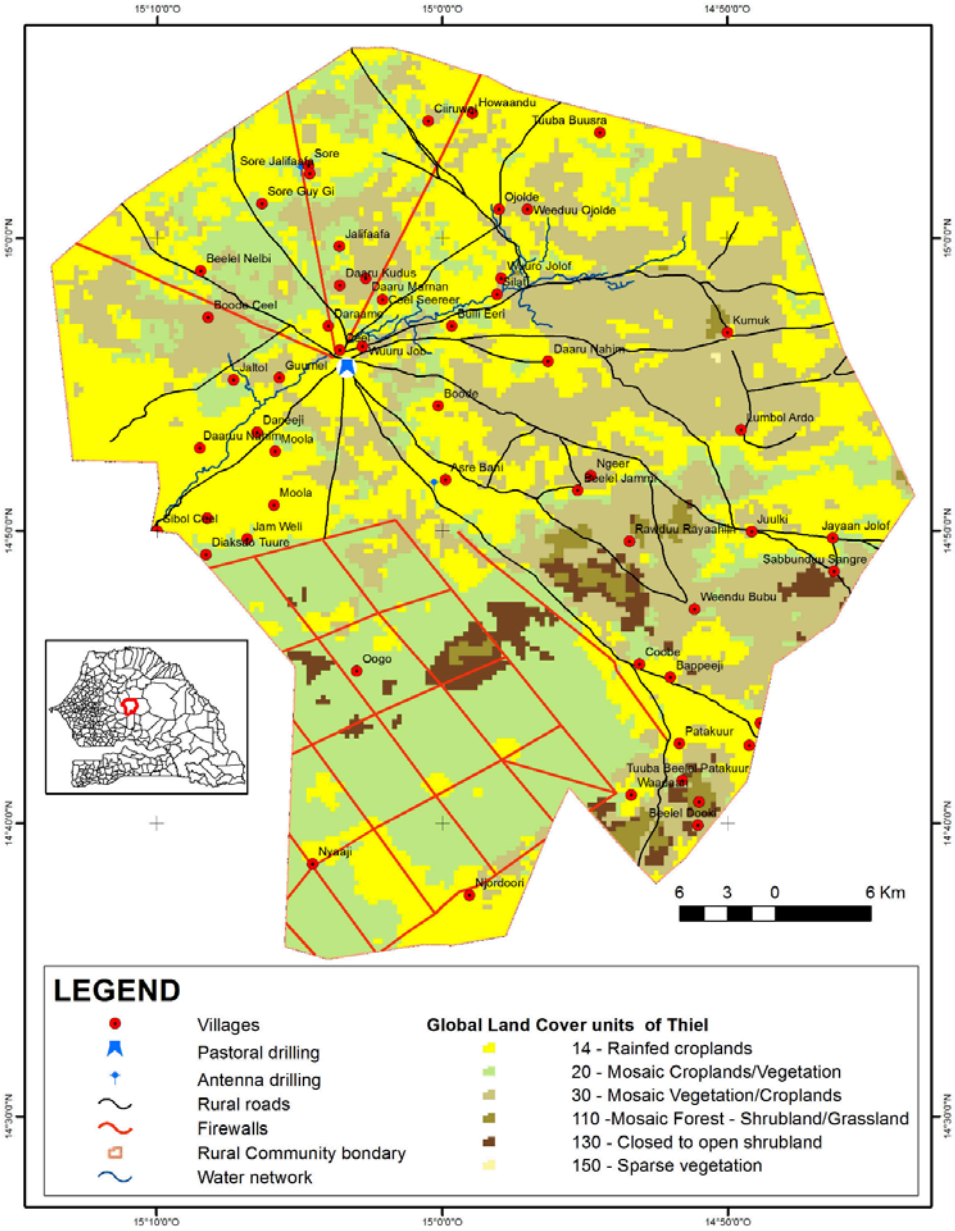
Value chain analysis increasingly requires a minimum amount of statistical data. In the Sahel, data collection requirements were broadly highlighted by a large study from the World Initiative for Sustainable Pastoralism (Hatfield and Davies, 2006). Moving towards quantifying value chain analysis is highly recommended (Rich *et al.*, 2011) to better evaluate the performance and impact of innovative interventions, although network complexity is already qualitatively characterised in livestock systems (Riisgaard *et al.*, 2010).

Our study was conducted in 2013 in the agropastoral area of Thiel, located in the south of the Senegalese Sahel on the edge of the peanut basin (Figure 1). This main peanut cultivation area extends along the north-south strip of 220 km and the east-west strip of 200 km. It represents a third of the farmland and is a source of employment for many households in the region. In 2012, peanut production in Senegal declined significantly. In this context, the agropastoralists of Thiel produced 270 tons of peanuts, averaging 1.9 tons per encampment. This production remains too marginal compared to national peanut production.

In terms of scientific research, there is an increasing consensus concerning the need to provide statistical evidence to better understand complex agropastoral production systems and livelihoods, even though the mobility of actors, informal relationships and non-market drivers do not facilitate such an orientation.

