Contributed Paper Template:

Analysis of Sahelian Herders Market Behaviours to Facilitate Moving Towards Structural and Sustainable Transformation of Pastoral Economies

Abdrahmane WANE[1]*, Aliou Diouf MBALLO[2], Ibra TOURE[3], Nelly NJIRU[4]

[1] Development Economist - CIRAD-SELMET – ILRI-PIL, ILRI Campus, Mara House Building, PO BOX 30709, Nairobi, Kenya - awane@cirad.fr / A.wane@cgiar.org – **corresponding author**

[2] Statistician Economist, Consultant in Agricultural Statistics, FAO, Viale Del Terme Di Caracalla, Rome, Italy

[3] Geographer - CIRAD-SELMET– Hosted at CILSS – 03 BP 7049, Ouagadougou, Burkina Faso

[4] Research Associate in Agicultural Economics at ILRI, ILRI Campus, Mara House Building, PO BOX 30709, Nairobi, Kenya

Contribution presented at the XV EAAE Congress, "Towards Sustainable Agri-food Systems: Balancing Between Markets and Society"

August 29th – September 1st, 2017

Parma, Italy

Abstract

Many research and development institutions advocate the integration of economic sectors to markets to benefit from them and reduce poverty. This is not so simple for Sahelian pastoralists living in uncertainty and absence of contingent markets. Sahelian pastoralists use livestock markets but these markets don't systematically influence their production and marketing decisions. Based on the case of Senegalese Sahel, we use a spatial panel model to estimate the magnitude impacts of spatial and time factors on pastoral income generation. Then, we extent discussions to show that Sahelian livestock keepers alternate *homo oeconomicus* and *bounded* behaviours vis-à-vis the markets that they know well even if markets don't know much about them - and that is one reason it can be hard for a real structural transition. The problems of pastoral marketing systems are still examined from the perspectives of infrastructure buildings while it is also necessary to reduce transaction costs and information asymmetry to boost livestock sales and purchases.

Key words: *spatial panels - Income – market behaviours – structural transformation – pastoralism - Sahel*

Acknowledgements

The authors would like to thank the CILSS (Permanent Interstate Committee for Drought Control in the Sahel which, throughout the World Bank Regional Sahel Pastoralism Support Project (P147674), for commissioning and supporting this study. Many people generously contributed to the study by providing documentation and suggestions, including CIRAD-SELMET researchers and team members of GIS-PPZS (an Interest Scientific Group known as Pole on Pastoralism and Drylands) based in Senegal with a regional mandate.

INTRODUCTION

The Sahelian livestock systems are dominated by traditional and informal pastoral activities that involve production, consumption and marketing in a changing environment. Increasingly, pastoralists are strongly invited to engage more actively in markets. However, in situations characterized by high levels of uncertainty and absence of contingency markets, Sahelian pastoral households use livestock markets in a timely manner to balance short-term consumption needs and long term herd building strategies to meet future consumption (Wane *et al*, 2010; Fadiga, 2013).

The largely shared idea to link rural smallholders to high value or growth markets (Henson and Jaffee, 2006) assumes that markets create value and positive impacts on poverty reduction (Bhagwati and Srinivasan, 2002; Dollar and Kraay, 2004; Maertens and Swinnen, 2009). However, some authors cautiously predict correlation but not causality effects (Annabi *et al*, 2008). Assuming *homo economicus* behaviours, the main recommendations consist of reducing distance to physical markets by facilitating access through new infrastructures even though, in East Africa, simulations on the presence of infrastructure programmes show a mixed impact on long-term sales (Baldwin *et al*, 2001).

Producers in Sahelian extensive systems participate in market in an opportunistic way. Market fundamentals are not the primary drivers; cultural, social, and non-commercial factors more often than not play a more significant role in producers' decision to sell. A consistent literature on inequality (Sen, 1981; Sutter, 1987; Wane *et al*, 2009; Mulder *et al*, 2010) and vulnerability of pastoral populations (Swift, 1989; Ancey *et al*, 2009) show the complexity of pastoral strategies to secure their livelihoods, as it is necessary to take into account the embeddedness between social and biophysical factors particularly in African extensive crop–livestock systems. So, extensive systems cannot be measured in purely terms of endowments as they continually evolve and adapt to accommodate (entitlements) an increasingly uncertain biophysical environment and monetized commercial world (Chambers, 1990; Van Dijk, 1997; Bovin, 2000).

Although Sahelian pastoralism cannot be measured only in monetary terms and has also significant non-market drivers, we focus on market realizations to address the singular market behaviours of Sahelian livestock keepers and factors that constrain sustainable marketing of animal products.

Thus, the main stake of this paper is to describe the reality of average pastoral incomes and under which conditions Sahelian pastoral producers could benefit from lucrative market opportunities and in extent to respond to the challenge of rising consumption of meat and milk in Africa (Delgado *et al*, 1999).

