



Volume 5 No: 7 (2020)

Potential and Drivers of Livestock Production in MALI

Alpha Oumar KERGNA and Ousmane Niallibouly

March, 2020



Citation

Kergna AO and O Niallibouly (2020). Potential and Drivers of Livestock Production in MALI. . FARA Research Report 5 (7): PP51

Corresponding Author

Kergna AO (akergna@yahoo.fr)

FARA encourages fair use of this material. Proper citation is requested

Forum for Agricultural Research in Africa (FARA)

12 Anmeda Street, Roman Ridge PMB CT 173, Accra, Ghana Tel: +233 302 772823 / 302 779421 Fax: +233 302 773676 Email: info@faraafrica.org Website: www.faraafrica.org

Editorials

Dr. Fatunbi A.O (ofatunbi@faraafrica.org); and Mr. Benjamin Abugri (babugri@faraafrica.org)

ISSN: 2550-3359

About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organisation responsible for coordinating and advocating for agricultural research-for-development. (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.

FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).

FARA's vision is; "Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises" its **mission is the** "Creation of broad-based improvements in agricultural productivity, competitiveness and markets by strengthening the capacity for agricultural innovation at the continental-level"; its **Value Proposition is the** "Strengthening Africa's capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation". FARA's strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is in turn designed to support the realization of the CAADP vision.

About FARA Research Result (FRR)

FARA Research Report (FRR) is an online organ of the Forum for Agricultural Research in Africa (FARA). It aims to promote access to information generated from research activities, commissioned studies or other intellectual inquiry that are not structured to yield journal articles. The outputs could be preliminary in most cases and in other instances final. The papers are only published after FARA secretariat internal review and adjudgment as suitable for the intellectual community consumption.

Disclaimer

"The opinions expressed in this publication are those of the authors. They do not purport to reflect the opinions or views of FARA or its members. The designations employed in this publication and the presentation of material therein do not imply the expression of any opinion whatsoever on the part of FARA concerning the legal status of any country, area or territory or of its authorities, or concerning the delimitation of its frontiers".

Acknowledgement

This work was carried out in the context of the Program of Accompanying Research for Agricultural Innovation (PARI). The PARI project is coordinated at the global level by the Center for Development Studies (ZEF), University of Bonn in Germany and in Africa by the Forum for Agricultural Research in Africa (FARA). The PARI project is financed by the German Federal Ministry of Economic Cooperation and Development (BMZ).

The authors are indebted to researchers in ZEF and FARA for the reviews of the proposals and the final outputs of the research endeavors. The contributions of Dr. Fatunbi Oluwole and his team in FARA, as well as Dr. Heike Baumüller and her team at ZEF, Carlos Sere for his guidance are well acknowledged. We would like to express our gratitude to the authorities of the Institut d'Economie Rurale (IER), the national agricultural research institute of Mali on various levels for scientific and administrative supports as well as for providing data base on institutional, farms and households. We would also like to thank all the enumerators and external consultants who contributed to this study. The authors wish to thank the editors for revision of the manuscript.

Executive Summary

Mali is a semi-arid, landlocked, agrarian, low income country with a rapidly growing population. The country is mainly rural. Poverty is high, specifically in rural areas; however, the number of people living with less than US\$ 1.9/day has declined from 60% to 51% from 2000 to 2010. Agriculture (including livestock) provides 36 to 40% of Gross Domestic Product (GDP) according to different sources. Livestock products value chain in the country is relatively underdeveloped due to feedstock constraints, poor local breeds, lack of appropriate infrastructure and distribution system. Live animals are commonly traded on the domestic market and exported to neighboring countries. The potential exists to increase livestock productions, but it requires appropriate policies, effective public institutions, capacity building, positive business environment, security and increased investments by both the public and private sectors. This report seeks to inform policy makers, private and public investors about promising innovations in the Mali livestock value chains and their context that could enable a transformation of the livestock economy taking into account its multiple trade-offs and co-benefits. The main objective is to inform public and private decision makers on opportunities to invest in the livestock value chain based on existing information, data, successes, analyses and lessons learned in the livestock sector in Mali. This study essentially builds on literature review and consultative workshops. Main challenges faced by Mali livestock systems are: feed problems, productivity of animals (genetics) and market information. Many households in Mali keep livestock, and the impact of livestock is significant on rural economies. Livestock rearing, especially small ruminants (S/R), is a pathway out of poverty for large numbers of households. Households use revenues from sales of S/R to purchase cattle as an addition to household wealth creation. Meat and milk per capita consumption in the country is low compared to FAO standards, and the gap between domestic supply and demand is projected to increase even further as population increases in urban areas. The livestock systems, which are based on feed availability and animal genetics, are not performing well because of low productivity of animals.. Most of the country's herds are in the pastoralist system, which faces market access and fair pricing constraint. The challenge of increasing livestock productivity and taking advantage of the increased demand for animal protein entails addressing the availability of feed, water and climate change. Many technologies have been implemented to overcome the challenges (feed rations, pastoral perimeters) and genetic improvement. The initiatives should be accompanied by quality animal health care, though services have improved with privatization. Livestock grazing areas in Mali are reported to be in decline from a combination of agricultural use, overgrazing and climate change. Conflicts are occurring as pastoralists seek access to their traditional corridors to access grazing lands. There are numerous live animal markets in the livestock surplus areas. The infrastructures of these markets and the corridors that link them are in poor condition or in a complete state of degradation. There is a lack of personal security, and livestock theft is a common occurrence. These risks result in market inefficiency. The use of ICT has not been effectively deployed. Furthermore, the Government of Mali's (GOM) priority has been on agriculture and horticulture. There is no database of key players along the commercial supply chain from the Sahel to coast markets which would be interested in quality livestock from Mali.

Introduction

Country context

Mali is a semi-arid, landlocked, agrarian, low income country with a rapidly growing population. Climate change and increasing human pressure are among others challenges for the essentially agricultural economy. Rainfall is irregular, poorly distributed, low and declining. The population estimated at 19 million in 2018, is very young with a median age of 16 years and growing at an average rate of 3%. Rural areas account for 63% of the population, and the informal sector provides 80% of the jobs. Per capita gross national income was US\$ 760 in 2015. Life expectancy is low (58 years), malnutrition is high (28% of children less than five years are stunted), and most of the adult population is illiterate (69%). The economy is predominantly informal.

Poverty is high, specifically in rural areas; however, number of people living with less than US\$ 1.9/day has declined from 60% to 51% from 2000 to 2010. Poverty level is higher in the southern part of the country where population density is higher. According to UN Human Development Index (HDI), Mali ranked 175 out of 188 countries in 2015. Mali's poverty and welfare indicators such as education and health are among the lowest in the world; and several Sustainable Development Goals (SDG) seems not reachable.

The country is a member of the West African Economic and Monetary Union (WAEMU), the Economic Community of West African States (ECOWAS), and other African cooperative initiatives such as the Comprehensive Africa Agriculture Development Program (CAADP). Agriculture (including livestock) provides 36 to 40% of Gross Domestic Product (GDP) according to different sources. The economy depends on agriculture, growing at an annual rate of 5%, is hampered by bad weather. The country's economy is also dependent on sizable financial support from development partners which spurred public investment and a revival of private consumption.

Agriculture is the cornerstone of economic growth and poverty reduction. Any strategy and program for sustainable development in Mali should give priority to agriculture in general and to livestock in particular. The Agriculture Orientation Law (Loi d'Orientation Agricole) passed in 2006, the most recent policy documents and investment frameworks which included (i) the National Agriculture Development Policy (NADP, 2013) and its National Agricultural Investment Plan (PNISA, 2015–25), developed through the CAADP process; and (ii) the National Livestock Development Policy (revised in 2015) are proofs of engagement of the Government for considering the agricultural sector as the development gate. Livestock is an important economic activity in Mali considering its contribution to GDP, employment, and food and nutritional security. Meat and milk are protein sources that provide high levels of nutrition more than other foods and have high amount of iron, zinc and vitamins. The meat consumption standards established in Mali are 12.5 kg per capita per annum in rural areas and 20.8 kg capita per annum in urban areas while the projections for the year 2025 are 18 kg and 25 kg, respectively. Total production of red meat is estimated at 94,328 tons in 2018 for an estimated population of 19.4 millions (DNPpop 2018). An average of 5 kg of red meat per person per year is consumed, while milk intake is estimated at 44 liters per person per year (INSTAT, 2015). The FAO

standards recommends 62 liters/person/year. As a consequence of low intake of animal foods, children are vulnerable to infections.

It is estimated that the population of Mali will grow from about 15 million in 2009 to more than 30 million in 2025, and that 60% of the population will live in urban areas by 2025 (Institut de Recherche et d'Application des Methodes (IRAM), *Institute for Research and Applied Development*). This implied that agriculture would have a lesser proportion of the workforce. As a result of the projected population increase, demand for animal protein will also increase, and the supply of livestock to meet this growing demand within the country will be a challenge given natural conditions (low livestock productivity, pressure on the natural resources and the impact of climate change), trade trends (high export of live animals towards coastal countries) and increasing income and urban demand. Livestock products value chain in the country is relatively underdeveloped due to feedstock constraints, poor local breeds, and lack of appropriate infrastructure and distribution system.

The potential exists to meet these challenges and increase meat and milk production, but it requires appropriate policies, effective public institutions, capacity building, positive business environment, security and increased investments by both the public and private sectors.

Background of livestock value chain in Mali

Livestock is a key sector of the Malian economy and an important productive activity for more than 85 percent of the population. The national livestock population is estimated at more than 12 million cattle, 38 million small ruminants, 40 million poultry, and more than 1 million camels. In terms of wealth creation and national exports, livestock is third, behind gold and cotton. In recent years, the sector has contributed about 22% of national GDP; providing income to about 30% of the population; while public annual funding to the sector represents barely 11% of agricultural expenditures and less than 2% of the national budget.

The Malian herd has experienced rapid growth over the last decade. As of 2018, the estimated livestock figures stand at 12 million cattle, 18 million sheep, 25 million goats, 572,730 horses, 1,121,898 million camels, 40 million chickens and 85,000 pigs. The average annual growth rates are 3.1% for cattle, 5.2% for sheep and goats, and 1.0% for camels.

Livestock producers have associations, cooperatives or unions based on areas of specialization/interest. Pastoral livestock farming is generally not market-oriented but oriented towards meeting cash needs. Livestock is used as a "rural bank" by rural households to absorb shocks from unpredictable agricultural (crop) production. During years of good crop production, households invest and increase their herd size, while during years of poor harvests and rainfall shortage they sell their livestock. The traditional livestock sector is characterized by its low productivity and the low weight of animal carcasses. The average carcass weight is 25% to 40% below what is achieved under proper and adequate feeding management. Genetic improvement programs have been established with the objective to create genotypes capable of producing more milk and meat. Cross-breeding indigenous breeds with imported breeds from Europe, US and Southern Africa has been promoted. This practice is particularly dominant in the peri-urban dairy value chain. In 2017, a total of 14,194 cows were inseminated with semen from dairy bulls, while 1,153 cows were inseminated with semen from bulls of meat-type breeds. A total of 3,482 farmers benefitted from the program.

Animal health issue is an important aspect and has strong influence on livestock productivity.

The animal health services remained unorganized and unregulated and are generally offered by private sector actors without standards and quality control. A total of 137 veterinary posts, 34 clinics, and 245 veterinary pharmacies are scattered throughout the country. In addition, 162 accredited private agents with health mandate support the activities of the government to cover animal health needs (Direction Nationale de Services Vétérinaires (DNSV), 2018). However, veterinary and animal health services are geographically dispersed and weak, leading to high rates of diseases. The DNSV faces logistical and manpower constraints which severely restricts their capacity to control animal diseases and the trade in unregistered vaccines and drugs.

Agro-industrial feed for livestock, mostly used by cattle fatteners, are an important part of livestock feeding during the dry season. Some 76 Malian companies transform cotton seed and other agricultural by-products into animal feed. Production of enhanced feedstock based on maize or rice by-products mixed with molasses or other forms of energy source presents an opportunity. This activity remains largely informal. Animal feed is often in short supply due to seasonal variations in demand, production is also exported to other countries in the region. In 2017, the government granted 1 billion F CFA (~\$2 million) in subsidies to farmers.

Live animals are commonly traded on domestic markets and exported to neighboring countries. At the national level, transactions of live animals take place across 220 livestock markets. There are four broad types of market: collection markets, grouping markets, terminal markets, and export markets. The collection markets are localized in areas of production. Grouping or redistribution markets are in strategic urban centers or along the main roads of the country while terminal markets are in the major cities; export markets are located at the borders. Transactions are facilitated by brokers, who guarantee transactions between sellers and buyers of livestock. The price of animals is based on attributes such as color, breed, size and shape of the horns, and transactions are settled in cash at the time of purchase. These existing traditional practices harm modern companies for which the main pricing criteria is the weight of an animal.

According to USAID (2018), in 2017, exports of live animals stood at 111,760 heads of cattle, 613,431 small ruminants (sheep and goats), 536 donkeys, 247 camels, and 464 horses. The cash generated amounted to FCFA 60 billion (~\$120 Million). Yet, the lack of adequate transportation logistics remains a major impediment to exporting. The livestock transport fleet is limited and unsuitable. Cattle are transported in trailers with a maximum capacity of 35 heads, while meat is transported by truck, cart and motorcycle. The existing means of transportation is a major constraint to the marketing of livestock and export in particular.