In Senegal, the main agropastoral and pastoral production system is concentrated in the Ferlo region, which is 67,610 km^2 and makes up approximately a third of the national territory (Touré *et al.*, 2003). With a surface area of 1,031.46 km^2, the agropastoral unit of Thiel is located in the silvopasture reserve of Ferlo, which is approximately 60 km southeast of Dahra, the largest livestock market in Senegal. Its closeness to the Senegal

Figure 1. The agropastoral rural community of Thiel.



Source: GLCn-FAO, 2005, Touré 2014.

groundnut basin and the advancement of the agricultural front strengthen the land tenure competition between farmers and breeders. However, crop-livestock integration is increasingly observed in the rural community of Thiel. Thus, during our investigations in 2013,

92 percent of household heads identified themselves as agropastoralists, and 1 percent of respondents reported exclusively practicing agriculture, whereas in surveys conducted in 2006–2007, only 48.1 percent of household heads identified themselves as agropastoralists (Wane *et al.*, 2009a). Crop-livestock integration facilitates cross-fertilization because crop residues feed animals, which in turn contribute to soil fertility through organic matter transfer.

The ethnic composition in the rural community of Thiel is diverse and includes three major groups: the Fulani, the Seereer and the Wolofs.

2.2 Conceptual framework: peanut value chain mapping

The "value chain" concept is similar to the notions of productive chains, the French "filières," marketing chains, supply chains and distribution chains (Webber and Labaste, 2009). Basically, the value chain is the full range of value-adding activities required to bring a product or service through the different phases of production, including procurement of raw materials and other inputs, assembly, physical transformation, acquisition of required services (such as transport or cooling) and ultimate response to consumer demand (Kaplinsky and Morris, 2002).

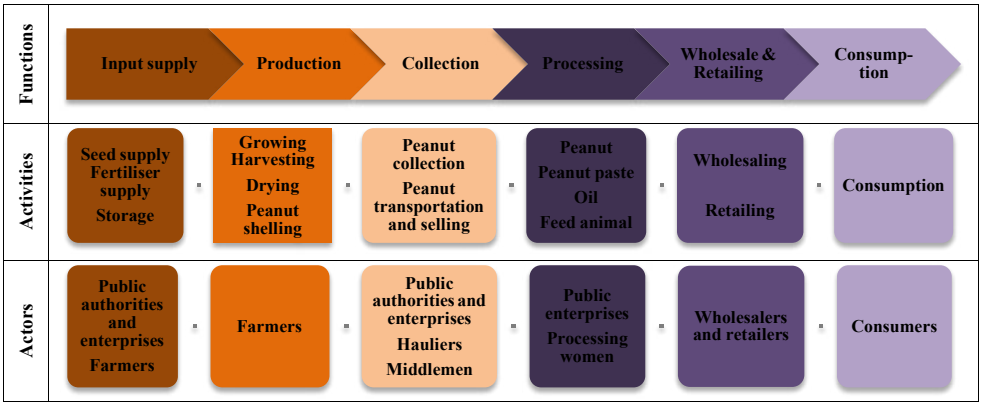
Farmers and agropastoralists are the first link in the peanut value chain in Thiel (Figure 2). Another important link in this chain are the public and private support unit firms that provide inputs and buy back the peanuts produced. Traditionally, government authorities sell subsidised seed to producers, then collection points are set up at harvest time to buy peanuts in exchange for vouchers redeemable in the future. Other actors in the value chain include women—usually the wives of household heads—who produce oil, peanut paste and food concentrate from peanuts that are purchased or harvested. In 30 percent of the encampments in Thiel, women perform this processing activity.

Another important value chain node is the traders, who buy large amounts of peanuts from the producers for resale in markets in Touba, the flagship city located 100 km from Thiel and the economic peanut hub in Senegal. Much of the production is sold in Thiel. Traders process the peanut seeds to remove mould and pests before reselling. Transactions on peanuts also involve a large group of players that are very active, such as middlemen who buy and shell peanuts. These traders are often based in Touba, and they also sell seeds, as well as the derivative products used for animal feed and energy products. These traders also constitute an important link in the value chain and offer support services to producers trying to sell to Touba. Usually, they have trucks that can carry 40 peanut bags from 30 to 50 kg, for a transportation cost of 1,000 XOF[1] per bag.

Note the existence of two terminal markets that shorten the marketing chain of peanuts: the local market of the rural community, where most collectors and processors sell shelled peanuts, oil and peanut butter, and the assembly market of Touba, where the middlemen trade only unshelled peanuts.

[1] XOF represents the ISO currency code for the West African CFA franc. In June 30, 2012: 1 XOF = 0.0019305381 USD.

Figure 2. The peanut value chain mapping of Thiel.



Source: authors' elaboration.