To highlight all this, we rely on two surveys conducted in 2005 then in 2015 in the Senegalese Sahel and based on monitoring of the main livestock markets and investigations of 276 (in 2005) and 178 (in 2015) encampments[1] on five (in 2005) and four (in 2015) pastoral and agro-pastoral sites chosen for their representativeness of the diversity of the Ferlo socio-ecosystem (Wane *et al*, 2010).

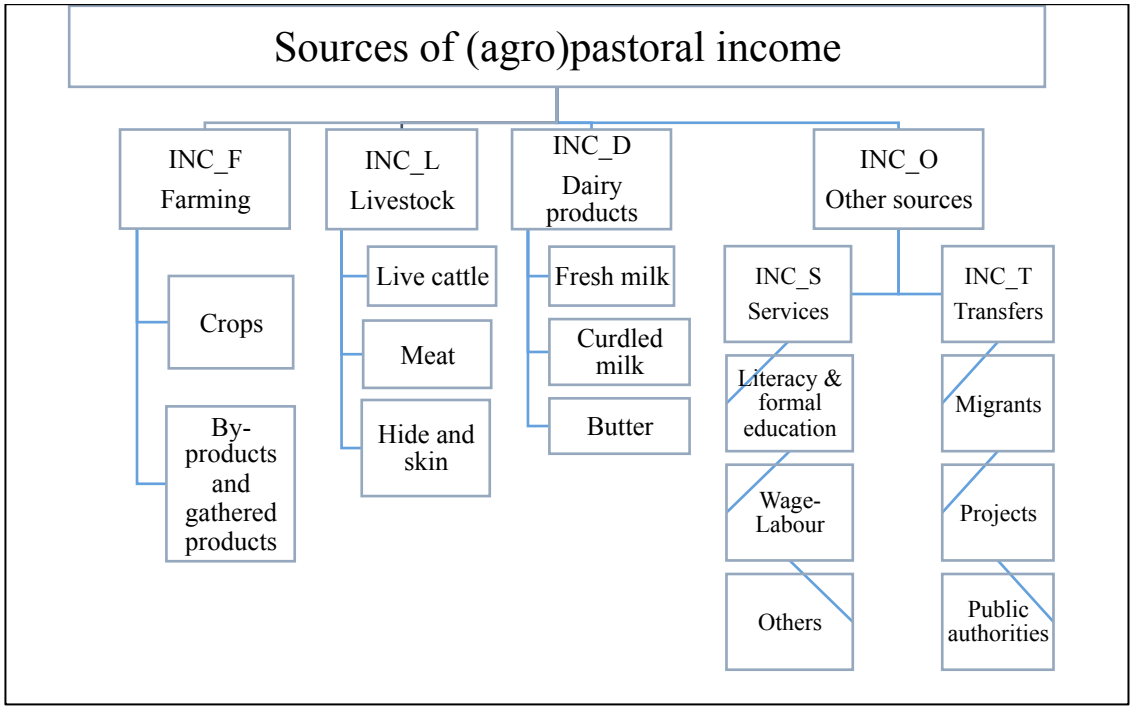
2- CONCEPTUAL FRAMEWORK AND PRIMARY DATA COLLECTION PROTOCOL

In this section, we give a definition of pastoral household income and the limitations we used in this study and describe the conceptual framework, the study area and finally the sampling approach of targeted households for primary data collection.

Definition of pastoral household income sources

This paper is far to talk about total economic valuation of pastoral systems, which is still debating and deeply discussed by Krätli (2014). Pastoral household income may be classified through four main sources. These are: farming, pastoralism, services, and transfers. The income from pastoralism should include produced crop and livestock for own household consumption in addition of all market sales and monetary transfers. For ease of reference and mainly to focus on market behaviours, we simply consider in this paper the products and services valued on market prices as well as the monetary transfers.

Figure 1 – Main sources or (agro) pastoral income



[1] The encampments (in Fulani: *guuré* in plural, *wuro* in singular) are large units of residence grouping many households. Encampments are directly identifiable settlement units that reveal the level of market income aggregation that we chose to assess in this study (Wane *et al*, 2009).

Conceptual framework

We build income indicators by using information provided from investigated pastoral households and descriptive statistics to produce first estimates of the contribution of each source of income to overall income. Then, we use spatial econometric models to highlight spatiotemporal variability in pastoral income and especially the interaction effects among geographical units across time and space. In terms of modelling, there are various approaches that differ especially by incorporating level of spatial lags of dependant and/or independent variables. An absence (Baltagi *et al*, 2003) then a partial consideration (Kappor *et al*, 2007) of spatial lags of dependant variables were usefully completed by a systematic inclusion of these lags for both dependant and independent variables (Baltagi and Liu, 2008, 2011; Elhorst, 2011; Mutl and Pfaffermayr, 2011) to show that spatial econometric models could usefully quantify the magnitude of direct and indirect effects in various time horizon.

We also take into account the spatial dimension (Florax and Folmer, 1992) to react to eventual spatial correlation and heteroscedasticity of errors (Anselin *et al*, 2008). Ignoring this spatial dependence in variables could be costly as one or more relevant explanatory variables could be absent in the regression equation (Le Sage and Pace, 2009). Its non-consideration in the disturbances could pose efficiency problems (Elhorst, 2011). To be complete, we build a spatial weight matrix to materialize the spatial dimension and give information on individual closeness that could result from geographical, social or technological aspects.