The livestock sector in Mali has so far, largely failed to be vertically integrated into the system. The few existing slaughter houses within the country are under the government parastatals that are poorly managed; they fail to meet the basic standards of hygiene. Pervasive underinvestment in the energy sector preclude the construction of at-scale refrigerated warehousing systems, a problem compounded by few refrigerated freight options and a poor road network. As a result, most animals are slaughtered informally. A lack of market information on prices is also an impediment to value creation at the processing level.

The GOM's interventions through the national budget are partially driven by donors' priorities. A recent Performance, Vision, Strategy (PVS) assessment by the *Organisation Internationale de l'Elevage* (OIE) for Nigeria suggested that a government needs to invest at least 30% of its

agricultural budget to the livestock subsector to meet Comprehensive Africa Agricultural Development Program (CAADP) guidelines of an average annual growth rate in agriculture of 6%. The GOM has not met this benchmark even though livestock is the third largest contributor to foreign exchange earnings after gold and cotton in Mali.

The current research seeks to inform policy makers, private and public investors on particularly promising innovations in the Mali livestock value chains and their context that could enable a transformation of the livestock economy taking into account its multiple trade-offs and co-benefits. The study aims to provide private and public decision makers with guidance on investment opportunities, building on a review of broad trends of the Mali livestock development and more in-depth analysis of success stories in selected countries to encourage wider lesson-learning and knowledge-sharing.

Study objectives

The main objective is to inform public and private decision makers on opportunities to invest in the livestock value chain based on existing information, data, successes, analyses and lessons learned in the livestock sector in Mali.

Specifically, the study will provide:

- Brief overview of the national livestock sector and its recent development, including the evolution of the policy environment and a description of major innovations;
- Analysis of major factors contributing to the success;
- Potential for further development and scaling;
- Lessons for other countries wishing to apply similar innovations.

Methodology

This study essentially builds on literature review and consultative workshops. The review and consultations assisted in identifying promising opportunities for the sector. Two major livestock products were taken into consideration: meat and milk, for their importance in the livestock value chain. To accomplish the objectives of the study, this work was carried out in 3 phases described as follow:

Phase I : Organisation of the study

An inception workshop was carried out in Nairobi (Kenya) in early October 2019 and a Skype call was organized to monitor progress of the work and direct research team towards the aims of the study. This helped the research team to sharpen the tools for information gathering and better plan their activities (consultations).

Reviewed literature provided existing data, documented projects, annual reports, policy documents and articles on livestock issues in general, solutions proposed and adopted, constraints, opportunities and challenges of the sector. It also allowed the research team to formulate questions to capture missing information in literature to address the study objectives during discussions at consultation meetings.

Phase II : Consultative workshops

Three focus group discussions including researchers, development agents and farmer

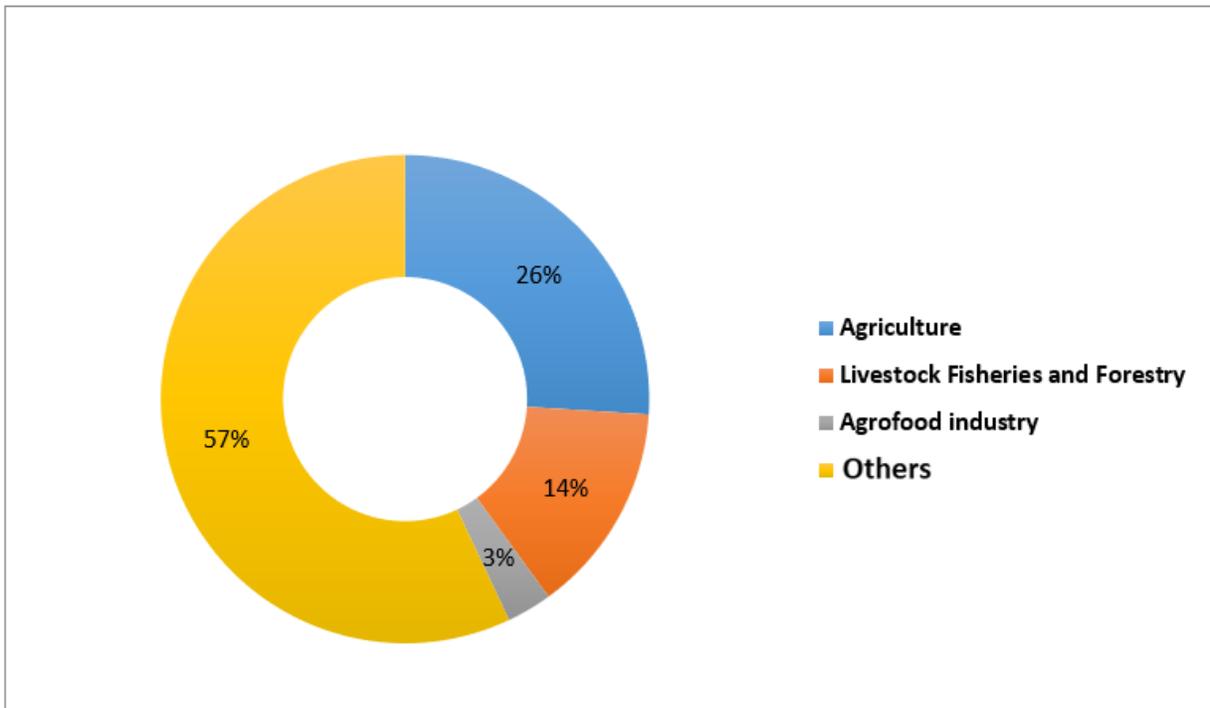
organizations were held. Each group identified the main constraints to livestock value chain development and technologies (innovations) which needed to be prioritized to overcome the constraints. Also, each group attempted to respond to missing information identified during literature review. Each group identified domains where innovations should be scaled up for the development of livestock value chain in Mali. After the collation of the outcomes of the consultations, the research team, with the assistance of resource persons, came up with a list of innovations among which 3 were prioritized.

Phase III: Validation workshop

The research team and the resource persons collated a report based on the first 2 phases and had it presented to representatives of stakeholders. The report was discussed, and observations and recommendations were considered. Three innovations were retained considering their potential contribution to livestock value chain development. The innovations are related to : animal feeding, animal genetics improvement and livestock marketing.

Brief overview of livestock sector in Mali and its performance in the last 5 years

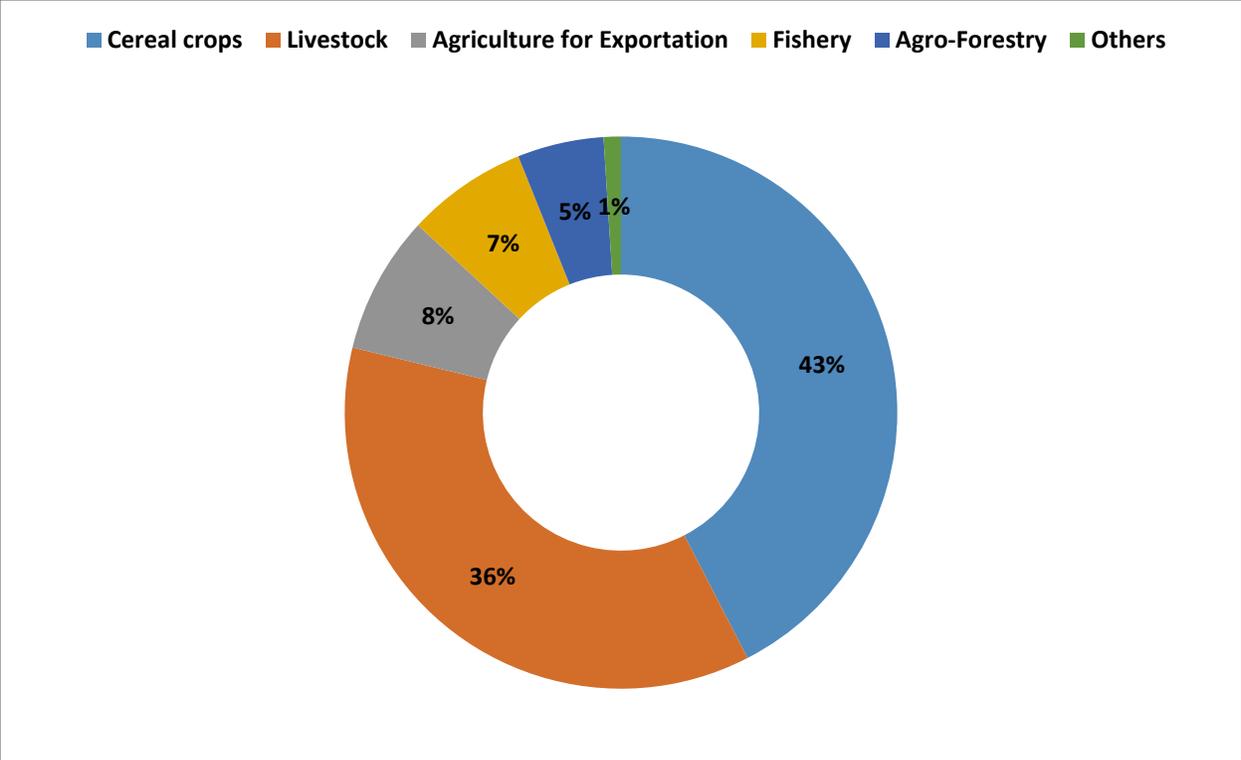
Mali is a traditional livestock country and the sub-sector occupies an important place in the agricultural sector. It is practiced by at least 85% of Malian farmers, particularly by the poorest segment (RGA, 2004). The sub-sector is livelihood for more than 30% of the population and contributes more than 20% to agricultural GDP. Among livestock products, meat represents 50% of the contribution to GDP, milk 21%, and skin and hides 29% (Dembélé, 2017). Between 2000 and 2016, Mali's GDP grew at an annual rate of 5%. Agriculture has been one of the drivers of growth with the added value in the sector growing at the same rate of 5%. The sector is highly fragmented and subsistence farming is the dominant model. Farms are small (68% of farmers work on fewer than 5 ha of land) and few have access to modern production technologies (only 1% of farmland use mechanized tractors). Only two products, cotton and livestock, account for 90% of total agricultural exports. The following figure represents the contribution of the primary sector in the national GDP.



Source: USAID, 2018

Figure 1: Mali sub-sector GDP distribution (%)

Within the primary sector, certain value chains have more social and economic significance. Cotton and livestock are the 2nd and 3rd largest exported products, accounting together for close to 20% of total export earnings in 2016. Dry cereals contributed close to 43% of primary sector's share of overall GDP. Livestock made up 36% of share of the sector's overall GDP, while rice and cotton alone represent 15% and 5%, respectively.



Source: INSTAT, 2016

Figure 2: Share of primary sector GDP in 2016 (%)

The livestock sector has been experiencing continuous expansion with annual growth rates of 3.1% for cattle, 5.2% for sheep/goats and 1% for camels. Its significant economic weight is evidenced by the fact that 10 to 35% of the total cash income of rural households is generated by livestock sales (USAID, 2018). Livestock is both an export-oriented agricultural product and a form of capital in rural society. A relatively minor dietary component domestically (only 5% of daily protein intake), livestock is predominantly utilized in agriculture as a source of cash, fertilizer production and as beasts of burden. The market supply of livestock is uneven throughout the year which is determined by the dry season with concomitant loss of weight by animals. Livestock accounts for an important share of employment in agriculture as many traders intervene in the value chain, each applying a premium on sale price. A wide array of actors, ranging from breeders to fatteners, follow multiple channels through which the final product is routed to different markets. The livestock sector uncovers ample opportunities for higher value addition notably through the production of derived products, such as milk.

Despite its economic significance, livestock’s local value addition remains extremely limited due to a combination of constraints at various levels of the value chain. The lack of modern zootechnical inputs, animal health services and artificial insemination, as well as underdeveloped commercialization of by-products, all contribute to the sub-optimal state of the sector. Currently, most of the animals are exported live and processed elsewhere, with Mali in turn importing the derivatives, essentially paying for the value the sector could have captured if equipped with better processing capacity. Milk imports, for example, amounted to US\$ 30.0 million in 2016. These constraints notwithstanding, the livestock sector has significant

potential for future development. Driven by population growth, urbanization, rising incomes, meat consumption , demand for products which meets international hygiene and traceability standards are growing at a fast pace in Mali and in regional economies. Improvements in animal productivity are gradually materializing with the provision of animal health services and the cross-breeding of species.

In 2004, reflections and studies were carried out leading to a national livestock development policy constituting the consensual and realistic vision of what should be the livestock landscape in the medium and long term. This shared vision would make it possible to sensitize the public, private or associative actors of the sector on the objectives that are sought and on the actions and measures to be taken by stakeholders. These efforts enabled the livestock sub-sector to increase meat and milk production. Total controlled meat production in 2015 was 62,420 tons, of which 69% was derived from cattle (Direction Nationale des Productions et Industries Animales (DNPIA), 2016). The dairy sector , a very important sector, generated more than 972 million liters of milk in 2010 (FAO, 2012), which could be further increased by improving the genetic potential as well as techniques and breeding conditions (through artificial insemination). The following table provides the evolution of the herd size in Mali.