2.3 Method description

The limitations of the traditional value chain approach are most notable in agropastoral value chain analysis. Such analysis is supposed to assist in both the invention of mechanisms of data collection adapted to the characteristics of pastoral activities (mobility, informal activities, self-centred economy and self-bounded rationality) and the intelligent use of tools, such as social network analysis. Challenges within the social network can be identified by analysing vulnerabilities within the network, thus helping to move to a more resilient system (Alary *et al.*, 2016). The role of networks as facilitators of the coordination and distribution of productive resources could be analysed by using social network analysis as a comprehensive framework for investigating network phenomena through primary data collection.

For the agropastoralists of Thiel, the main hypothesis that should be tested is whether there are strong links among social relationships, technical cooperation and knowledge sharing.

The two most important parameters in social network analysis are the individual factors called "nodes" or "vertices" and their links or relationships, also called "edges" or "ties." Thus, a social network R(N,g) is defined by a group of nodes: N = 1,2,…,n and real-valued nxn matrix g. Each line i and each column j of this matrix represents an individual node, and their intersection g_{ij} indicates whether there is a relationship between them; g_{ij} takes a binary value according to the existence (1) or absence (0) of a link. In addition, there is an important notion of distance that characterises the position of one node in relation to another. This distance between two nodes – also called the geodesic – determines relevant indicators, such as the *density measures* (which are easily calculable) and the *centrality measures* (which are slightly more complex to determine) (Gomez *et al.*, 2013). Whereas density measures highlight the connection level of the network by comparing the present links and those possible if all nodes were linked, centrality measures determine what makes one node more prominent than another (Gomez *et al.*, 2013).

Centrality refers to the importance and the influence of a node in terms of the numbers of links that the node has. Centrality indicators can be elaborated to reflect the multidimensional character of this notion: The *degree centrality* considers which important nodes have many relationships or links (edges) with others (Wasserman and Faust, 1994). The degree centrality is equal to the number of neighbours that a node has. In the case of an oriented social network, one distinguishes between *in-degree* and *out-degree* measures. *In-degree* indicates the number of links that nodes receive and is interpreted as a prestige indicator, and *out-degree* indicates the number of relationships from the node and represents the influence of the node. Dividing by n - 1 should standardize these indicators. The *betweenness centrality* considers that the importance of a node depends on the frequency with which it serves as an intermediate between two nodes. Therefore, a vertex has power if it stands on the geodesic of two actors. However, this power is lowered if the geodesic of these two nodes is not unique; in this case, there is another canal from which the information can pass. Formally, the importance of a node i is measured by dividing the number of times that i stands on the geodesic between two nodes j and k by the number of geodesics of these two nodes.

Thus, the *betweenness* of a node is calculated as

$$I = \sum_{k,\ j \neq i} \frac{P_i(kj)}{P(kj)} \tag{1}$$

with $P_i(kj)$ being the number of geodesics between k and j that pass by i and $P(kj)$ being the total number of geodesics between k and j.

The standard version of this indicator is

$$I_S = \frac{2\sum_{k,\ j \neq i} \frac{P_i(kj)}{P(kj)}}{n^2 - 3n + 2} \tag{2}$$

The *closeness centrality* measures the distance between one node and other nodes of the social network (Beauchamp, 1965). It is equal to the inverse of the average geodesic between this node and the other. The closer a node is to other nodes, the shorter the average distance between one node and the others. Thus, the formula for the closeness centrality of a node i is

$$P = \frac{1}{\frac{\sum_{ij} d_{ij}}{n-1}} \tag{3}$$

with d_{ij} equaling the number of links in the geodesic between i and j[2].

[2] The analysis could be technically extended to consider bi-dimensional cost-distance communication aspects between two nodes and to select from detailed information about non-dominated vectors (Gomez et al., 2013). However, this is outside the scope of this exploratory paper.

Table 1. Procedures for determining the level of influence of value-chain actors.

Dimension	Variables	Questions asked	Modalities
Setting power of the price	qa35	How are input prices fixed?	Regardless of him, by consensus, by himself, by market prices
	qa37	Are you able to influence input prices?	Yes, No
	qa41	How output prices are fixed?	Regardless of him, by consensus, by himself, by market prices
	qa43	Are you able to influence output prices?	Yes, No
Dependence on market	qa38	Do you have to buy inputs even when prices are high?	Yes, No
	qa44	Do you have to sell outputs even when prices are low?	Yes, No
	qa49	Do you have alternative possibilities to sell even if your major clients don't buy?	Yes, No
Asymmetric information	qa47	Are you able to control the market?	Yes, No
	qa48	Do you know the final destination of your product?	Yes, No

Sources: authors' elaboration.

Relationships between peanut value chain actors should be further characterised by the analysis of the influence of each of them (i.e., the power relationships). In this paper, this influence is studied through three criteria: dependence on markets, information asymmetry and pricing power. The power relationships in the value chain will be located through simultaneous examination of these three criteria and a multiple correspondence analysis (MCA).