The model is written as follows: $\mathrm{INC\_T} = \lambda(\mathrm{I_T} \otimes \mathrm{W_N})\mathrm{INC\_T} + \mathrm{X}\beta + \mu$

with INC_T the matrix of total income on four periods (rainy season 2005, dry season 2005, rainy season 2015, dry season 2015). The matrix X concentrate the components of the total income as described in ***Figure 1****, the household size (HS), the residency area (RA), and the breeder category (BC).*

Thus the disaggregated model is as follows:

$$INC_{T\,it} = \lambda \sum_{j} \omega_{ij} INC_{G\,jt} + \beta_1 INC_{D\,it} + \beta_2 INC_{L\,it} + \beta_3 INC_{F\,it} + \beta_4 INC_{O\,it} + \beta_5 HS_{it} + \beta_6 BC_{it} + \varepsilon_{it}$$

with INC_D: dairy income; INC_L: livestock income; INC_F: farming income; INC_O: other income.

In our approach, we both implement fixed and random effects models. These specifications depend on ε_{it}. To avoid size effect and to maintain an elasticity approach, all variables have been turned into logarithms. The models are estimated by the maximum-likelihood method. The best one has be selected among these two models by using the Haussman criteria

Primary data collection protocol

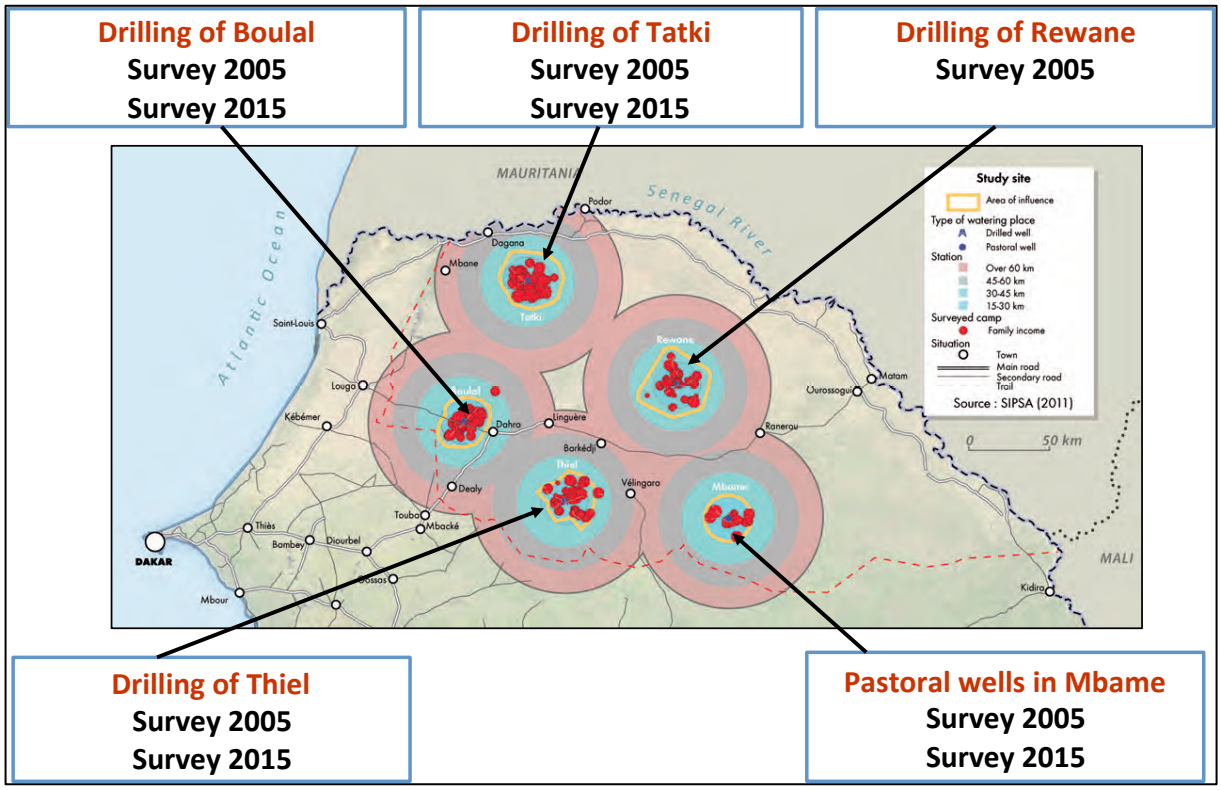
The investigations were conducted in 2015 with pastoral households located in the Senegalese Sahel known as Ferlo, a dry geographic space that covers 67,610 km^2 (PPZS, 2004), roughly a third of the Senegalese territory. Its climate is characterized by rainfalls concentrated in 2 to 3 months, with an annual average lower than 200 mm in the extreme North and higher than 550 mm in the South. For this study, the idea was to investigate in 2015 the same pastoral encampments georeferenced and interviewed in 2005. In 2005, the fieldwork on agro-pastoral and pastoral households was concentrated on five sites.