Table 1: Evolution of livestock during the last 10 years

Years	Cattle	Sheep	Goat	Horse	Donkey	Chamel	Pigg
2009	8,896,392	11,300,247	15,735,670	478,187	861,820	904,425	74,272
2010	9,163,284	11,865,259	16,522,454	487,751	880,694	922,514	75,015
2011	9,438,182	12,458,522	17,348,576	497,506	899,981	940,964	75,765
2012	9,721,328	13,081,448	18,216,005	507,456	919,691	959,783	76,523
2013	10,012,968	13,735,521	19,126,805	517,605	939,832	978,979	77,288
2014	10,313,357	14,422,297	20,083,145	527,957	960,414	998,558	78,061
2015	10,622,620	15,143,415	21,087,150	538,545	979,510	1,008,440	82,425
2016	10,941,400	15,900,500	22,141,650	549,270	999,200	1,028,700	83,200
2017	11,415,900	17,400,000	24,023,800	561,500	1,099,900	1,192,900	84,150
2018	11,758,377	18,270,000	25,224,990	572,730	1,121,898	1,216,758	85,160

Source: Direction Nationale des Productions et Industries Animales (DNPIA), 2018

Table 2 : Estimation of milk availability (in tons)

Regions	Cattle	Sheep	Goat	Camel	Total
Kayes	32,185	11,567	11,711	753	56,214
Koulikoro	43,364	8,340	14,757	2,825	69,285
Sikasso	48,170	7,410	8,874	0	64,453
Ségou	34,089	8,719	13,811	214	56,832
Mopti	84,617	18,418	26,551	4,446	134,032
Tombouctou	30,582	12,645	20,973	56,583	120,784
Gao	26,050	20,318	26,884	63,078	136,330
Kidal	2,146	12,085	15,286	143,715	173,232
Bamako	1,001	380	237	0	1,618
Total	302,204	99,880	139,084	271,614	812,781

Source: Rapport Annuel 2016-DNPIA

The Malian herd has experienced a decline despite its initial positive growing rate as a result of different production systems. Most livestock owners use livestock as a “rural bank” to absorb shocks from the unstable and unpredictable agricultural (crop) production. During years of good crop production, households invest and increase their herd size, while during years of poor harvests and rainfall shortage they sell their livestock.

3.2. Livestock systems in Mali

The assessment identified three prominent livestock production systems in the major ecological zones of Mali: pastoral, agro-pastoral and sedentary, and peri-urban. These systems have unique and defining characteristics, but the systems are linked through the livestock and the owners and herders of the livestock.

Table 3: Production systems related to agro-ecological zones

Agro-ecological zone	Production System
Pre-Guinean zone (> 1100 mm of rain)	Agropastoral associated with rainfed crops in cotton zones
Soudanian Zone (>600 to 1100 mm of rain)	Agropastoral associated with rainfed crops in cotton zones
Sahel zone (200 to 600 mm of rain)	Pastoral associated with rainfed crops
Inland Delta of Niger (200 to 600 mm of rain)	Agropastoral
Desert zone (< 200 mm of rain)	Pure pastoral and nomadism
Peri-Urban zones	Semi-intensive to intensive peri-urban areas (élevage hors sol)

Pastoral Systems

Pastoral systems are based on rainfall patterns and the resultant availability of grazing. Formal

animal health delivery systems are more difficult and expensive for this group of herders. Control of contagious livestock diseases is more difficult because of constant movement and commingling of livestock herds in communal grazing areas. It takes livestock longer time than normal to reach their maximum genetic potential weight because of annual fluctuations in feed availability. Most herders indicate that milk production and capital asset accumulation are major reasons for keeping livestock. Without control of stocking rates over grazing areas, number of animal will approach and exceed carrying capacity during periods of the year. Pastoral herds supply the bulk of animals for fattening by agro-pastorals and sedentary producer households. The system is characterized by:

- livestock feeding based on the exploitation of natural resources through the mobility of livestock (transhumance);
- herd vulnerability to environmental and climatic factors; - often the presence of many challenges: mismatch between pastures and water points, land degradation through overgrazing, internal crises at country level (often community conflicts), extension of agricultural spaces, etc.
- problems with corridors related to trans-boundary transhumance.

Agropastoral systems

Sedentary livestock systems exist in close synergy with crop production (agro-pastoral systems fit somewhere in the spectrum between pastoral and sedentary depending on definition of activities.). Households are less mobile, though there are agro-pastoralists who move with their livestock but in a more defined space, pattern and season. The herders will generally return to a permanent settlement. Households engage in both crop and livestock production. Producers have better access to livestock services except in rural areas farther from cities and towns. Agro-pastoralists have been observed to move their livestock to the southern areas of Mali because of higher rainfall, more feed resources, and better access to veterinary services.

Semi-intensive to intensive systems

Peri-urban livestock systems are concentrated around, and in towns and cities. These producers are more commercially oriented than producers in the other two groups because of the close proximity to large number of consumers and they operate on a fixed land base. Households and commercial enterprises intensively operate dairies, fattening centers for cattle and small ruminants, poultry and swine. Cross-bred animals are raised in these areas. Animal health services and medicines are more readily available. These producers have access to more agricultural by-products for feeding their livestock. The open discharge of animal waste around slaughterhouses and homes poses a potential threat of transfer of zoonotic diseases, contamination of drinking water and the pollution of the environment.

It is important to mention poultry production because it is the singular most important livestock enterprise in the peri-urban areas. There has been a rapid increase in broiler and egg production in Mali. The growth of the industry has attracted the largest number of private veterinarians and animal husbandry specialists to service the industry. In 2018 the system registered 47,254,830 chicken. Poultry meat is filling the gap in meat demand and supply. The following table shows the SWOT analysis of the livestock sector in Mali.

Table 4 : SWOT analysis of the livestock sector in Mali

Strength	Weakness
<ul style="list-style-type: none"> • Existence of large herd size • Existing policy and development strategy documents considering livestock sector (LOA, PDA, PNISA, PNDE, CREDD) • Policy to support actors through incentives measures to boost livestock production (inputs and livestock equipment subsidy) • Elaboration and implementation of the national strategy for valuing local milk and creation of National Center for Artificial Insemination in 2015 • Existence of private networks of animal health agents and inseminators • Existence of a dynamic sub-regional and national plan for securing pastoral livestock system and improving livestock productivity by implementing structuring projects such as (PRAPS, PDIRAAM, Programme de Coopération Technique Belge 2017-2020 pour la région de Koulikoro et Ségou) • Implementation of a sanitary committee (DNSV-LCV-CNASA) to evaluate sanitary risks 	<ul style="list-style-type: none"> • Poor livestock productivity and vulnerability of traditional pastoral systems to climatic hazards • Few alternatives in livestock feeding (poor access to quality animal feed, production and forage conservation, etc. • Poor access of livestock producers and private investors to credits/technologies/innovations/adapted equipment • Predominance of major zoonotic diseases (brucellosis with prevalence rate estimated at 18%, 2014; foot and mouth disease) • Insufficiency of intervention in terms of sanitary monitoring of animals and quality control of products • Absence of a monitoring frame because of the mobility of the herd.
<ul style="list-style-type: none"> • Large national demand for milk (estimated at 600,000T), with preference for local milk (taste) • Existence of several livestock organizations (unions), very active in advocacy • Willingness of livestock professionals to start a transition from a subsistence production toward a more profitable and sustainable system near peri-urban areas. • Identification and characterization of production basins; 	<ul style="list-style-type: none"> • Insufficient milk supply, seasonality and unfair competition with imported subsidized powdered milk • Poorly developed distribution and commercialization channels • Reinforcing of organization at basic level (cooperatives) in terms of representativeness, functioning and advocacy • Government support for a structured organization of producers;
<ul style="list-style-type: none"> • Construction and equipment of milk collection centers • Existence of processing units (Meat and Milk) • Support of local and international NGOs 	<ul style="list-style-type: none"> • No respect of contractual deadlines and contract by enterprises benefiting construction funded by local Government ; • Low knowledge of products conditioning conditions for

	consumption; <ul style="list-style-type: none"> • Poor functioning of management committees (problem of leadership, trusty and miss management); • Low capacity of local actors for a better profit from existing infrastructures and to perpetuate changes.
<i>Opportunities</i>	<i>Threats</i>
<ul style="list-style-type: none"> • Decision of Government to allocate 15% of national budget to rural development • Vision of the Government to improve producers' income and to make Mali a powerful agricultural exporter toward 2018 horizon • Determination of different actors (local technical services, ministries, projects, programs, NGOs, collectivities, etc.) for synergy actions to make necessary changes in productivity and improvement of livestock system; • Existence of several Banks and Micro Finance Institutions • Unsatisfied milk demand of population and highly appreciated local milk • Donors' willingness to support livestock value chain development • Artificial Insemination programs development with a perspectives of increasing production and productivity • Mali belongs to several sub-regional organizations (WAEMU, ECOWAS (367 million inhabitants) ; Niger Basin Authority, CILSS) 	<ul style="list-style-type: none"> • Low competitiveness of local milk comparing to imported powdered milk • Competition with better conditioned milk products from other countries • Vulnerability of traditional systems and poor resilience of pastoral communities to climatic change • Poor interest of private operators to invest in livestock development and to sustain the value addition policy of processing products • High overhead charges (energy, technology, transports, etc.) • Institutional, organizational and managerial difficulties (human resource management, marketing, etc.); • Low access to quality animal feed.

Innovations to be scaled up

The livestock value chain in Mali faces several problems among which the most important are: animal feed availability and access; production and productivity linked to animal genetics and market information. To overcome these problems innovations were developed; for the present study an innovation was selected for each problem. Thus, to reduce the feed burden in pastoral system, pastoral perimeters were chosen; to increase livestock productivity, artificial insemination was retained and for market information system, **Livestock Market Information System (LMIS)** was selected.

A. Innovation related to animal feeding in pastoral system: *Pastoral perimeter (range land management)*

About 95% of Malian herds are managed by traditional pastoralists or agro-pastoralists which are characterized by their low productivity and low weight of the carcasses of animals. The average carcass weight is 25% to 40% below what is achievable with adequate feeding. However, access to proper feeding is limited by quantity, quality, and cost of livestock feed available for herds and for fattening operations. Traditionally, the herd moves on grazing lands that are increasingly drought-prone with cyclical and climate-dependent food availability. Herd movement varies from year to year depending on the availability of resources (water, pasture, etc.). Several projects and programs particularly in the northern Mali and also in other regions have built water points and implemented pastoral schemes. Many of them developed practices adaptable to each context, but they remained localized and used different methods and tools for management. A vulnerability map of pasture lands showing animal concentration zones and animal abandoned zones already exists. This could serve as a tool for anticipating where to build pastoral perimeters. Pastoral perimeter is an innovation that can help in reducing herd mobility and increase animal production and productivity during the dry season (7 to 8 months).

Description of pastoral perimeter and its context

a. Livestock background of the area

Pastoral perimeter is meant for the pastoral system where transhumance is practiced using natural pastures in combination with water points. The system is widely practiced in the Sahel precisely in Western Sahel of Mali, where rainfall ranges between 450-600 mm. The herd size is large and animals rely mostly on grazing, which makes them vulnerable to environmental and climatic factors. The system faces often the presence of many challenges: mismatch between pastures and water points, land degradation through overgrazing, internal crises at country level (often community conflicts), extension of cropping land, conflicts between herders and other natural resource users, etc. The mobility of animals within the system causes problems of corridors related to trans-boundary transhumance. Most species encountered are cattle, sheep and goat which rely on natural resources for feed (transhumance). During the dry season, animals have to move for long distances to access grazing land which results in significant weight and animal loss.

In the current decentralization context, the different communities in the territories should be developed through a scheme that fixes the vocation of areas identified at the local level. At commune level, pastoral perimeters are identified, but the major challenge remains the delimitation of an area exclusively for pastureland (crop producers invade the area). Once,

the area is identified, other challenges are its development and management in a consensual way. The first priority of herders is securing feeding and watering of the herd in the perimeter. The pastoral perimeter offers security on feeding, watering, health, organization and improvement of zoo-sanitary parameters.

b. The Innovation: how pastoral perimeters work

- The average size of pastoral perimeters

A pastoral perimeter has an average size of 20,000 ha split in several plots. A well equipped with a generator, a water tank and a watering place is built in the perimeter. The carrying capacity of a perimeter is 2,500 Tropical Livestock Unit "*Unite Betail Tropical*" (UBT) during 7 to 8 months. Firebreaks are built around the perimeter and enriching activities with forage species takes place during the rainy season (when animals are not using the perimeter).

Once the perimeter is built, the quantity and quality of the forage and water are estimated to determine the number of animal it can carry during 7-8 months period. Forage and water availability within the perimeter are evaluated twice a year.

- The investment in fencing and waterpoints

Since the perimeter is very large, iron fencing or wall fencing is not used. Existing trees maintenance, planting of trees and assisted natural regeneration of trees are carried out by herders' cooperatives, who are the users of the perimeter. These activities if carried out correctly ensures that non-members are kept-off the perimeter. Investments in waterpoints (well + generator + water tank + watering place) are estimated at \$510,563.

- The owners of the perimeter

Initially the perimeter is built by a donor project under the governance of the technical service of the Ministry of Livestock and Fisheries. A community under the leadership of the local administration delimits the perimeter. The local administration has the right to pass the management of the perimeter to a herders' cooperative. This requires implementation of management plans that have producers involved in operations and payment of recurrent costs of operation.

- Regulation of herders' participation

The cooperative in charge of the management of the perimeter fixes an entering fee for each animal (this amount varies by animal category) in agreement with the local administration, the technical service of the Ministry and the herders. Each animal is vaccinated before entering the perimeter; a census is carried out until the carrying capacity is reached.