The first approach is traditional; it only allows the identification of groups of influential actors. It does not give details about the individuals that influence or the level of their power. Thus, the concepts of distance and dispersion between two groups of individuals, the distance between two modalities, the distance between a modality and the centre of gravity, and barycentric relationships between groups of individuals and modalities allow an initial overview of the degree of influence of each stakeholder. However, this does not necessarily serve to identify power disparities inside each group of stakeholders. The second approach provides an indicator that calculates the influence of particularly influential individuals as follows:

$$\boldsymbol{I_i} = \frac{1}{\boldsymbol{Q}} \sum_{q=1}^{q=Q} \sum_{j \in j_q} \boldsymbol{W_j^q} \; \boldsymbol{k_{ij}} \tag{4}$$

with W_j^q being the weight accorded to the modality j of the question q and k_{ij} being the

answer given to the question by the individual *i*. The indicator of influence is the sum of the modality weights declared by individuals. Following this, to classify individuals according to their degree of influence, we developed a threshold of influence calculated as follows:

$$\boldsymbol{S = max(I_{non\text{-}influent}{*}M_{non\text{-}influent})+min(I_{influent}{*}M_{influent})} \quad (5)$$

with M_j being the weight of the class *i*.

2.4 Sampling strategy

The livelihoods of Ferlo's herders are so specific that it is useful to specify the contents given to the investigation units. The pastoral family does not limit itself to the parents and their direct descendants. There are four types of residency units in the Sahel: (1) villages (in Fulani: *nokuu*), or places where physical presence is important; (2) pastoral household activities, which allow us to identify the concessions (*guuré* in plural, *wuro* in singular) that are large units of residence; (3) encampments (*gallédji* in plural, *gallé* in singular) that are socio-economic units of people (with blood ties or not) who totally or partially combine their resources to foster collective well-being; and (4) households (*poye* in plural, *foyré* in singular) composed of relational atomic units of people tied by blood or by marriage (Wane *at el*., 2009b).

For the fieldwork, we focused on the borehole of Thiel, which is a structuring or keystone element of pastoral and agropastoral activity in this area. The first phase of the fieldwork involved updating an existing database built in 2006–2007 with a census of pastoral and agropastoral encampments dependent on this borehole (Wane et al., 2009). This complete database of 163 encampments provides basic information, such as the names and surnames of the encampment head, his ethnicity, the geographical coordinates, and herd composition by species. This updated database facilitates the definition of a representative sampling of the socio-demographic diversity of the Thiel site. In 2013, our investigation covered 120 encampments, which from a statistical point of view should represent a margin of error of 4.61 percent and a confidence level of 95 percent.

From this initial investigation, we found that only 80 encampments among the 120 encampments (67 percent) produce peanuts. Of these 80 encampments, only 22 have women as owners of peanut processors. We interviewed the household heads of these 80 encampments, as well as 22 women who were peanut processors. Investigations in these 120 encampments will allow us to identify the real position of producers (in terms of influence) from Thiel in the peanut value chain, calculate the added value created at each node, analyse the interactions between the peanut value chain actors, and identify bottlenecks in order to provide alternative interventions to improve the value chain. To achieve these goals, we conducted interviews with other key value chain actors: three big collectors, three important middlemen and nine haulers.

3. Position of peanut producers in the value chain: solid social relationships but weak technical and economic interconnections

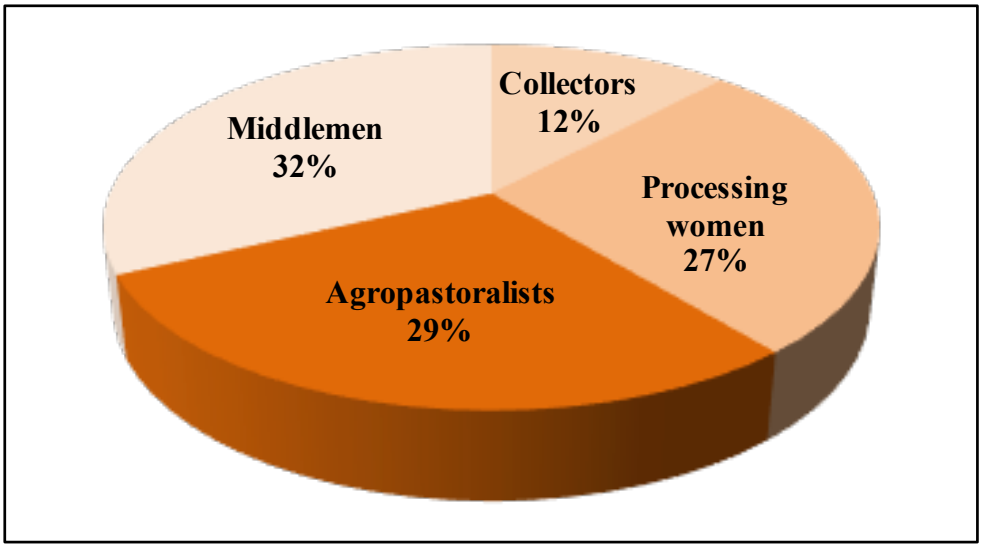
Using descriptive statistics, we first present some overall features of peanut activity at the agropastoral site of Thiel. We then highlight what seems to be the main difficulty for the producers: technical cooperation and knowledge sharing are seriously limited. Finally, we describe the asymmetry in the distribution of power among the stakeholders of the value chain.