The sites were chosen following a North-South transect to have a representative ecological, geographical, pastoral and biological diversity of the extensive production system in Senegal.

The site of **Tatki** is a sandy area exclusively pastoral located in the Northern frontier of the Ferlo. Its proximity to national roads and the Senegal River Valley (40km) facilitates economic trade and social links with farming populations. The communities in this site are scattered around a pastoral borehole built in 1953.

There exist basic infrastructures (most not functioning very well) and the intermittent presence of a health officer that provides health services to the population, a weekly livestock market mainly for small ruminants, and a primary school located close to the borehole.

Figure 2: study areas in 2005 and 2015



The site of **Rewane,** an area of extensive livestock production is located in the Centre-East of the Ferlo. As for Tatki, this site has basic mostly non-functional infrastructures. There are 2 boreholes: the first one was drilled in 1956 (with a depth of 270 meters) and the second one was operational in 1987 (with a depth of 294 meters). The two boreholes are not operating as the second broke down in November 2014. It is planned to drill a third one in 2017 funded by the government. There are some privately owned drills with lower flow and higher costs. There is a health office, a school with only two teachers, and a non-resident extension agent coming from Dahra (82 km) to visit them from time-to-time.

The site of **Boulal** is located near the big agglomeration of Dahra. It has a pastoral borehole around which breeders population valuing pastoral patrimony organize their activities. The interest of this site is also its proximity to the urban city of Dahra, the biggest cattle market of the country.

The site of **Mbame**, at the southeast of Ferlo, is an agrosilvopastoral area and a wildlife nature reserve. It is characterized by the quasi absence of public policy footprint as there is no structuring infrastructure. Unlike other study sites having public pastoral drilling, the site of Mbame has many private pastoral wells.

Further South, in the agro pastoral area of the Ferlo there is the site of **Thiel**, a locality where Fulani livestock keepers are cohabiting with farmers from other ethnic groups (Wolof and Sereer). Thiel is an important hosting area for transhumant. There are basic infrastructures that function better comparing to the other sites. There are successively two boreholes: the first was built in 1951 (with a depth of 251 meters) and the second in 1993 (with a depth of 237 meters). The relatively well functioning of the school is explained by the presence of family farmers that are sedentary. The bi-weekly market of Thiel (Wednesday for livestock and crop market and Friday for cattle) could be linked to the closeness of Dahra (km 40).

The surveys were conducted in the encampments in which the main respondants for all questionnaires were the heads of household and their spouses. The distinction between encampments and households derives from the fact that the Sahelian pastoral family is a set of households (in Fulani: *kiralé* or *poyé* in plural, *hirandé* or *foyré* in singular) living in encampments (*galleji* in plural, *gallé* in singular) which are management and production units (Wane *et al*, 2009).

In 2005, we finally make a sampling of 276 in a total of 740 listed encampments; 20 percent of these investigated encampments are located in the site of Rewane, 29 percent in Boulal, 20 percent in Thiel, 23 percent in Tatki and 8 percent in Mbame. From a statistical point of view, this sampling represents a margin of error of 4.68 and a confidence level of 95 and corresponds to statistical standards (Anderson *et al,* 2001).

Due to the early entry of the lean period in February 2015 (generally expected in April-May), the last survey was only conducted on four sites (Tatki, Boulal, Mbame, Thiel). We decided not to integrate the site of Rewane because most of pastoralists had already moved towards better conditions. Thus, we investigated in 178 encampments and had complete data from Tatki, Boulal, Mbame and Thiel.

Assumption on the comparability of the data across the time

In the 2005 database, the income are aggregated and thus do not distinguish seasonality income generation. This is not the approach chosen for the 2015 database in which all sources of income are seasonally identified. For ease of reference and in view to compare the four periods necessary for the spatial panel model, we assume that the income structure according to the season does not vary much over a decade. It supposed that income, population and consumption structure does not change a lot during a decade. Even though this assumption might appear too strong, it may be recalled that in many countries mainly in Sub-Saharan Africa, the 5 or 10-years Budget-Consumption Surveys usually adopt the assumption that the expenditure structure does not change (ANSD, 2010, 2011). Furthermore, the Banque Nationale de Belgique (2010) reported that components of income structure grow at the same proportion in long term. Thus, in this paper, we apply the proportions calculated in 2015 on the seasonal source on income in 2005.

3- MAIN RESULTS

Our investigations in the Ferlo resulted on interesting findings on the sources of monetary nominal income for pastoral breeders. We present first, a brief description of data we used for our modelling then present the main findings highlighting the direct and indirect impacts of each source of income by distinguish results based on the spatial distance matrix and those on the spatial contiguity matrix.

3.1. Description of used data for modelling

Our model incorporates four categories of nominal income resulted from the sales of farming, livestock and dairy products as well as services and transfers.

Dairy incomes are provided by seasonal sales of fresh and curdled milk as well as butter.