The cooperative must manage and maintain the waterpoints and protect the perimeter. Activities such as tree cutting and bush burning are not allowed within the perimeter. The cooperative is assigned to conduct activities for trees regeneration or plantation on degraded spaces, the implementation of soil and water conservation technologies and maintaining an equilibrium charge on pasturelands (water, forage, animals).

- Respect of non-participants

Herders who have not subscribed to the cooperative (meaning they have not paid an entering fee) are not allowed enter the perimeter. However, some non-participant herders attempt to violate the regulations and enter the perimeter without permission; this

sometimes results in conflicts between members and non-members.

The innovation was first tested through ILCA (now ILRI) in collaboration with ODEM (Operation de Developpement de l'Elevage Mopti), which conducted researches on nutrient content of pasture land and vegetation potentials of grazing lands, forages and natural resources in grazing lands, productivity of grazing lands, irrigation possibilities, soil fertilization and degraded soil regeneration. It went through several steps before being implemented by the "*Projet d'Appui au Developpement de l'Elevage au Sahel Occidental*" (PADESO) in the Western Sahel of Mali.

The herds within a perimeter graze from plot to plot in a rotation system during the dry season (7 to 8 months). The herds graze in the perimeter during daytime and leave during the nights. The perimeter belongs to a community but it is managed by a cooperative. For the implementation of a perimeter, a project or a government agency in charge of livestock development elaborated the technical and socioeconomic feasibility. Any herd penetrating the perimeter must pay entry fees and the cooperative has the responsibility of maintaining the well and protecting the perimeters. By this rotation and equilibrium system, conflicts are avoided; grass is available during the entire dry season and animals maintain good weight and health.

The land is not bought, but a community endowment. The wells, the generator for water pumping from the well and the watering place need financial investment. The cost of these equipment varies and could reach at least \$ 510,563. The amount paid as entry fee also varies for species of animal (cattle, sheep and goat) and could be up to \$5 per head for the entire season (7 to 8 months). All animals entering the perimeter are vaccinated against common diseases (foot and mouth, etc.).

Technical and socioeconomic analyses

The role of livestock has been ignored with regard to its importance in food security. The government had given lower priority to livestock compared to (crop) agriculture. Policy makers have not always recognized the role of livestock in household survival strategies. Households rely on livestock for food (meat and milk), transport, fuel, and as an item of importance in barter for cereals.

By determining and securing an area where animals can graze during the dry season, when grass and water are scarce in the Sahel instead of moving to far distances, helps avoid conflicts among herder groups, and between herders and other farmers. Animals stay closer to owners who can monitor the increase of their herd and give all necessary health care to them.

By accessing enough feed and water, animals maintain good shape and could be sold at profitable price in the different markets. Animals of the same species and age have different selling price on the market because of their shape. In fact a bull fed in the perimeter could be sold at \$600 while a bull from outside the perimeter may attract lower price of about \$500. Also, production of animals increased due to availability of feed and water which is beneficial to the owners. They are also able to sell the milk or other animal products. A cow grazing in the perimeter provides more milk per day than others grazing in traditional system and the milking period is also longer.

The benefits of this innovation includes, natural resources management, less intra and inter communities' conflicts. Owners benefit from the milk produced by their animals for sale or

home consumption. Also animals maintain better shape and could be sold at higher prices. Other benefits are community based resources protection, slowing land degradation and financial resources generation.

Once the perimeter is set, only herders (cooperative) are involved in different activities with the support of government technical services (local government, livestock specialists, cooperative members). The number of herders involved depends on the size and the carrying capacity of the perimeter. A census of animals is conducted as they enter the perimeter until its carrying capacity is reached and then, the owners are registered. Only registered animals will remain in the perimeter during the entire season.

Currently, after the end of the support project "*Projet d'Appui au Développement de l'Élevage au Sahel Occidental*" (PADESO), the perimeters are currently controlled and managed by the cooperatives under the quest for legal and judicial security "*Organisation pour l'Harmonisation en Afrique du Droit des Affaires*" (OHADA) act. Entry fees constitute the main revenue and its management is according to the cooperatives' legislation.

Cooperatives recruit guardians for the perimeter. They have bank accounts, which allow them to access credit for buying animal feed or fund activities such as sheep fattening for Tabaski and cattle for the Ramadan.

A continual supply of quality forage and fodder year round is a major constraint to the development of the livestock sub-sector. Only a few companies produce commercial feed. The feed industry has remained unstructured without norms or standards. Feed rations are seldom analyzed for their nutritional content or sold on this basis. This limits the opportunity for small livestock feeders to purchase necessary prepared rations for animals. The price of cottonseed cake a commonly used feedstuff by herders during the dry season to supplement animals' rations has an increased , ranging between \$200 and \$210 per MT for the meal, which contains 38% crude protein. Feed producers need to be prepared to provide high quality feeds on a continual basis and at a competitive prices by using 20% to 30% cotton seed meal CSM in the ration.

Developing a commercially viable animal feed sub-sector requires an increasing demand from producers to monitor production costs and apply good business practices in the management of their production activities. The basic elements of such a program should include: (1) application of basic regulatory measures to control the quality of major feed ingredients and blended feeds sold in domestic markets; (2) technical and business development support for feed producers; and (3) extension and training for livestock producers in improved feeding and farm management practices. (Cook, 2003). This will take long time to achieve and many transhumant herders are not able to support the cost to feed the high number of animals they own. Therefore developing pastoral perimeters could be a better alternative for transhumant herders.

Livestock fattening is a specialized business where crop by-products are available and producers have access to cottonseed cake. Producers and traders purchase animals in the dry season when they are lean and feed them for 90 days. Cattle can gain between 1 to 1.5 kg per day, while small ruminants about 0.2 kg per day on a concentrate ration. The common fattening periods are February to April, and May to July. Prices for fattened animals could be higher during this periods because fewer livestock are available in the marketplace. Cattle are initially fed on forage and then gradually offered rations composed

of cottonseed cake (CFA 7,500/50kg bag (\$15)), hay (CFA 75/bale (\$0.3)), millet or sorghum bran (CFA 3,000/100kg = \$6), salt (CFA 175/ kg=\$0.4), cowpeas leaves, bourgou, minerals and some molasses when available. Health treatment costs CFA 5,000/head (\$10). A feed mill owned by a Lebanese businessman in Bamako sells concentrate feed for CFA 8,000/50kg bag (\$16). The shortest duration sheep were placed on feed was 5 months and 2.5 months for cattle. In Table 4, producer's return estimated to be CFA 80,000/head. The cost to feed and treat one head of sheep or goat for 90 days is around CFA 35,000 (\$70) (personal interview with veterinarian in Bamako). A fattened sheep or goat for Tabaski is sold for around CFA 50,000 (\$100) on average. The price of cottonseed cake has risen to CFA 7,500 (\$15) for a 50 kg bag due to decline in quantity supplied so farmers have reduced their purchases. Demonstrations of proper feeding programs with lead farmers would benefit producer groups. Livestock can be fattened on native pastures during the rainy season, and confinement feeding during the dry season using bourgou and other native species of fodder.

Table 5.- Gross margins for feeding one head of cattle for 90 days in Mopti, 2011

Aminal Breed	CFA/head	USD/head
Market price castrate Zebu	150,000	300
Cost of feed and medicine	70,000	140
Sub-total	220,000	440
Sale price	300,000	600
Gross Margin to labor, management, capital, risk	80,000	160

Livestock fattening is a well established aspect of the livestock subsector, which holds a lot of potential for income generation for groups of producers. According to staff of livestock organization *Fédération des Eleveurs de la Filière Bétail et Viande au Mali* (FEBEVIM), livestock feeding is centered in some regions (Mopti, Segou, Sikasso, Kulkulo and Kaye). Fattening occurs mainly in the dry season from January to June. The association represents 272 groups with each group having about 15 members. These livestock are mainly for the export market. The association has a program for training of trainers (TOT), and 25 members have been trained. Over 1,500 people have been trained in livestock fattening.

Adoption and impact

IN 2014, PADESO had 19 pastoral perimeters with 293,135 cattle, 177,250 sheep, 173,500 goat, 2,222 individual livestock fatteners, 18 livestock fattener associations and 17 women's groups with 14,420 and 44,478, fattened cattle and sheep, respectively. The operating result for one group was 36,487,380 CFA francs (~\$72 974.76). Women involvement in the innovation proves that it is inclusive. It is necessary to analyze the functioning of these perimeters in order to remove the constraints inherent to this kind of sets, to propose solutions, then to consider the multiplication of these successes in other breeding areas of the country.

The cooperatives managing the perimeters are able to provide enough animals in better shape compared with other sources to consumption markets (Bamako), especially during the Tabaski and Ramadan period at acceptable price.

Although PADESO project ended, perimeters continued to be used by herders. Other projects such as PGRNCC and PRAPS are creating tens of new perimeters attesting that the innovation is well appreciated by beneficiaries.

Environmental issues (positive and negative)

The innovation helps to keep natural resources by avoiding overgrazing, the soil is protected therefore less degradation and with the manure improving soil fertility. The innovation is beneficial to the environment. By scaling the innovation to other regions resources degradation will be reduced.

However, the cooperatives have poor capacity to renew equipment (well, generator, water tank, etc.). There are also space management problems:

- reduction of pastoral space because of crop production colonisation ;
- non controlled dwelling of wells at the vicinity of the perimeters with negative effects on rational management in one hand but also the deterioration of social harmony between different users on the other hand . In fact, perimeters' experience through their impact on animal production and the important amount of money mobilized by the cooperatives have inspired herders to dig wells and destroy the natural environment of the perimeters.

Potential for scaling up

Any development of livestock in the Sahel where large numbers of herd move from period to period for grazing and water should consider the possibilities of developing perimeter where animals have access to grass and water during the dry season. Drivers for scaling up the innovation are decentralized resources management, availability of space for grazing, organization of farmers. This is an opportunity to access animal products at any period during the year; reduction of conflicts among herders and between herders and crop growers; employment creation and conservation of natural resources.

Climate change

The forecast of the impacts of climate change on livestock production can cause changes in production patterns. Populations with their livestock are shifting to the southern areas of Mali with higher rainfall. Livestock patterns are changing, so is the incidence of animal diseases. Herders change the structure of their herds to have more small ruminants (Seo and Mendelson., 2006). In fact, with climate change, availability of natural resources are becoming scarce and types of forages which resist climate change effect are suitable for small ruminants. Also small ruminants herding requires less resources (forage, water, etc.); the turnover of a small ruminant takes less time than for a cattle or a camel. Actually in many regions of the country the turnover of sheep and goat brings more income to owners with less burden compared to cattle. In the south of Mali, there are evidence of herds with cattle and small ruminants. Climate change affects crop yields (projected to decline from between a 17% to +6%), forage yields (decline from 5% to 36%), and livestock live weights (decline of 15%). Economic losses could range from US\$70 to US\$142 million for all perimeters in a year (PADESO, 2010). The effect of climate change would require

pastoralists in the drier areas to focus on breeding and selling of stock/year to producers in the higher rainfall areas. The shift to small ruminants needs to be accompanied by more commercial off-take, as sheep and goats can be destructive to the ecosystem if not properly managed.

Livestock producers can adapt their husbandry practices in the following ways:

- Reduce number of livestock but increase animal productivity resulting in more meat and milk
- Greater specialization of production with herders in the north supplying young, light weight animals for fattening in the wetter southern areas of Mali
- Land use designation to protect marginal lands for livestock grazing
- Increase feed use with retention and treatment of crop by-products;
- Develop heat tolerant forage cultivars; and
- Reduce outright fire in pasturelands

Lessons

Mobility is the essence of pastoralist livestock system and it results in land degradation, conflicts and low value animals (low weight, diseases, etc.). Pastoral perimeters provide grazing to animals during 7 to 8 months when forage and water are scarce. By this, livestock owners can benefit from products (meat and milk) and sell their animals at better price. Health of livestock in the perimeters are better managed, and constructing perimeters is a tool for sustaining rangeland productivity. However, maintaining the pastoral perimeters is difficult by cooperatives in charge of their management. Wells, generators, watering guards are expensive to maintain without support from the government or a donor. Though, participating herders in the perimeters are charged fees, but the management and utilization of funds are hampered by the illiteracy of committee members.

Pasturelands in Mali are under pressure; in some areas due to climate change and the loss of traditional grazing areas by the colonization of other agricultural activities, conflicts between agriculturalists and livestock herders and among herders. For a perimeter to sustain forage quality and quantity, improvement activities should be undertaken by the cooperatives. There is evidence that pastures can be improved with a number of species, such as *Panicum laetum* (Andropogon) and *Cenchrus biflorus* (Gyanus) These grasses are in abundance in the grazing areas and therefore are adaptable. Soil conservation practices can be introduced which allow for movement of livestock so that pasture can be rejuvenated. Reserved grazing areas can provide needed fodder when other sources of feed are limited towards the end of the dry season. Small-scale producers promote dual-purpose crops such as cowpea, sweet sorghum and groundnut, which simultaneously provide human food and livestock fodder. Many projects have also introduced improved forage species such as Bourgou and Bracharia to increase the availability and quality of feed biomass and reduce losses during the dry, lean season. Further, projects are ongoing to scale up integrated packages in order to develop more intensified production models, including cattle, sheep fattening, dry season strategic supplementation of lactating cows and better management of draught cattle.