3.1 Overall features of peanut activity

In 2012, the production of peanuts in Thiel was carried out at four sites in the southwest of the rural community near agricultural areas (Thiel Seerere, Moola, Darou-Nahim-Nguer and Siilat). Nearly 95 percent of agropastoralists create value from their primary crop production; the remaining 5 percent produce crops exclusively for self-consumption. However, the overall value is still unevenly distributed among producers (*Gini index: 0.65*). Only a small number of agropastoralists manage to capture significant value creation, and 90 percent of them receive half of the total value added along the value chain.

Almost all agropastoralists (95 percent) create value by selling at markets, and they generate 162 XOF or each kilogram of peanut product, which represents 29 percent of the total added value per kilogram obtained (Figure 3). The middlemen of Touba contribute more by providing 177 XOF (32 percent) towards the formation of the overall added value, processing women contribute 146 XOF (27 percent) per kilogram of peanut processed to oil, and collectors contribute 63 XOF (12 percent).

Figure 3. Contribution of each group of actors to the formation of the overall value.



Sources: authors' elaboration.

The dominance of middlemen in the formation of the added value is explained by their monopoly position in the market. They are price-makers and thus have the power to set the purchase price at which they buy peanuts from growers and the price at which they sell. They are in high demand, and agropastoralists use them to sell their products. The middlemen are in theory able to make an option on the total production.

In the process of peanut production, the producers of Thiel use peanuts as seed and fertilizer. An important proportion of the peanuts used for seed comes from purchases made by public authorities or middlemen (89 percent), but they also come from stocks after harvest. Bearing in mind the lack of flexibility in government administrative procedures, seed obtained from middlemen is more available and accessible for 58 percent of agropastoralists. In addition, 44 percent of producers are supplied from the public support units, and a similar proportion uses stock; however, the ability to use stock depends on the quality and quantity of the previous crop year. Few farmers (1 percent) declared getting seeds from their neighbourhoods.

Groundnut cultivation in Thiel is largely dependent on the volumes of seed and to a lesser extent on the quantities of fertilizer used, as well as the amount of labour and livestock available. The villages, which get large quantities of seed, experience better performance. A number of agropastoralists (30 percent) only use fertilizers and labour to cultivate, whereas a very large proportion (80 percent) use cattle to till the land for growing peanuts. The latter situation is not surprising because the area is dominated by agropastoral activities.

Seed prices vary depending on the suppliers. The average price fixed by the government is 225 XOF/kg. However, the average price from other suppliers is 433 XOF/Kg and, at times, the price reaches 800 XOF/Kg. Fluctuations in current prices fixed by middlemen depend on the quality of the previous crop year and prices of inventories and influence the supply of crop seeds from agropastoralists, as well as from those who are engaged in farming. The main uncertainty of the government's supplies derives from the uncertainty of their ability to provide sufficient quantities and quality at the right moment. Although the prices offered by the government are relatively stable due to a form of implicit subsidy, there are some logistical constraints in the distribution channel. Sahelian agropastoralists react to fluctuating prices by combining various supply sources, including the government, the middlemen and/or their own stocks.

3.2 Social network analysis of the peanut value chain

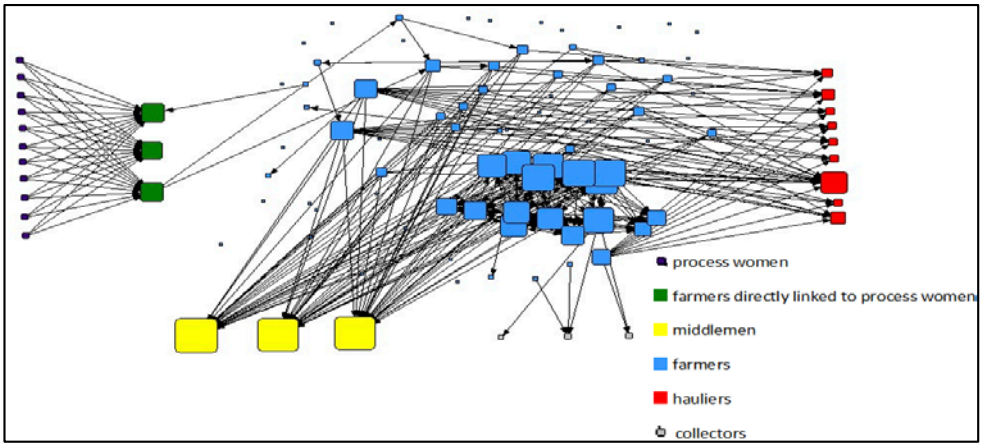
The matrix of social networks (Figure 4), which represents the positions of the different players in the value chain, shows that the bigger the square, the more important the requests from actors to any one given actor.