Three categories of live animals were taken into account in our model: cattle, sheep and goat. These three categories are the main animal species found in the Senegalese Sahel.

From farming, incomes are generated by sales of agricultural products such as millet, corn, cowpeas, groundnut, gum Arabic (acacia gum), jujube and fruits of the Baobab (monkey bread).

Finally, the other incomes used into the model are those from various services (wage-labour as shepherd, teaching and literacy, agriculture services, trading and whelk water) and various transfers from development projects, public subsidies and migrants.

The size of household is determinate from the declarations on number of people living in the same encampment.

In addition, the herd size is built to provide three categories of livestock keepers. These thresholds are discussed and co-validated with producers (Wane *et al*, 2010). Thus, the small livestock keepers (SLK) are people having less than 5 cattle and less than 30 small ruminants, the average livestock keepers (ALK) between 5 and 29 cattle and/or between 30 and 99 small ruminants and the large livestock keepers (LLK) with more than 30 cattle and/or more than 100. It is also important to note that all encampments are georeferenced.

3.2. Main results from the model

The Lagrange multiplier test showed that the spatial dependence should be taken into account in panel modelling. The associated p-value of 0.02 shows a spatial autocorrelation of residuals. Similarly, the "technological" distance between agro-pastoralists has an effect on their income. Furthermore, the specification results with random and fixed effects and should be interpreted both for the distance and contiguity matrix.

Spatial distance matrix

Overall results with the criteria of belonging to the same area are consistent with initial assumptions.

Table 4: results of the estimates with the spatial distance matrix

	Coefficients	Standard deviation	t-value	p-value
$\boldsymbol{\lambda}$	-0,00016967	0,000069987	-2,4243	0,0153
Constant	3,97270058	0,251169245	15,8168	0,0000
INC_D	0,0153957	0,005923654	2,5990	0,0093
INC_L	0,7030986	0,014641687	48,0203	0,0000
INC_F	0,0465681	0,031917773	1,4590	0,1446
INC_O	0,0277855	0,008205004	3,3864	0,0007
INC_{HS}	0,0371358	0,059389639	0,6253	0,5318
Average Livestock Keeper (ALK)	0,14294882	0,087315852	1,6371	0,1016
Small Livestock Keeper (SLK)	-0,47216459	0,154874268	-3,0487	0,0023
Large Livestock Keeper (LLK)	0,39366312	0,099792105	3,9448	0,0001

Sources: Author calculations

All coefficients of explanatory variable are positive meaning that there is a positive relationship between overall income and income categories. However, the household size and farming income are not significant and income from agriculture are not statistically significant at 5 per cent. These variables do not really affect the overall income of a given household with such specification. (**Table 4**).

The spatial autoregressive coefficient of -0.0017 is negatively significant at 5 per cent meaning that if the overall income increased by 1 per cent for households of the same area, the impact on income of aimed household could decrease by 0.0017 per cent. Thus, the increase in overall income of some households in a given area could reduce the overall income of another household located in the same site. For instance, for

dairy products, if a household sells more milk to collectors who come into an area, it could decrease the volume of milk sold by the other households given the limited storage capacities (all things being equal).

The income generated by the sales of live cattle, milk and others positively affect the overall income of the livestock keepers. However, the increase in live cattle income is more predominant as if it increases by 1 per cent, the overall income increases by 0.7 per cent. The coefficients associated to dairy income and others are respectively 0.02 and 0.03: if the sales of dairy products (others) increase by 1 per cent, the overall increase by 0.02 per cent and 0.03 per cent. Thus, a pro-herder income policy could be designed around the improvement in live cattle income.

The livestock keeper category has an impact on overall income. The reference group is the category of Average Livestock Keeper (ALK). The coefficients related to Large Livestock Keeper (LLK) and Small Livestock Keeper (SLK) are statistically significant at 5 per cent. The coefficient associated with the SLK is -0.47. So, when a livestock keeper moves from ALK to SLK, its overall income decreases by 47 per cent while those passing from ALK to LLK has overall income increasing by 39 per cent. Thus, the livestock keeper category plays an important role in the generation of overall income.

Spatial contiguity matrix

With the exception of the household size, all variable are statistically significant at 5 per cent. The positive link between income categories and overall income is confirmed. A unit variation in live cattle income leads to an increase of 0.53 per cent of overall income; the improvement remains quite low for dairy product income and others (respectively 0.03 and 0.09 per cent). However, the rising of overall income provoked by these last sources of income has improved compared to the situation known in the spatial distance model. In addition, a unit increase of farming income improves overall income but at a small proportion (0.04 per cent). Although the household size is significant at 10 per cent but it has a negative effect on overall income for the same reasons already given above.

The coefficient associated with spatial delay is significant and positive; it is positively related to overall income. An increase of 1 per cent of overall income in the same herd size class improves the income of the aimed household by 0.02 per cent. There are positive externalities of "technology" activities in the study areas. Indeed, household activities in a given area positively impact on the activities of others. One explanation for this might be the fact that households in the same herd size class share knowledge on farming practices and thus, each of them manages to increase its herd size and thereby enhance its overall income. Moreover, the herd mimetic behavior could explain this phenomenon. For instance, decision to sell or to go transhumance depends on the observations of the behaviors developed by others, and especially those being in the same category.