The preservation of the ecosystem in the perimeter should be given priority over the financial gain from the fees paid by herders. However, charges related to renewing the well,

solar generator and constructions are very high, and too exorbitant for the herders to bear and therefore require the help of donor partners, the government and financial institutions.

Livestock are managed at a low input – low output level of production. The improvement in livestock production requires matching up production systems with genetics, feed and animal health services to meet market requirements. The objective of improved productive systems is for greater marketable outputs of livestock products with the same or smaller national inventory because the forecast is for greater volatility in prices of inputs and outputs because of climate change. Household welfare and nutritional status of vulnerable populations (especially women of childbearing ages and children) will be impacted when food prices rise. Livestock development needs to be conducted in a holistic approach that includes the animals, the people and the natural resources. A stovepipe approach will not be effective if only one problem is addressed, e.g. establishing water points without considering the impacts on the ecosystem.

Innovation II: Genetic improvement through artificial insemination

There has been debate for many years concerning endemic breeds versus imported exotic breeds and their respective productivity and roles in livestock development. Trypanosomiasis is the single most important constraint to animal production in sub-humid and humid zones. Trypanosomiasis control depends on three techniques: 1) control of the vector (tsetse fly); 2) trypanocidal drugs; and 3) trypanotolerant livestock.

Vector control through bush clearing and use of pesticides produces negative effects on ecosystems. Trypanocides cost approximately \$1/dose per animal and two doses per year are required. Herders with huge number of heads have difficulties to pay for the doses. Also, the drugs are toxic and pose a hazard to public health if used improperly and withdrawal times prior to slaughter are not followed. The use of trypanotolerant breeds reduces the need for the two previous interventions. Cross-breeding trypanotolerant breeds with other breeds could improve the size and productivity of local livestock.

Each of the three major ruminant species has an endemic breed in Mali which is trypanotolerant: N'Dama cattle, Djallonke sheep, and the West African Dwarf goat. These endemic breeds carry genes that confer resistance to several diseases in humid climates (e.g. trypanosomiasis, endoparasites, and dermatophilosis) as well as unique genetic traits that allow them to adapt to challenging ecological conditions. Concurrent infections, poor nutrition, and other stress factors can cause a breakdown of trypanotolerance in endemic breeds.

However, exotic breeds of cattle and their crosses with N'Dama are particularly susceptible to epizootic diseases and require a higher level of veterinary care. More susceptible animals such as Zebu and equines cannot tolerate even a low challenge of trypanosomes and require a more extensive management system.

Endemic livestock in West Africa also have an advantage over exotic breeds in resilience under harsh climatic conditions and poor feed conditions. They are tolerant to high temperatures and high humidity and have the ability to use low-quality high fiber feed sources. These traits favor the use of endemic livestock breeds by smallholders in rural communities with limited resources where the cost of maintenance of exotic or crossbred animals would be prohibitive. Therefore, crossbreeding of exotic breeds with endemic breeds could be undertaken considering the environment with the view to promote sustainable production systems and conserve livestock biodiversity

Considering Mali's herd size, national milk production could meet local demand if appropriate processing and distribution systems are applied. However, the country imports enormous volumes of milk (powder or concentrated) each year, which has significant negative economic implications. The phenomenon is more visible in urban areas, where milk demand is very high. The following table presents quantities and values of milk importation in Mali from 2016 to 2018.

Table 6: Evolution of imported milk values in Mali

2 018		2 017		2 016	
Value in \$	Net Weight in Kg	Value in \$	Net Weight in Kg	Value in \$	Net Weight in Kg
35,455,218	17,308,540	42,713,646	23,715,457	38,465,133	44,566,326

Source: INSAT, 2019

Table 6 shows the trend of milk export to Mali in 2016 to 2018. The fluctuating trend indicated that quantity and value of imported milk was not fixed due to variation in national annual production. Local cows produce at most 3 liters/day and milking period lasts for only 3 to 4 months. Most of the milk is produced in the rural areas.

Farms attempt to provide urban consumers with local milk but the volumes produced are not enough due to poor performance of animal breeds, carrying capacities and production costs. By improving the performance of animals in peri-urban and urban farms, imports of milk from overseas could be sharply reduced. One way of improving animal performance is crossbreeding.

Description of artificial insemination and its context

a. Background of artificial insemination in Mali

Artificial insemination is generally practiced in the semi-intensive to intensive systems, where farmers purchase feed from the markets, cultivate fodder, and utilize agro-industrial by-products (concentrated or coarse), cereals, cakes, bran, straws, etc. These systems are developed in the cities or in their periphery and have gained momentum over the last 25 years because of increasing urbanization and demand for animal products that pastoral systems could not satisfy. Usually milk production or animal fattening are the main concern of individual enterprises. However, some milk production enterprises are mostly family or jointly owned. In the system, exotic breeds or their crosses increasingly ensure production, which is far beyond local genotypes. Intensive cattle fattening (fattening of cattle in permanent housing, based on concentrated feeds and purchased fodder) is also widely practiced today for export purposes.

b. The innovation: Artificial insemination innovation

Genetic improvement programs are established with the objective to create genotypes capable of producing more milk and meat. To improve the size and productivity of local breeds, the practice of cross-breeding indigenous breeds with breeds imported from Europe has been adopted. Government and donor programs deployed efforts to promote artificial insemination by importing quality semen from Europe, Morocco, and the US to inseminate local genotypes. Newly trained artificial inseminators were employed to perform this

specific activity. This practice is particularly common in the peri-urban dairy value chain. In 2017, a total of 14,194 cows were inseminated with semen from dairy bulls, while 1,153 cows were inseminated with semen from bulls of meat-type breeds. A total of 3,482 farmers benefitted from the program.

In Mali, artificial insemination was introduced very early (1949) at the Federal Center for Zootechnical Research of Sotuba with fresh semen. The use of frozen semen began in the 1960s in the same Center. Today, artificial insemination is experiencing a new boom with the creation of the National Center for Artificial Animal Insemination (CNIA) in 2015 as a Public Institution (EPA). CNIA's mission is to contribute to the improvement of animal production and productivity through the use of the technique of artificial insemination in the urban and peri-urban areas. For this purpose, the center is responsible for:

- the production, export, import, packaging, storage, quality control and distribution of animal semen and embryos
- monitoring and evaluation of artificial insemination activities at the national level
- capacity building of inseminators
- monitoring the activities of approved private artificial insemination centers
- testing of breeding bulls
- the supply of approved private centers for inputs for artificial insemination

The CNIA currently carries out artificial insemination activities throughout the country through private inseminators paid for by the farmers themselves.

Technical and socioeconomic analyses

Artificial insemination is a technique for improving animal production. Peri-urban farms are targeted for supplying milk, milk products and meat to households. Farms could be individual or collective (cooperative). Generally, farmers are organized in cooperatives to access feed or to sell their products at better prices. All cities in Mali are targeted through projects funded by the government or the donor community; however the main cities are regional capital cities such as Bamako, Kayes, Koulikoro, Segou, Sikasso, and Mopti. Other cities like Kati, Koutiala, San, Niono, Bougouni are also targeted by the project for intervention. The cost incurred under the innovation entails purchase of viable cows, semen for insemination, veterinary care and high quality feed for the offspring. Usually a veterinarian is hired to monitor the animals' health; this could be a challenge for farmers who do not have enough financial resources. Another major constraint with artificial insemination in Mali is the availability of semen, and the relative low success rate of the procedure.

Benefits of artificial insemination are increased milk production or larger animals, increased number of calves for the adopting farmers; and all year availability of more milk for the society. This could increase Mali's milk consumption per capita, and reduce the country's heavy dependence on imported milk. Adoption of artificial insemination through a project or government support could attract for a cost of 10 000 CFA (\$20) per head of inseminated cow, but the cost could vary if a private veterinarian is engaged and semen is acquired without government support. From herders' perspective, adoption of artificial insemination could require reduction of the size of his herd and be more efficient in management. Improving the productivity of the animal will allow the farmer to produce at a lesser cost and sell at higher price (especially for crossbred animals). Local breeds weigh at most 250 to 300 kg (liveweight) while crossbreeds could weigh as much as 400 to 450 kg (live weight). Also, milk production of local breeds is at most 3 liters per day with shorter milking period

while crossbreeds could give up to 12 liters per day with a longer milking period.

In each region, there are trained artificial inseminators; their engagement has increased employment rate in the country. The inseminator is paid between 5000 CFA (\$10) to 10 000 CFA (\$20) per session. The CNIA will not subsidize artificial insemination continuously; but will support the activity for a period only and then will leave it at the hands of the farmers' cooperatives. Currently CNIA is not making any financial benefit from artificial insemination, but since it is supported by the government which promotes genetic improvement of local breeds, the goal is more political.

Adoption and impact

The exact number of farmers who adopted the innovation is not known; however, the CNIA report as shown in the table below, indicated that the number of registered herders for artificial insemination increased from year to year. It was 328 herders in 2014 and it reached 4,466 in 2017. The number of cows increased as well during the same period.

Table 7: Status of inseminated cows by race and month

Years	Herders	Nature of Interventions		Inseminated cows
		Natural heat	Synchronized heat	
2017	4,466	4,352	10,933	15,285
2016	2,468	2,839	4,834	7,673
2015	1,965	2,051	3,911	5,962
2014	328	194	2,657	2,851
CUMUL	9,227	9,436	22,335	31,771

Source: CNIA 2018

The results obtained by the CNIA attested to its ability to meet certain challenges. Indeed, Table 7 shows a clear evolution of the number of cows inseminated over the years with an average success rate of 62%. This development is linked to the technical ability of the inseminators, the support of breeders and the availability of semen. However, as a result of difficulties encountered in providing semen and mobility for the private inseminators the number of inseminated cows decreased in 2018. The number of the inseminated cows and the number of farmers involved in the activity in 2018 is presented by region on Table 8.

Table 8: Status of inseminated cows by region in 2018.

Regions	Inseminated cows	Farmers
Bamako	256	81
Kayes	901	270
Koulikoro	2,607	795
Sikasso	1,455	499
Ségou	703	200
Mopti	139	67
Gao	8	5
TOTAL	6,069	1917

Source: CNIA 2018

On the other hand, the low number of animals inseminated in 2018 could be linked to a slowdown in the activities of insemination due to budgetary restrictions resulting in the cessation of the supply of inseminators with liquid nitrogen and synchronization materials. Also, the numbers of cows inseminated by region varied as shown in Table 8. The number of inseminators also varies by region, they were only 42 for the whole country (17 agents for Bamako/Koulikoro, 2 for Kayes, 1 for Kita, 11 for Sikasso, 3 for Koutiatla, 5 for Ségou, 2 for Mopti and 1 for Gao).

The number of birth was affected by health management and feeding of inseminated cows, some cows had twins. The table below shows the calving rates of inseminated cows from 2015 to 2018.

Table 9: Registered calving by inseminated cows from January to December 2018

Years	SEX		Total	Rate
	Male	Female		
2018	3,154	3,236	6,390	70
2017	1,975	2,703	4,678	43
2016	2,113	1,917	4,030	83
2015	1,030	1,017	2,047	52
Cumul	8,272	8,873	17,145	62

Source: CNIA 2018

At the level of each circle and region, the breeders are organized in a cooperative society, some for milk and others for meat, and many of them require artificial insemination services. All these associations/cooperatives are found at the national level unions such as FEBEVIM, FENALAIT or SYNELPROV. The success of these inseminations would lead to the creation and strengthening of milk processing units and the reduction of imports of dairy products. Jobs could be created for this transformation and the transport of milk from farms to processing units. This would improve the level of household income and nutrition.

Improving the access of private sector operators to financing will basically depend on their adoption of better business practices and on a policy environment that reduces the risks presently associated with commercial transactions in the sector. Such an environment should include credit policies that favor those prepared to apply such practices. In the absence of policies that pragmatically favor commercial development of the sector within a formal business context, it is unlikely that operators will substantially change their present habits or that new investments will become a reality in the short-term.

a. Environmental issues

Adopting artificial insemination will help reduce overgrazing on pasturelands by using more industrial feed; because animals movement are restricted. Also, health monitoring of the animals is regular which helps prevent diseases.

b. Potential scaling up

Artificial insemination has made it possible to obtain heifers with high milk potential compared to cows of local breeds. Daily milk production of cows of local breeds varies from 1 to 2 liters or 1.5 to 2.5 liters. Improvement in milk production was observed in heifers with

high milk potential resulting from artificial insemination. Also, heifers from artificial insemination start milk production between 2 and 3 years while local breeds start milk production between 4 and 5 years. Daily milk production of cross-bred heifers varies from 5 to 14 liters in Sikasso, 4 to 10 liters in Koutiala and 3 to 8 liters in Bla (DNPIA Report, March 2019) and 10 to 25 liters in Kassela.

Farmers appreciate the technical skills acquired and artificial insemination benefited them significantly compared to those who had not adopted the innovation. They explained the benefits obtained through the trainings received, the field trips made and the commercial events in which they participated. These different advantages have allowed them to see more clearly all the benefits they can derive from the application of this information in their breeding activities.

According to the results of a survey conducted in 2019, 64% of respondents received training in the livestock sector, compared with 36% who did not. The reasons often mentioned for non-participation in training were (age, illness or absence at the time of training, training not deemed necessary, etc.). The subject of the training courses received and mentioned by the beneficiaries mainly focused on raising awareness on artificial insemination, feeding techniques for calves and dairy cows, and raising awareness on forage production.