Middlemen from Touba (*in yellow*) are the most requested actors and have a dominant role in the peanut value chain. It seems that all the 120 investigated farmers sell to one of the three middlemen, who are in an oligopsony situation. Considering past interactions, most farmers seem to be conservatively attached to at least one of these three middlemen.

In fact, there is perhaps hardly any support for or transfer of technical and cultural practices among the agropastoralists themselves (Figure 5). Only agropastoralists from

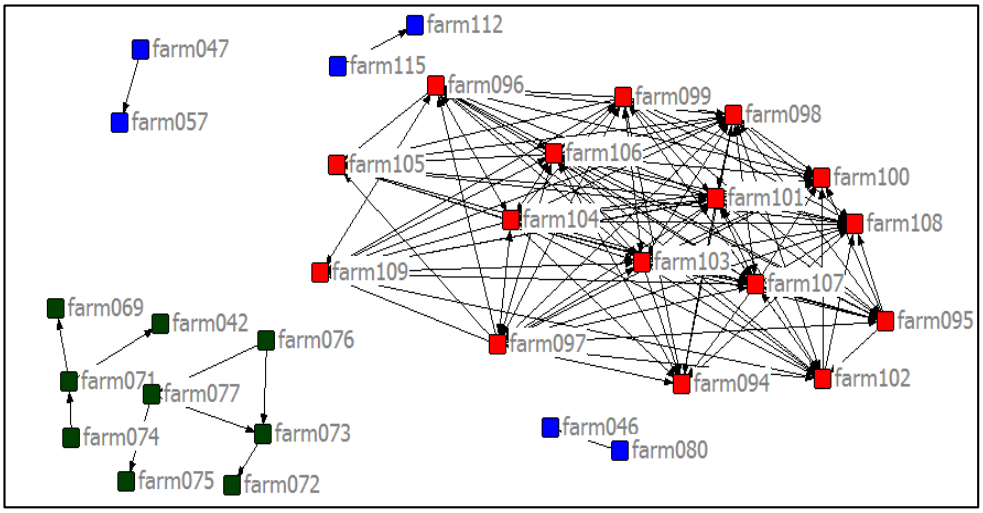
Thiel Seerere (*in red*) and Moola (*in green*) share knowledge on their agricultural practices. The others do not help each other; they almost all consider agricultural production as secondary to livestock activities. Cooperation in disseminating knowledge, understanding of practices and cultivation techniques could help minimise input quantities and costs in light of current conditions and help reduce post-harvest losses.

Figure 4. Relationships among actors in the peanut value chain of Thiel.



Source: authors' elaboration.

Figure 5. Capabilities transmission among producers.



Source: authors' elaboration.

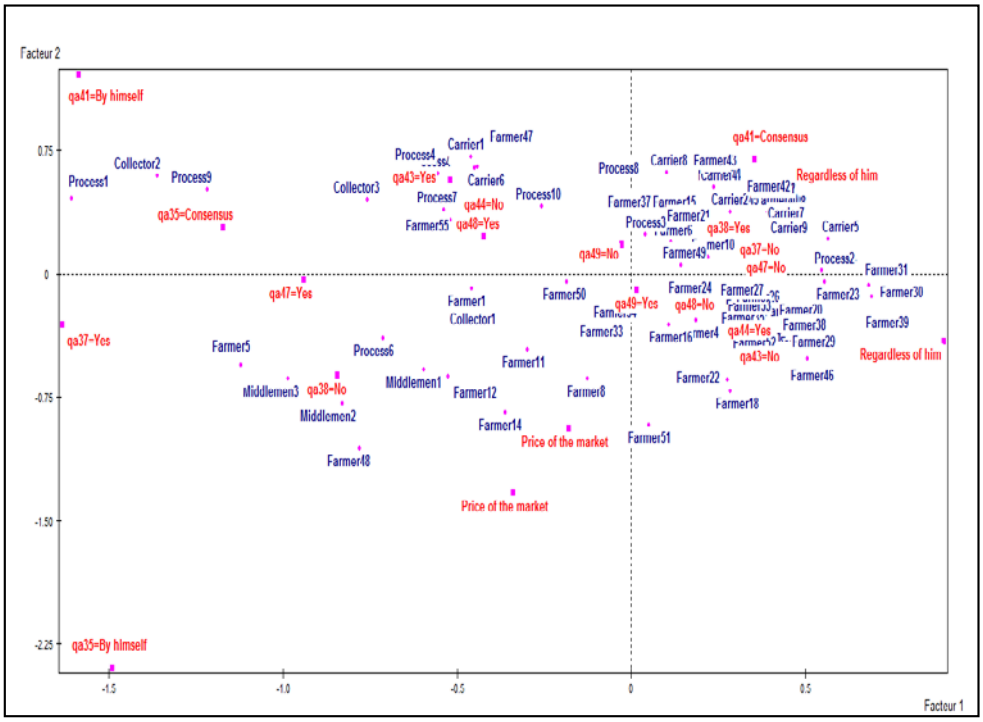
However, overall in the rural community of Thiel, there are very few technical and economic links. This was discovered by measuring the density of the value chain, which accounted for only 3 percent of the overall potential links. Social links are also very important as revealed by almost all interviewees.