Table 5: results of the estimates with the spatial contiguity matrix

	Coefficients	Standard deviation	t-value	p-value
$\boldsymbol{\lambda}$	0,104928	0,0172511	6,0824	0,0000
INC_D	0,027324	0,0065223	4,1893	0,0000
INC_L	0,528248	0,0153961	34,3104	< 2,2e-16
INC_F	0,037874	0,0143981	2,6305	0,0085
INC_O	0,085544	0,0078912	10,8405	< 2,2e-16
INC_{HS}	-0,148720	0,0828197	-1,7957	0,0725
Average Livestock Keeper (ALK)	0,405845	0,1257175	3,2282	0,0012
Small Livestock Keeper (SLK)	-0,889392	0,1847061	-4,8152	0,0000
Large Livestock Keeper (LLK)	0,434097	0,1661069	2,6134	0,0090

Sources: Author calculations

The livestock keeper category continues to play an important role in the constitution of overall income. It positively or negatively impacts according to movements towards highest or lowest categories. A household, increasing his herd size to move from ALK to LLK, increases its overall income by 80 per cent. However, passing from ALK to SLK negatively impact the overall income which declines by 89 per cent. (**Table 5**).

4- Discussions

Here, we highlight the main trends identified on the specific populations investigated in this study then we strengthen the analysis through a general discussion on the contingent relationships of Sahelian livestock keepers' vis-à-vis the cattle markets.

Population-specific discussion

The physical distance between pastoral settlements influence the overall income generated by livestock keepers. Pro-pastoral income policies should promote the development of pluriactivity while improving the volumes of production and breeding activities. These policies should contribute to facilitate market access not only through market infrastructures. Of course, by assuming an exclusive *homo economicus* behaviour, the main recommendations consist of reducing distance to physical markets by facilitating access through new infrastructures. However, it should be noted that simulations on the presence of infrastructure programmes in East Africa show a mixed impact on long-term market sales (Baldwin *et al*, 2001). The problems of pastoral marketing systems do not systematically and exclusively examined from the perspectives of infrastructure buildings, it is also necessary to reduce transaction costs and information asymmetry to boost livestock marketing. The suggestion to stimulate the pluriactivity makes sense as the diversification usually observed in pastoral areas does not have enough impact on income generation as agricultural activities are rudimentary and mainly oriented towards the subsistence of actors and also ensure their food security. The lean period remains the hardest time for agro-pastoralists.

Expanding livestock herd significantly improves livestock keeper income. This must be done through promoting the feed supplementation in the dry season and drilling construction. Rousseau (2010) highlighted the importance of supplementation of animals especially for lactating cows and its importance in the management of calves in particular, and the herd in general. Fieldworks have shown that livestock keepers mostly need support during the dry season and mainly during the lean season. A particular focus should be done on small livestock keepers who do not have sufficient capacity to deal with these very changing environment. In addition, a specific support should also be done on income inequality reduction that remains very high in Senegalese pastoral areas (Gini index: 52.8) with a clear break between the North very driest (Gini index > 50 per cent) and the South relatively more watered (Gini index < 50) (Wane *et al*, 2009).

More generally, there are common factors that could contribute to increase livestock keeper income (feed supplementation, pluriactivity); however, the sociocultural characteristics should be considered in political decision-making process to improve the livelihoods of Sahelian agro-pastoralists.

General discussion and conclusion

Sahelian pastoralists always do a differentiated supply on the livestock markets. They generally sell animals when it is necessary to meet minimum household consumption requirements. They rather develop a bounded rationality-satisficing approach (**Figure 3; point A**) and generally propose culled animals. Most of them keep animals for their variety of benefits (milk, butter etc.). As part of heritage, animals are generally marketed when they exceed a depreciation threshold or are above the holding costs. While neoclassical approach is tempted to materialize optimization interactions (**Figure 3; point B**), Sahelian pastoralists usually hold money to cover current expenditure. This is the reason for which, the relative price between consumer goods and animal constitutes their main reference. They do not have accurate information about market parameters and rely on the prevailing belief on market trends. This is a shortsighted and the animal

production is often disconnected from market parameters except where they have a more clear market view (during some religious feasts for instance). Pastoralists are often involved to the markets by providing rigid supply particularly for small ruminants and realize the reality of market prices once they are in the presence of others markets actors (middlemen, buyers). Globally, sales under optimization behaviour are higher than those observed under bounded rationality ($Q_b \succ Q_a$). This current situation in the Sahel leads to livestock markets structurally very tight with upward prices that sometimes do benefit neither pastoralists nor final consumers. If prices are lower than those expected, overall income decreases (R_a^-) and barely covers the already very austere current consumption; thus leading pastoralists in vulnerability zone. Conversely, if prices are higher than those expected, what happens after that depends of middlemen that can either reallocate surplus to pastoralists (R_a^+) or maximize their own money earnings (**Figure 4**). In other contexts, particularly during periods of great religious or customary holidays, *homo oeconomicus* behaviour prevails among some pastoralists who supply animals with great discernible visual qualities. Thus, they base on quality conventions covering such a broad spectrum: estimated weight and visible physical characteristics (colour, horns). In this favourable market conditions, pastors develop a pure optimizing behaviour so prevalent market rules compete with conventional direct confrontation between supply and demand (**Figure 3; point B**).