Raising and fattening small ruminants holds the greatest potential for producers to quickly accumulate the necessary savings to invest in cattle ownership. Priority needs to be placed on establishing pilot demonstration sites for small ruminants, showing how household livelihoods could be improved ("What Why and How" of small ruminant production). Women and children could be the key beneficiaries of such program.

Consequently, new and innovative credit mechanisms are needed in the short-term to promote investment and provide a stimulus for change. Though likely donor-financed, such mechanisms should provide models useful to government in developing future policies for the financial sector. The beneficiaries of such mechanisms should be entrepreneurs who are prepared to invest in modernizing existing enterprises or in creating new ones. The focus should be on supporting professionals who are prepared to make medium or long-term investments.

c. Challenges

Breeders have been keen to practice artificial insemination as part of improving milk yield of their cows. The implementation of the program in the field encountered a number of difficulties which included the following:

- The institutional anchoring of the artificial insemination program: as the artificial insemination component was attached to APCAM (Assemblée Permanente des Chambres d'Agriculture du Mali). The program did not receive the necessary technical support and follow-up from the DNPIA and the National Center of the Animal Artificial Insemination (CNIA);
- Lack of semen and liquid nitrogen cylinders at the regional level: this made it difficult to supply semen and liquid nitrogen to inseminators, who were on the fields and often far from Bamako.
- Monitoring and supervision of activities in the field were not carried out up to the desired level.
- Poor organization of the breeders: it is only well-functioning breeders' organization, that could facilitate artificial insemination as the professional organization of breeders, which

must recruit inseminators among their members to ensure sustained insemination activities.

- Insufficient information and sensitization of agro-pastoralists on Artificial Insemination (AI): was often denounced by farmers despite their enthusiasm about this technique.
- Non-compliance with the instructions given by the inseminators to agro-pastoralists: inseminators believed that very often the breeders did not comply to their instructions (isolation of the bull, flushing of cows before and after insemination);
- High failure rate: this was often mentioned by breeders; which, created suspicions for the practice of insemination.
- Non response to reports of return to heat of cows: inseminators do not cover the return to heat of cows, especially after synchronized heat.
- Inadequate inseminators on the fields: the number of inseminators to cover all the regions concerned was insufficient.
- Low technical ability of certain inseminators: some inseminators lacked technical skills.
- No monitoring of success after insemination: the monitoring of insemination activities is not ensured by the agents;

To overcome these constraints some recommendations have been made:

- Organize farmers around the production sectors (milk, meat)
- For all artificial insemination activities, give technical responsibility to the National Center for Artificial Animal Insemination (CNIA), a specialized structure created in 2015
- Develop quality control service for semen and insemination results (in connection with the CNIA, the LCV and the DNPIA)
- Training of new inseminators and periodic recycling of old ones
- Make regional deposits of semen and liquid nitrogen;
- Increase awareness among breeders about the practice of artificial insemination
- Sensitize farmers on the conditioning (health, food and habitat) of the cows to be inseminated and animals born through the crossing by using artificial insemination.

Lessons

There is still a general lack of knowledge in good management practices in animal health, feeding and marketing. Only ten percent of the export livestock meet export quality grade according to Williams et al. 2004, Fattening cattle, preferably Zebu castrates, and sheep and goats could reach good body condition (increased muscling) in the shortest amount of time would yield economic benefits. Williams et al. 2004, found that producers can get more beef from the same number of animals by as much as 34 percent with fattening programs, and producers, traders and consumers would all benefit from producing premium quality meat.

Mali has the largest animal population within the West African Economic and Monetary Union (WAEMU) zone and ranks second within the Economic Community of West African States (ECOWAS) zone after Nigeria. Despite this very important potential, livestock farming does not yet cover national milk requirements.

In fact, Mali spends more than 30 billion FCFA each year on the importation of milk and dairy products, due to the low national production. The low genetic potential of the country's local breeds constitutes one of the major constraints for the development of animal production.

Crossbreeding of foreign cattle breeds having high dairy and meat potential (Rouge des steppes, Montbéliard) with our local breeds (Zébu Maure, Zébu Peulh, N'dama, Méré) carried out in Mali since the colonial period in 1949 and later, have made it possible to have interesting experiences in artificial insemination and in the breeding of animal cross (1/2

blood, $\frac{3}{4}$ blood). The difficulties AI experienced are related mainly to the control of technology. Indeed, this technology has long been driven by private and even public services with inexperienced agents who have more or less failed, hence success rates of less than 20%. This has led breeders reluctance to embrace AI technology.

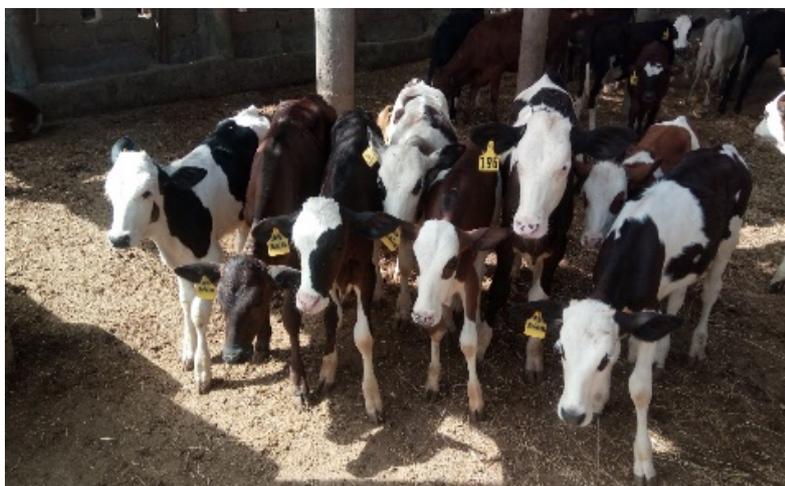
Furthermore, the highest political and administrative authorities in Mali and strategic development partners recognize today more than ever that food sovereignty/security has become a major concern. This is linked, on the one hand, to the generalized rise in the prices of food and petroleum products worldwide and, on the other hand, to the downward trend in the income of producers in the cotton zone characterized by the rise of the prices of inputs globally.

The creation of National Center for Artificial Insemination initiated the intensification of animal production in the urban areas. The CNIA's mission is to contribute to the improvement of animal production (milk and meat) by using the technique of artificial insemination and to coordinate all artificial insemination activities in Mali.

Following the creation, very significant advances have been made in terms of mastering AI technology through capacity building. This has improved the success rate to more than 60%. It should be noted that goats have also been included in the insemination program. In 2018, 175 goats belonging to 29 breeders were inseminated.



Photos 1: Calves born in CNIA supported farms (Source: CNIA 2017)



Photos 2 : Calves born from artificial insemination in periurban farms (Source: CNIA 2018)



Photos 3 : Cross of local race with montbeliard race (CNIA 2017)



Photo 4 : Cross of local race with Charolais race (CNIA 2017)



Photos 5 : Cross from Sahel goat with Saanen goat (Source: CNIA 2018)

Innovation III: Livestock Market Information System (LMIS)

Increase in productivity do not lead to improved outcomes without sufficient linkages to strong markets, and strong markets require strong information systems. Feed The Future Mali Livestock Technology Scaling Program (FTF-MLTS) worked with the Observatoire du Marché Agricole to revitalize the Malian Livestock Market Information System, which will helps herders make decisions regarding where and when to sell their herds. The project also worked directly with herders and exporters to develop business plans and more profitable and competitive family fattening models targeting local and export markets.

Background of the innovation

The Livestock for Growth (L4G) project aims to improve the quality and value of livestock production (cattle, sheep and goats), expand market access and incentives, and include poorer households in value chain development. The L4G targets herders and small producers who do not have reliable access to inputs or financial services, particularly female producers, who are largely isolated from markets and training programs due to cultural norms. Working closely with local partners, staff train private sector animal health providers to educate farmers on improved practices; link buyers and sellers to build market relationships; conduct awareness campaigns on good nutrition; and work with livestock cooperatives to create resource management plans to better oversee pastureland and water. These activities will help the livestock sector become more competitive and contribute to increased agricultural GDP and economic growth. A strong agricultural sector is necessary for Mali to grow, and helping small producers and women will help the country as a whole. The L4G focuses on the livestock production and trading center in Mopti, working in 260 villages in 28 communes in the surrounding Bankass, Bandiagara, Mopti, Djenné, and Koro circles.

Description of the innovation

With mobile technology rapidly penetrating Africa at a larger scale, ability to capture data at individual and household levels has provided tremendous opportunities to gather near real-time trade information about livestock to ensure informed decision making by Sahelian vulnerable smallholders especially the women, main owners of small ruminants. However, the idea of taking advantage of technological opportunities is not so new in the Sahel. Many information systems were developed and increasingly improved since the 1980s without leading to truly sustainable long-term development, particularly in the primary agricultural sectors. Within the agricultural sector, livestock sub-sector is to date, problematic for many research and development actors in the Sahel countries.

The current situation has historical roots which Ancy (2016) described as double misunderstanding: “on the one hand, the underpinning schemes in the information systems do not help policies managing the specific core features of the reproduction of the pastoral systems; on the other hand, the pastoral population’s avoidance strategy, which has historically allowed them to escape from pressure exerted by the administration, currently hinders their ability to influence fundamental debates within their countries”. Fieldwork in Mali in July 2016 made it clear that it was not only the case of pastoralists but also of sedentary mixed crop livestock farmers as well.

After an initial phase of implementation in 6 livestock markets in 2008 (Kidal, Gao, Gossi, Konna, Niamana and Kati), then 27 in 2009 and 32 markets in 2012, the ambition was to reach and cover 70 markets. However, the coup d'état that occurred in Mali in 2012 stopped the process. The idea of restarting the process emerged with the USAID-Feed The Future (FTF) project coordinated by the International Livestock Research Institute (ILRI). Thus, 14 markets were sampled in the project intervention areas to collect price data in view to operate the LMIS since 2010.

Institutionally, the LMIS depends on the Observatoire du Marché Agricole (OMA), a body of the Agriculture Permanent Chamber of Mali "*Assemblée Permanente des Chambres d'Agriculture du Mali*" (APCAM) with the support of the Ministry of Agriculture and as integral part of the national system of food security supervised by the office of the President. The LMIS technical device was developed by the "Agri Life Research" Department of the University of Texas in collaboration with agents from DNPIA and OMA. However, only the OMA and the University of Texas have privileged access to the LMIS database. The LMIS is supported by data collected on primary collection markets (e.g., market of Mpellé), intermediate markets (e.g., market of Koutiala) and regional markets (e.g., assembly market of Sikasso that is also a terminal market exporting towards international markets of Ivory Coast). At all stages, the agents of the DNPIA ensure data collection through its various divisions. The Observatoire du Marché Agricole (OMA) provides technical training courses for all agents.

Data collection requires the observation of procedures tested and validated by the OMA. Initially, enumerators walked around the market to make their first estimates of available supply and the number of animals present. Then they apply investigation instruments on dominant species on the market. They collect data based on dominant species and identify livestock categories differentiated by sex, age, and body size and conditions (adult males, castrated males, others males, adult and young females and body condition: fat, medium and lean). By species, category and body condition, they compute and report prices using average of the prices of animals.

A first level of data aggregation is made by the enumerators to generate average prices. Data collected on a sample of contracts are transmitted by mobile phones on the server using Short Message Service (SMS). Thus, a number of codes were developed and assigned to each market (e.g., KAT for the market of Kati), each collector (e.g., SAM for Samaké) to each species (e.g., C for cattle), to each animal breed (e.g., ZP for Fulani Zebu) in each age category at the date of collection (e.g., 21 September, 2016). Once in the server based on the OMA, data is retrieved for compilation, analysis and reporting (weekly, bi-weekly, quarterly and/or annual). The same data is available on the website www.malibetail.net and can be used to conduct price analysis at defined timescales. Then, OMA's agents perform a second level of data aggregation and analysis. The gaps between two situations are analyzed and interpreted by the Chief Analyst of OMA. The processed information is disseminated via cell phones as SMS (text messages). The OMA also has a web interface which facilitates access to market data based on requests. The web interface also provides access to graphical analysis. Information on price and animal conformation for the previous week are also displayed on livestock markets. Thirty contracts were established with local radio stations to closely disseminate market information in local languages.

Core funding sources of LMIS activities come from the Malian government through a share of 5% of the total allocation of CFA 300 million (\$600,000) granted to the OMA. This grant covers the operating expenses of the OMA (salaries, enumerators, motorcycles etc.). The

LMIS also benefits from the support of external partners such as ILRI through the USAID-FTF project that funds the LMIS up to CFA 60 million (\$ 120 000) to cover the collection operations (field work, small equipment, etc.). The LMIS could potentially benefit from additional funding from PRAPS.

To function, the LMIS is supported by a staff of 14 enumerators, 2 senior managers from DNPIA, 3 senior managers from OMA and 2 regional directors who supervise the region and 2 other executives who handle M&E activities. In terms of equipment, the system consists of a new generation of data servers located primarily in OMA offices and secondary in DNPIA offices (for back up), mobile phones and GPS for enumerators, two laptops, internet connection and a video projector and a team equipped with motorcycles for the field works.

The social and technological analysis

Following severe and successive drought periods of the 1970s and 1980s in the Sahel, emphasis was placed on food security. Market Information Systems (MIS) have been developed in the Sahel by national administrations supported by international donors to prevent and manage food crisis by improving the functioning of markets and developing cereal balance sheets (Egg and Gabas, 1997), to allow the implementation of cereal production readjustments and surplus reallocation throughout the Sahel region. The information systems have been gradually upgraded (Franck Gaultier et al., 2014) to improve on output performances (Toure et al., 2012). The prevention of food crises takes into account the evolution of conceptual approaches to food security and also the importance of support provided by humanitarian organizations in compensation for poorly coordinated sectoral policies (Touré et al., 2012).