3.3 Influential power of peanut value chain actors

To thoroughly represent the influence of each actor in the value chain, we use a graph (Figure 6, here) that is supported by questions summarised in Table 1. Thus, the first axis summarises all the information contained in the data. Indeed, from the left to the right of this axis, we pass from actors that have modalities related to influential individuals to actors that have modalities for non-influential individuals. Therefore, using the first axis ordering consistency (FAOC-I) criterion, the first axis is sufficient to characterise the actors according to their level of influence.

There are two types of individuals: those attracted by modalities that characterise an influential individual, and those attracted by modalities of the variables specific to a non-influential individual (refer to Table 1 for the variables). The individuals who are on the

Figure 6. Influence levels of the different nodes of the peanut value chain.



Source: authors' elaboration.

side of negative abscissa participate in pricing the inputs; they are not obliged to buy if the price of inputs is high (i.e., they do not depend on the market). These individuals fix or contribute to fixing the sale price, and they are not obliged to sell if the price is low. They master the market and know the final destination of the product. These characteristics are typical for an influential individual in a value chain.

However, the non-influential individuals must buy even if the price of the inputs is high. The sale prices of their products are fixed, and they must sell even if the price is low. Finally, they do not master the market or know the final destination of their products. They are real price takers, and their modalities are those of individuals who have little influence within the value chain.

The main actors of the value chain are all in very different environments. The middlemen of Touba act within a vast market, with many agents coming from several cities of Senegal or from abroad (Morocco, Vietnam, the Ukraine and China). The agropastoralists also deal with the middlemen of Touba if they cannot sell in the local market of Thiel. The processing women and the collectors, for whom intermediary activities are not a priority, are in the same position. Therefore, the middlemen of Touba have a larger market share and are the dominant actors in the value chain. They even have equipment for post-harvest crop processing, such as machines for hulling and the capacity to recruit personnel. On the contrary, agropastoralists and processing women have little capital with which to purchase equipment and machines or to hire competent personnel. The middlemen of Touba, the collectors and some processing women have the modalities characteristic of an influential individual. This is explained by the fact that Touba is considered the heart of the peanut market in Senegal. The middlemen completely master the market and buy the crops for the prices they have set, even if they consider the prices fixed by other middlemen.

The collectors can buy the products supplied by agropastoralists with more competitive prices because they expect that some of the agropastoralists must sell to meet their daily consumption needs. Therefore, the balance of power gives no choice to agropastoralists because they have low production volumes as well as weak financial and economical capacity, although some producers can be influential. Influential producers use their stock to sow and sell it only if they perceive favourable prices. They seem to be more informed than the others.

The position of the processing women is mixed. Those who are on the positive side of the abscissa are not influential; others are on the negative side and are influential.

The collectors, the middlemen of Touba, and to a lesser extent the processing women, are the most influential members of the peanut value chain of Thiel. On the other hand, agro- pastoralists and haulers remain vulnerable. The indicator built on the multiple correspondence analysis (MCA), which appears more precise in the identification of influential actors, supports this result. Therefore, 80 percent of the processing women are influential within the value chain. Only 22 percent of haulers are in this position. The producers are the most vulnerable in the market: 80 percent do not have any influence in the value chain.

Capital is also very important in the development of a value chain: it reinforces the production capacity of agropastoralists through the purchasing of seeds, materials and fertilizer, and it helps middlemen practice product management and motivates them to buy more peanuts from the producers. Access to capital assists the processing women in

acquiring high-quality process materials, which are also more adaptable and better adhere to health and safety specifications.

In the rural community of Thiel, the agropastoralists do not have access to formal agricultural credit. Only 29 percent of the peanut producers turn to financial credit. Among these agropastoralists, 77 percent were somewhat or completely dissatisfied with the quality of financial services, which are expensive and require prohibitive repayment conditions.

Most agropastoralists practice self-financing to buy seeds and fertilizer and/or to recruit people. The processing women are in the same position because the decision to borrow from financial operators depends on the position of the encampment chief and his creditworthiness. The collectors also claim that inadequate capital is a barrier. According to them, one of the principal ways to improve the peanut value chain is through access to credit.