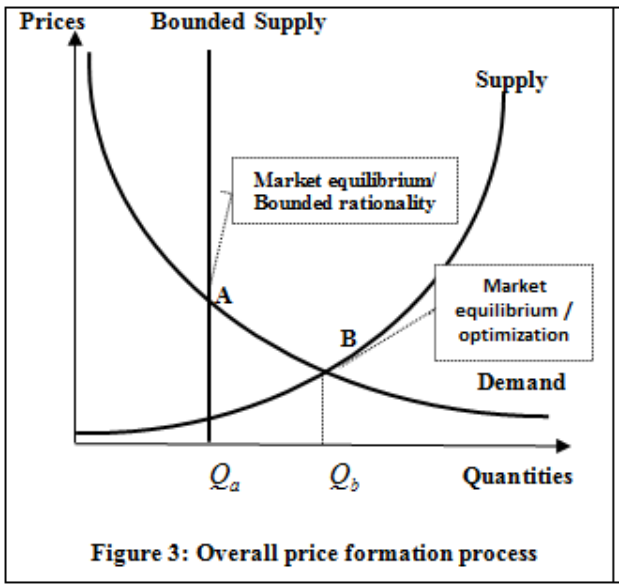


Figure 3: Overall price formation process

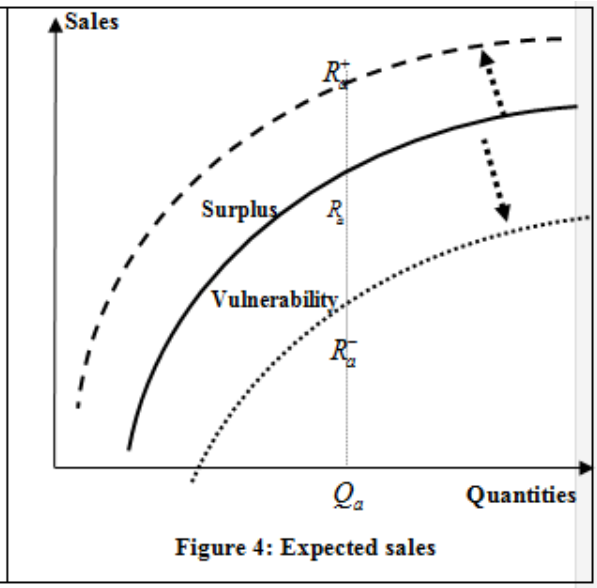


Figure 4: Expected sales

The supply of livestock (especially small ruminants) seeks to coincide with a very high demand. The pastoralists are aware of the ephemeral nature of this situation and have a good knowledge of the market functioning.

Livestock keepers in Sahelian areas continue even today to respond to production shocks (mobility, forced sales, herd splitting, herd diversification, flexible social organization, seasonal labour, wage-labour, fertility transfer with crop systems etc.) that enabling environment has difficulties to manage, as it should be expected**.** Although production, trade, storage and safety nets policies are useful to support producers and consumers to cope with price fluctuation impacts, it is also necessary to consider intangible aspects by reducing transaction costs, information asymmetry, risks and uncertainties and unequal access to pastoral resources to make commodity and livestock markets more dynamics.

The main limitation of our survey is based on the unavailability of time series. Indeed, data for the whole period 2005-2015 were not continuously available. It might be interesting to have a full panel survey (each year or each two years) in order to enhance the quality of this promising work.

5- References

Ancey V, Ickowicz A, Touré I, Wane A, Diop AT (2009). La vulnérabilité pastorale au Sahel: portée et limite des systèmes d'alerte basés sur des indicateurs, In : Duteurtre G. et Faye B. Ed., « *L'élevage, richesse des pauvres – Stratégies d'éleveurs et organisations sociales face aux risques de paupérisation dans les pays du Sud* », Editions QUAE, p. 117-132.

Annabi N, Cissé F, Cockburn J, Decaluwé B (2008). Libéralisation Commerciale, Croissance et Pauvreté au Sénégal: Une analyse à l'aide d'un MEGC micro-simulé dynamique. *Économie et Prévisions*, Vol 186, 2008-5

Anselin L, Le Gallo J, Jayet H (2008). Spatial panel econometrics. In: Mátyás L, Sevestre P (eds) The econometrics of panel data, fundamentals and recent developments in theory and practice, 3rd edition. Kluwer, Dordrecht, pp 627-662

Baldwin KL, Foster K, Jones K (2011). A stochastic approach to evaluating livestock marketing policy. *African Journal of Agricultural and Resource Economics*, African Association of Agricultural Economists, vol. 6(2), September, 104-17

Baltagi BH (2005) Econometric analysis of panel data, 3rd edition. Wiley, Chichester

Baltagi BH, Liu L (2008). Testing for Random Effects and Spatial Lag Dependence in Panel Data Models. *Statistics and Probability Letters*, 78, 3304–3306.