As elsewhere in the Sahel, Mali followed this path and as a large livestock producer and exporter, this sector was increasingly integrated in the national monitoring systems. Almost all livestock trade in Mali is in the form of live animals inasmuch as current policies have been unfavorable to the development of animal product processing. The livestock sector significantly contributes to trade in live animals that increased in real terms from US\$ 13 million in 1970 to US\$ 150 million in 2000 in West Africa (Williams et al, 2006).

As growing agricultural sub-sector, livestock sector also contributes to 19% of the Gross Domestic Product (GDP) and remains the third source of export earnings from commodity exports after gold and cotton. However, the livestock sector does not always receive the attention it deserves in terms of public policies and investments (Alary et al, 2011) and benefits less than 2% of the national budget and only about 8 to 12% from the allocated budget to rural development sector (Dembélé, 2017).

As a dominant segment of the animal production system, Malian pastoralists and agro-pastoralists continue to face many risks that exacerbate their vulnerability. One source of this situation is the poor functioning of markets (Bizimana et al, 2015). Cattle market is poorly integrated due to long distances and high transaction costs that constrains easy access to livestock markets.

Among the multiple ways to improve this situation, the development of Information and Communication Technology (ICTs) tools for market information could be a strong lever of market integration (Van Campenhout, 2012) as was the case in Niger, between 2001 and 2006, where use of mobile phone significantly reduced grain price dispersion. More specifically, ICTs would help provide accurate information to agricultural and livestock value chain actors and to usefully link smallholders to the markets (Magesa, 2015). However, the real impact of Market Information Systems (MIS) remains particularly difficult to measure as

rates of return to investment in MIS are strongly influenced by assumptions made about supply and demand elasticity's (Staatz et al, 2011). The use of mobile phones has been shown to be the vector of information dissemination which contributes to market efficiency (Aker, 2008), farmers' decisions to increasingly sell in distant markets (Kpenovoun et al, 2009) and a significant rise in income (Kizito, 2011). Market information would be useful if the final users can act on it and if it is also complementary with other government programs and policies such as infrastructure development and investment in education (Kizito et al, 2012). On the other hand, it is proven that SMS-based information dissemination does not lead to significant improvements of farmers' activities even if these actors believed that it would help in negotiations (Fafchamps and Minten, 2012) while others concluded that it had no influence on cereal market integration (Bassolet and Lutz, 2011).

Although the idea of developing dynamic and effective livestock market information system has been revitalized with USAID cooperation. The need for market information along livestock value chains was not so new in Mali. In 1969, a government-funded system took the initiative to establish a centralized information system domiciled with the Malian livestock production and meat board (OMBEVI). Efforts were made to strengthen livestock market integration during the structural adjustment program with the launching of a more adequate "Market Information System" (MIS) in 1989 as a key component of the country's cereal market reforms to provide timely, accurate and low-cost information on price and supply for government, donors and stakeholders. In 1998, the restructuring of the MIS resulted in the establishment of the Observatoire du Marché Agricole (OMA). This was to ensure that the country was better equipped to meet future challenges such as the growing integration of regional markets, new business opportunities, capacity building of Malian stakeholders to assess new market opportunities and partners, and the need to develop appropriate grades and standards to respond to different market segments (Dembele and Staatz, 1999; Dembele et al, 2003). In 2008, a USAID-funded initiative under the Mali Livestock and Pastoralist Initiative (MLPI) re-launched the Livestock Market Information System for Mali to benefit from the growing development of mobile phone services as opportunities to disseminate livestock market prices and volume data to livestock sector actors and consumers (Bizimana et al, 2015). Today, there co-exists two different data collection systems on animal products in Mali: one under the supervision of the Direction Nationale des Productions et Industries Animales (DNPIA) that includes a livestock component among agricultural products monitored and the Livestock Market Information System (LMIS) managed by OMA.

Strength and weaknesses of the innovation

A SWOT analysis was applied to establish a reliable and rapid diagnosis based on strengths and weaknesses of the internal environment and opportunities and threats of the external environment of the LMIS for Mali.

Strength: Web and mobile integration; relatively long experience in MIS; timely and reliable price information via different media (e.g., maps, tables, graphics); user-friendly system, capacity enhancement for informed decision-making and bargaining.

Weaknesses: Rapid turnover of data collectors; insufficient capacities of the LMIS host to provide in-depth market analysis; written messages for users including many producers who are still illiterate; not really an early warning system for economic activities evolving in

uncertain global context; insufficient segmentation of information provided.

Opportunities: Existence of a structured framework for data integration and information management; cooperation framework for sharing experiences on MIS with Niger, Ethiopia and Kenya; increasing awareness about the need to consolidate the various existing data.

Threats: Political and institutional instability; unstable and temporary nature of the funding; insufficient human and technical capacity.

Lessons

Additional lessons that could be learned from the SWOT analysis are:

- **Too exogenous seed funding:** Like the majority of MIS in Sub-Saharan Africa, the LMIS of Mali has always been re-launched with external funding from donors such as USAID.

- **Unclear business model:** There are no real business models that ensure the financial sustainability of the system that seems to always depend on donor support. Discussions with team managers of the LMIS did not include a clear view on income generation policy to cover operating costs of the system (user-fees' policy, advertising for additional revenue, partnership with mobile network operators and so on). The market price information is usually considered and designed as a public good with a strong involvement of public services making it difficult for private companies to find their place in the system.

- **Diversification of information:** Malian animal production systems are almost exclusively dependent on pastoral and agro-pastoral systems as primary animal suppliers. Malian production systems are a livelihood and an economic activity involving production, consumption and marketing of goods and services in a changing global setting (climatic, economic, socio-political). In very traditional low-input low-output pastoral systems, market dynamics are not a major concern. However, the Malian pastoral system is dynamic and global, today the majority of livestock owners, even in remote extensive systems are dependent on markets to some extent. This relatively new increased involvement and dependence of agro-pastoralists and pastoralists on markets is not without risks; market shocks can occur due to many factors: drought, market quarantines on animals, price instability and others. During market shocks, livestock prices often plummet while food prices increase, and this become the common shock-induced pattern in drylands. The major reason why pastoralists use livestock markets is to satisfy their own consumption needs (mainly in cereals), which are usually aggravated and increase during dry seasons and droughts. In this context, this important node of information user chain might expect additional information which goes beyond prices, including animal feed prices; weather forecasts and alerts, crop-related information, transport costs and so on. On the other hand, discussions with fattened animal value chain actors revealed their ignorance of the existence of the LMIS.

- **Enumeration:** The LMIS of Mali depends so much on up-dated field data collected from sampled markets. The market-based enumerators, as primary level of data collection, play a significant role to ensure a complete and continuous provision of price data. They directly go to public marketplaces, observe current transactions, calculate the average of the five prescribed prices, then report the collected information by using mobile phone. The market-based enumerators of the LMIS are public agents of the community level of animal industry and production unit (UAPIA) As an integral part of the whole system, these agents are paid, trained and managed to some extent through the LMIS system. The availability of these

public agents is challenging as they may be mobilized for missions other than data collection. In the current situation, there is no guarantee that ensures that priority has been given to data collection, and market-based enumerators are not subject to the OMA.

Scaling up recommendations

To achieve the objective of sustaining the development of the LMIS, there is a clear need to produce and disseminate accurate, timely, useful and affordable price information.

Accurate and close to real time market price information could be achieved by:

- Increasing the reliability of data collection by ensuring the physical presence of the market-based enumerators and by providing them with regular refresher courses on data collection method and basic tool analysis.
- Continuously subjecting data to validation systems including feedback mechanisms from end-users with view to identify data that seem irrelevant and incorrect.
- Addressing human resources requirements by engaging two executives as econometrics analyst and server management specialist and acquiring a high capacity inverter to solve power outages

Affordable price information is required:

- To develop a reasonable business model which will help to determinate “who pays what?”. This process should start with the principle to secure the LMIS’s liquidity requirements, to cover its operations and to increasingly move away from dependency on donor/external funding.
- To differentiate between the objective of price information as a public good on the part of government which provides for citizens’ well-being and the private sector’s profit making goal. We recommend public-private partnership on the long run.
- To consider and test the crowdsourcing approach as an option to the conventional information system.

Useful price information would be applied as follows:

- To develop appropriate grades and standards in response to different market segments.
- To identify mechanisms for information dissemination, such as Short Message Services (SMS), voice-activated messages (Interactive Voice Response technology) in local languages for illiterate participants. This would be in partnership with mobile network operators, policy-briefs, local radios and televisions for specific user-groups (producers, wholesalers, retailers, governments, universities, research institutions). The objective is to pass available information to people who require the information in the form they can understand and use.

To develop an independent LMIS for Mali

To integrate the monitoring of the market of Bamako and markets in other region to better address the dynamics of domestic consumption.

To ensure a complete hoisting of all technical aspects of the LMIS through a growing technical transfer from the University of Texas to the technical team of the OMA.

To assert a larger regional role given the significant contribution of Mali in the regional export market. Thus, the LMIS for Mali should also report some relevant prices in destination markets of Senegal, Ivory Coast, and Guinea etc.

TO STRENGTHEN Price Market Analysis

The LMIS is designed to collect prices tabulated on current transactions. However, it might be interesting to promote policy-oriented foresight analysis to facilitate timely anticipation and understanding of market parameters.

To extend the analysis to volumes actually traded with a view to contribute to the in-depth understanding of market dynamics.

To develop Early Warning System

To provide demand-driven services, making LMIS more responsive to the needs of all livestock value chain actors, including smallholders, women, the poor and marginalized.

Proposed strategy for a holistic development of the livestock sector in Mali

Matching the innovation by zone

Agro-ecological systems represent the integration of land, animals and people offering the best opportunity for increased livestock production in Mali while protecting and sustaining natural resources and improving livelihoods for livestock producing households. At the same time, there is a need to resolve issues of increased conflicts between agriculturalists and livestock owners centered on availability and access to land, forage/fodder and water. The following production related interventions are listed by agro-ecological zones with illustrative investments and expected verifiable indicators.

Table: Suggested Interventions for Improving Livestock Productivity in Selected Agro-Ecological Zones in Mali

Agro-Ecological Zone	Interventions	Investments	Verifiable Indicators
Arid Zone	Feed and Fodder Production	Irrigation equipment – pumps and pipes; land development	Tonnage of bourgou produced
	Water points established to expand grazing areas	Land allocated by GOM for wells, pumps, pipes and fencing	Pastoral associations collect fees for use of water points
	Establish pastoral associations to plan and manage animal and human health services	Pastoral associations contract with veterinarians and traders to commercialize their livestock activities	Increased commercial sales of livestock to pay for improved services
	Protection, equipment and improvement of livestock corridors to grazing areas and markets infrastructures	Formation of pastoral association with necessary training for management of grazing areas and water points; Leaders of pastoral associations visit similar corridor management schemes in West Africa	Kilometers of protected corridors and commensurate reduction in number of conflicts
Semi-Arid and	Pastoral perimeter	Investment in	Increase in

Riverine	for grazing areas established	training and infrastructure	commercial sales of livestock by pastoral and agro-pastoral groups
	Support access to loans for fattening groups for cattle and small ruminants	Guarantee loan program established for small-scale fattening operations	Contracts signed for delivery of fattened livestock at negotiated price
	Protection and improved use of pasturelands	Improvement in animal husbandry practices including the use of supplemental feeding and health programs for livestock	Increased weaning rates for cattle, sheep and goats
	Community fattening groups established for targeted market programs (Tabaski), especially women raising sheep and goats,	Guarantee loan fund for purchase of animals, feed and housing for fattening programs; field technician from private feed company provide advisory services on use of commercial feed ration	Number of women groups selling fattened sheep and goats
Semi-Arid Zone in irrigated zones	Renovation of "grazing parks" near sedentary areas for transhumants	Loans for pasture improvements in "set aside" areas for livestock; cropping and livestock systems development	Reduction in number of conflicts between pastoralists and agriculturalist.
Sub-Humid Zone	Community fattening groups established for targeted market programs (Tabaski), especially women raising sheep and goats.	Guarantee loan fund for purchase of animals, feed and housing for fattening programs; field technician from private feed company to provide advisory services on use of commercial feed ration	Number of women groups that participate in livestock marketing programs
	Provide assistance to regional veterinary	Building and equipment of	Diagnostic samples tested in regional

	services for carrying out basic diagnostics test	laboratory for testing samples for animal diseases and feed ration formulations	and private laboratories
	Production of livestock feed using cotton, corn and other crop by-products produced	Loans to small-scale feed millers for livestock feed	Tonnage of commercial feed produced

Market and trade

Creating new markets, both domestic and foreign, is an essential factor towards ensuring sustained economic growth of the sector. In the case of domestic markets, the development of a commercial animal feed sub-sector is of strategic importance. It will be important to improve the efficient use of available feed resources (e.g. cottonseed cake), as well as the creation of new product markets for feed inputs, particularly cereals and possibly other legume crops Cook, 2003).

The development of export markets should be a priority because they afford unique opportunities to promote up-stream investments for product development. Such efforts should focus on targeting segments of the meat markets, identifying sub-regional trading partners, as well as, developing more formal and efficient domestic distribution networks.