4. Population-specific discussion

In the background of relatively high risks and uncertainties that characterises the Sahelian livestock production systems (D'Alessandro *et al.*, 2015), agropastoralists of Thiel also depend on peanut production to secure their livelihoods. The peanut crop development in Thiel largely arises from its closeness to the Senegal groundnut basin that influences agropastoralists' engagement in these agricultural practices and production. The agropastoral area of Thiel is inhabited mostly by three categories of populations: the Seereer, the Wolofs and the Fulani. Each of these categories is characterised by specific cultural practices that influence production systems. Functionally, peanut production helps to distinguish between two groups. On the one hand, the group composed of both the Seereer and the Wolofs is keener to practice agriculture for cultural and economic reasons, although livestock remains a form of insurance and patrimony. On the other hand, the group exclusively composed of Fulani is mainly oriented towards animal production and practices agriculture as a secondary or diversification activity. For all these categories of population, the peanut crop is used as is and/or processed into cooking oil by women agropastoralists for self-consumption and marketing, whereas crop residues are destined for animal feed. In this overall context, which is also characterised by relatively weak production volumes, market fundamentals are not the main drivers for peanut crop production, given its multiple uses. There are some similarities with herd management in extensive and pastoral systems, in which the objective function of producers is a composite utility function that balances their short-term consumption needs and long-term herd building strategy (Fadiga, 2013). For these reasons, they participate in market(s) in an opportunistic way (Wane *et al.*, 2010). However, the peanut crop remains key for household livelihoods and provides them with food, animal feed and a cash crop. In this regard, the peanut value chain analysis displays the overall context shaping the actions of the Fulani agropastoralists, who are mostly hindered and characterised by a lack of incentives to perform adequately or at least at the levels reached by others ethnic groups, such as the Seereer.

For the Fulani, the low standard of living and acute need for cash could lead them to sell their weak production even without adequate and expected market prices. This sit-

uation is exacerbated by the poor supply of financial services (for instance, in the area, there is only one financial structure, and it provides predatory short-term loans with very high interest rates). In addition, infrastructure is weak, with all-weather poor rural roads driving up transportation costs. Furthermore, the strong dependency on rainfed agriculture constitutes an aggravating factor in a context of climate change. In such a situation, instead of trying to sell to the middlemen who usually propose higher prices, agropastoralists end up limiting the area in which they sell their production. In addition, the lack of incentive to engage in such a demanding journey to reach the main market forces agropastoralists to rely heavily on some collectors present in the local market. Finally, their lack of knowledge regarding peanut production in comparison to the other group (the Seerere and Wolofs), as well as the frailty of technical cooperation, does not facilitate the emergence of an enabling environment for producers, who remain the weaker node of the peanut value chain.

5. Conclusion with options to move forward

In these conditions, improving the peanut value chain in Thiel requires taking action to boost the agropastoralists' position—locally and eventually globally—to refine the economic environment.

5.1 At the producer level

One of the main points highlighted in this case study is the weakness of the economic, technical and organizational cooperation between producers, despite their claim to be developing strong social relationships. Thus, the capacity building of the producers should be more focused on pragmatic goals. For instance, it could be decided to gradually increase the level of technical cooperation and the sharing of knowledge in agricultural practices. In this case, it could be interesting to inclusively build from 3 percent of the overall potential economic and technical cooperation towards more significant levels.

5.2 At the value chain level

Public policies could help by providing a better integration of heterogeneous knowledge (including local scales) and by orienting agricultural research toward development outcomes. Due to the economic dominance of livestock activities in this semi-arid area and the importance of food in household budgets, the main option is to intensify crop-livestock activities to obtain viable and sustainable production systems (McIntire *et al.*, 1992). This implies the increased use of external inputs, adaptation of agricultural innovations to local conditions, and the provision of incentives for smallholder farmers in order to strengthen their production capacity, build trust along the value chains and create a favourable business environment.

One concrete way to attempt this inclusive objective could be to ensure that the actors of the value chain benefit from moving towards the establishment of genuine inter-professional actions through a technical, organizational, managerial and management innova-

tion platform. This platform, through which all stakeholders will be represented, should be a framework that considers different expectations, identifies the main constraints within the value chain, and allows the co-construction of innovations and the facilitation of their appropriation, which should include collective sharing of best practices in production and management.

The innovation platform members will be notably responsible for the ***(i)*** development of rules for the micro sector (participation requirements, definition of floor prices to maintain economic viability, reference prices, and technical specifications); ***(ii)*** the validation of quality conventions for inputs and final products; ***(iii)*** the capacity building of stakeholders through technical and technological training programs to increase agricultural yields, as well as post-production training in terms of management and organization (business plans, networking, central purchasing units, etc.) to improve agricultural productivity; ***(iv)*** the development of credit and insurance systems adapted to crop-livestock systems and ***(v)*** the implementation of market information systems to reduce information and position asymmetries.

In terms of policies, public authorities should consolidate existing producer organizations and networking across permanent frameworks for consultation, exchanges, collaboration and learning. They should design sustainable intensification options, minimise losses and wastes in peanut value chains and systematise impact assessments of major solutions through a gender lens, given that the impact of gender on these issues should be considered as improvement strategies are developed.

Finally, this study stresses the role and importance of social networks, which could be more finely analysed to design improvements for the training and organization of producers. Therefore, combining the traditional value chain approach with social network analysis is crucial to move forward towards resilient systems.

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