Baltagi BH, Liu L (2011). Instrumental Variable Estimation of a Spatial Autoregressive Panel Model with Random Effects. *Economics Letters*, 111, 135–137.

Baltagi BH, Song SH, Koh W (2003). Testing Panel Data Regression Models with Spatial Error Correlation. *Journal of Econometrics*, 117, 123–150.

Banque Nationale de Belgique (2010). Tendances et volatilité des revenus et de la consommation des ménages : une analyse comparée entre la Belgique et les pays voisins, Département des Etudes 16 p.

Bhagwati J, Srinivasan TN (2002). Trade and Poverty in the Poor Countries. *American Economic Review*, 92(2): 180-183. doi**:** 10.1257/000282802320189212

Bovin M (2000). Pastoralists Manoeuvring in the Drought-Ridden Sahel. In: *Manoeuvring in an environment of uncertainty. Structural change and social action in Sub-saharian Africa*. Berner and Trulsson eds. Sweden. 233-262.

Chambers R (1990). Editorial Introduction: Vulnerability, Coping, and Policy. *IDS Bulletin* 20 (2):1-7.

Chyi YL, Hwang CS (2011). Development of domestic markets and poverty reduction for poor developing economies. *Economic Modelling*, 374-381

Delgado C, Rosegrant M, Steinfeld H, Ehui S, Courbois C (1999). Livestock to 2020: the next food revolution, Food, Agriculture and the Environment Discussion Paper 28, Washington D.C.: Food, Agriculture, and the Environment, International Food Policy Research Institute (IFPRI)

Dollar D, Kraay A (2004). Trade, Growth and Poverty. *The Economic Journal*, 114, pp. 22-49, February.

Fadiga ML (2013). Valuation of cattle attributes in the Malian humid and sub-humid zones and implications for a sustainable management of endemic ruminant livestock , *Environmental Economics*, Volume 4, Issue 1, 2013

Florax R, Folmer H (1992). Specification and estimation of spatial linear regression models: Monte Carlo evaluation of pre-test estimators. *Regional Science and Urban Economics*, Elsevier, vol. 22(3), pages 405-432, September.

Henson SJ, Jaffee J (2006). Food Safety Standards and Trade: Enhancing Competitiveness and Avoiding Exclusion of Developing Countries. *European Journal of Development Research*, 18 (4), 593-621.

Kapoor M, Kelejian HH, Prucha IR (2007). Panel Data Model with Spatially Correlated Error Components. *Journal of Econometrics*, 140(1), 97–130. TSP and Stata software available at http://econweb.umd.edu/~prucha/Research_Prog3.htm.

Krätli S (2014). If Not Counted Does Not Count? A programmatic reflection on methodology options and gaps in Total Economic Valuation studies of pastoral systems. *IIED Issue Paper*. IIED, London, 52 p.

LeSage JP, Pace RK (2009). Introduction to spatial econometrics. CRC Press Taylor & Francis Group, Boca Raton

Maertens M, Swinnen JFM (2009). Trade, Standards and Poverty: Evidence from Senegal. *World Dev* 37 (1): 161–178.

Mulder MB, Fazzio I, Irons W, Mc Elreath R L, Bowles S, Bell A, Hertz T, Hazzah L (2010). Pastoralism and Wealth Inequality: Revisiting an Old Question , *Current Anthropology*, Vol. 51, No. 1 (February 2010), 35-48

Mutl J, Pfaffermayr M (2011). The Hausman Test in a Cliff and Ord Panel Model. *Econometrics Journal*, 14, 48–76

Sen A (1981). Poverty and famines: an essay on entitlement and deprivation, Clarendon, Clarendon Press, Oxford)

Sutter J 1(987). Cattle herd size and inequality. *Africa*, 57 (2), pp196-218

Swift, J. (2006). Why are rural people vulnerable to famine? In Chambers, Robert ed. Vulnerability: How the poor cope, *I.D.S. Bulletin* 20(2), pp. 8-15

Van Dijk H (1997). Risk, agro-pastoral decision making and natural resource management in fulbe society, central Mali, pp. 108-133, in *Nomadic Peoples* vol 1, issue 1, « Risk and uncertainty in pastoral societies » 1997

Wane A, Ancey V, Touré I (2009). Assets of the Market, Assets of the Rural World - Pastoral Market Income Distribution in the Senegalese Sahel (Ferlo), *Journal of Income Distribution*, Vol. 18, Number 3-4, September-December 2009, 232-248

Wane A, Touré I, Ancey V (2010). Pastoralisme et recours aux marchés: Cas du Sahel sénégalais (Ferlo). *Agricultures*, Volume 19, Numéro 1