Table: Suggested Interventions that Improve the Marketing of Livestock

Strategies	Interventions	Investments	Verifiable Indicators
Infrastructure	Improve market corridors (inclusive of all intra-zonal corridors) for young stock and export grade livestock	Funding for stakeholder groups; demarcations of corridors and the establishment of water points and grazing areas to promote specialization and export	Reduction in conflicts between pastoralists and agriculturalists
Infrastructure	Business plans that focus on PPPs for market infrastructures in or near specified corridors	Soft investments on training association staff on proper operation of market facilities	Revolving funds for market renovations in or near to livestock corridors
Infrastructure	Shorten the supply chain from production to fattening to export to slaughter	Feasibility studies and business plans for private sector participants in the livestock value chain	Producers share of the final sale price of their livestock in coastal markets increases from the baseline by at least 10%
Infrastructure	Building border markets, design	Funds to private sector company to design and	Prototype carriages constructed and

	livestock carriages for trucks and trains that are “livestock friendly” but can be converted for backhaul use	test prototype carriages for long haul of livestock to allow for feed and water	tested on shipping from Mali to coastal countries
Market Information	Market Information System (MIS) better links producers and fatteners for the fattening industry	Exchange visits between pastoral groups and fattening operations	Number of producers using direct sales of livestock to fatteners or a joint venture arrangement established
Market Contracts	Use of market contracts by fattening operators that shorten the supply chain	Training in preparation and negotiation of contracts between suppliers of feeder cattle and buyers of fat cattle (applies to small ruminants)	Number of livestock bought and sold under terms of contracts
Market – Branding	Establish a brand for Mali fattened cattle and small ruminants that can be promoted to buyers in coastal meat markets	Market promotion trips for buyers in coastal countries to travel to Mali to tour fattening operations with help of the Trade Hub projects	Number of direct contract sales by truck load of fattened animals to coastal countries
Marketing	Develop markets for specific cattle, sheep and goat breeds for targeted coastal markets	Market surveys in coastal markets on desired type, size and meat characteristic of livestock	Identity preserved Mali livestock recognized in coastal markets and receive a premium price
Nutrition – Livelihoods	Women groups engaged in value added processing of meat for home consumption and local sales	Training in “best” nutritional practices; Investments in solar driers for drying and smoking meat to retail and processed dairy products for improved household nutrition	Prototype dried and smoke meat and dairy products consumed by household or sold within local community
Nutrition – Livelihoods	Improve mother and children nutrition through sale of small ruminants for pastoralist and agro-pastoralists	Guarantee loan funds established to local NGO, to engage women groups in fattening sheep and goats, and the establishment of savings and loans entities	Number of Savings Groups established with set target for repayment rates on loans.

The policy

The strategy aims to develop for stable and predictable policies that booster trade, encourage investment and spur innovation. The policy area is targeted to meeting the challenges of the livestock industry. Not all the coastal markets are the same in size, in terms of demography and product requirements. In this regard, GOM policy will be to have a set of activities that differentiate actions by each target market rather than one general approach to livestock exports.

An environment is needed that encourages professionalism through the application of legislative and regulatory measures designed to promote access to: (1) production inputs and services; (2) financing the development of existing and new businesses; (3) commercial services – market information, transport, banking and conflict resolution; and (4) new domestic and export markets. (Cook, 2003)

A credible system of livestock certification facilitates compliance with existing animal health regulations in importing countries, thereby opening up potential markets; provides scientific support to rebuke allegations of noncompliance; and reduces the risk in not meeting product standards set by importers.

A specific set of policies are outlined in the following tables that will improve the business environment for the livestock sub-sector. The GOM needs a strategic plan for livestock that recognizes the synergies driven by good policies rather than just piece-meal interventions. The GOM would benefit from capacity building in setting a policy agenda for the livestock sub-sector.

Table: Policy Interventions that Support a Modern Livestock Sub-Sector

Strategies	Interventions	Investments	Verifiable Indicators
Productivity and Marketing/Trade - Commercialization	Build the capacity of the GOM to strengthen national and regional offices in livestock production and marketing environment	Strategic Planning Workshops with training in goal setting, financial budgeting, benefit-cost analysis, and market assessments to mention a few areas of support	The budget allocated to regional offices increase by ten percent per year from the current baseline for the next years
Productivity and Marketing/Trade – Commercialization	Allocate a larger share (30%) of agricultural budget to improving livestock infrastructure	Investment in key areas of the value chain to remove barriers, e.g. certified abatoirs	Budget allocation for livestock increases in each year until it reaches 30% within the next three years
Productivity	Removal of the livestock head tax	Increased investments by producers, traders and other investors because the tax is removed on	Tax repealed by regional authorities

		production	
Productivity	GOM supports private veterinarians in carrying out animal health services and only veterinary doctors can be mandataires (private veterinarians)	Veterinary doctors provided with more compensation for conducting local veterinary services	Veterinary doctors receive more income from veterinary vaccination programs
Productivity	GOM clarify its policy to strengthen the Community Animal Health Workers (CAHW) program with necessary training, kits and supervision by a veterinary doctor	Investment in training of trainers who carry out training programs	Number of CAHW able to establish their practice under the supervision of a veterinary doctor where possible.
Productivity	Install simple diagnostic services at the regional offices of the Veterinary Service (VS) of Mopti and Timbuktu, and support training of staff and the private sector lab <i>Pharma Vet Kone</i> (PMK) in Sikasso	Investment in training and equipment at three locations for the FTF initiative with support from the CVL	Number of diagnostic reports filed with Central Veterinary Lab (CLV) and more rapid response if and when an outbreak occurs.
Productivity	Review the production, pricing and distribution of vaccines and work with Global Alliance for Livestock Veterinary Medicine and Diagnostics (GALVmed) on distribution of Thermostable PPR vaccine	Invest in a business development plan on commercializing the vaccine production line of the CVL	Vaccine production unit able to raise their prices for vaccines. A business plan is completed and used to search for new investors.
Productivity	Strengthen and expand and update Pastoral Charter to encourage communities to set up <i>Projet d'Appui au Developpement de l'Elevage au Sahel Occidental</i> = Western	Carry out an awareness and community campaign on community oversight of grazing areas and corridors with Community Based Organization	Regional governments pass Pastoral Charter and begin to hold pastoralist groups meetings on planning the future. Group of pastoralist leaders visit the

	Sahel Livestock Development Project (PADESO) projects to manage natural resources and livestock in grazing areas with wells and corridors		GON project and observe maintenance of assets.
Marketing/Trade - Commercialization	Rescind the age restriction on export animals	Education and communication on the repeal of restriction on livestock trade	Increase in the number of unproductive cattle crossing the border check points
Marketing/Trade – Commercialization	Eliminate the slaughter slabs in urban areas	Train meat inspectors in municipal areas	Number of inspected livestock reported as slaughtered in Bamako increases
Marketing/Trade – Commercialization	Harmonize border crossing protocol with Senegal to reduce unnecessary and illegal fees	Investment in series of workshops with private sector and public sector agencies	Border taxes removed as well as requirement that requires using a trades license to move cattle through borders
Marketing/Trade – Commercialization	Harmonize the paper certificates for trade that meet OIE guidelines with neighboring countries	Chief Veterinary Officer (CVO) of Mali work with counter-part activities to meetings in Bamako	Proper OIE export certificates in place
Marketing/Trade - Commercialization	Communication with CVO with trading partners on a regular basis and plan Trans-boundary Animal Diseases (TAD) control	Regional meetings of CVOs of countries to be hosted every six months	Number of meetings held with an agenda published
Marketing/Trade – Commercialization	Control the uninspected slaughtering of livestock in the key urban areas	Investment in communication strategies for improving meat marketing in Bamako	Number of heads of animals in abattoirs rises
Marketing/Trade - Commercialization	Initiate PPPs in the areas of slaughter, processing and transport of meat in urban areas	Investment funds for co-financing of infrastructure improvements and management of facilities in long term	Private sector management companies take over the operation of abattoirs and markets.

		contracts	
--	--	-----------	--

Research has shown that under climate change, crop yield changes are in the range of minus 17% to plus 6% at the national level. Simultaneously, forage yields fall by five percent to 36% and livestock animal weights decline by 14 to 16%. The resultant economic losses range from \$70 to \$142 million, with producers gaining but consumers losing. The percentage of population found to be at risk of hunger rises from a current estimate of 34% to an after climate change level of 64% to 72%. A number of policy and land management strategies can be employed to mitigate the effects of climate change, particularly the development of heat resistant cultivars, the adoption of existing improved cultivars, migration of cropping pattern, and expansion of cropland. Such changes effectively reduced climate change impacts lowering the risk of hunger to as low as 28%. (Butt, McCarl, Angerer, Dyke, Stuth, 2005) As climate change affects the pastoral system vis-à-vis lower nutrient quality of grasses, less available water and undesirable social impacts will result

In Mali's extensive (pastoral) livestock system, changing climate is stimulating an expansion of crop farming into semi-arid regions which traditionally have been grazing areas for its transhumant populations. The displacement of herders and their livestock is disrupting migratory routes, coupled with increasing frequency of or longer droughts which is also disrupting grazing patterns. Herds are being confined on more limited grazing lands thus creating a potential for overgrazing, and thus reduction of the forage base. Lower quality forages result in lower quality animals, lower vulnerability to disease vectors, and lower market prices. Herders are being pushed into conflict more frequently with other groups and are forced to travel further to graze animals or to take livestock to markets. In the mixed crop-livestock system region, climate perturbations are causing disruption of feed supplies that result in lower volume of production (milk) or quality (meat), and in fewer animals. In addition, perturbations are increasing exposure to disease or disease vectors, higher levels of point-source pollution at slaughter houses or at the household level.

A number of financially attractive measures have been identified as means of avoiding future losses of existing land and livestock especially in the northern region. Some asset-based adaptation measures, such as irrigation systems and the provision of water for cattle, could contribute to the "climate-proofing" of crop and crop byproduct yields.

Conclusions

Over 90% of the households in Mali keep livestock, and the impact of livestock is significant on the rural economies. In fact the country underestimates the economic contribution of livestock to Gross Domestic Product (GDP) by not fully accounting for transport, plowing and manure in estimating the total economic value of livestock. Livestock rearing, especially small ruminants, is a pathway out of poverty for large numbers of households. Households use revenues from sales of small ruminants to purchase cattle as an addition to household wealth creation.

However, the current level of overall investment to improve the livestock-meat value chain is very low. The supply chain is inefficient caused by lack of necessary modern infrastructure (markets, trucks, cold storage for vaccines, feed processing and storage). The investments in the livestock-meat subsector by the private sector have not occurred because the returns on capital are not as attractive as alternative investments (compared to apartment and buildings in urban areas). Meat and milk per capita consumption in the country is low

compared to FAO standards, and the gap between domestic supply and demand is projected to increase even further as population will increase in urban areas.

The livestock systems are not performing well because of low productivity of animals. This is based on feed availability and animal genetics. Most of the country herd is in the pastoralist system, which faces market access and fair prices constraints. The challenge of increasing livestock productivity and taking advantage of the increased demand for animal protein will have to address the availability of feed and water and climate change. Many technologies have been implemented to overcome the challenges (feed rations, pastoral perimeters and genetic improvement). The technologies need to be accompanied with quality animal health care, though services have improved with privatization. Livestock endure stress during the long dry season when both feed and water can be in short supply. Livestock grazing areas in Mali are reported to be in decline from a combination of agricultural use, overgrazing and climate change. Conflicts are occurring as pastoralists seek access to their traditional corridors to access grazing lands.

There are numerous live animal markets in the livestock surplus areas. The infrastructure in these markets and the corridors that link them are in poor condition or in a complete state of disrepair. There is a lack of personal security, and livestock theft is a common occurrence. These risks result in market inefficiency. Markets do function but with few amenities for people or livestock. Some of these routes have become blocked by agricultural operations, which have led to conflicts. Cross-border trade in livestock has consistently been opened despite the presence of Trans-boundary Animal Diseases (TAD). The large coastal cities of West Africa are in deficit of meat, and high demand for fresh meat and offal exists in these markets. Livestock traders face a number of costs during transport (legal and illegal taxes), and on occasions they experience long waiting time to clear with the customs at the border. This can result in deaths of livestock while in transit.

The quality of government livestock services have been in decline because of budget shortfalls and the shift in policy to handover services to the private sector. The GOM officials have not had the budgets to upgrade their skill in delivery of knowledge-based technologies or necessary surveillance.

The use of ICT has not been effectively utilized. Furthermore, The GOM's priority has been on agriculture and horticulture. There is no database of key players along the commercial supply chain from the Sahel to coast markets who would be interested in quality livestock from Mali; Also, ICT has not been deployed to keep interested parties connected, capture baseline data on all stages of livestock value chain and transaction costs for establishing an efficient market system. The uncaptured data include marketing margins for a commercial market system as part of an "evidenced based" approach to transitioning to a commercial, formal marketing system for livestock.

Private sector investors are the key to transforming the livestock subsector in Mali if the livestock subsector is to become more efficient and commercialized. The subsector remains an informal supply chain with few grades and standards imposed with a general lack of good business practices. Transformation to a modern value chain requires both private and public investments along the value chain to achieve market efficiency and lower costs, and supply better quality livestock on a consistent basis.

The ultimate goal is to create a commercial supply chain for quality livestock products to the deficit markets in Mali. The supply chain will be more formal with a dependable supply of high quality cattle, sheep and goats for the export markets. The emphasis should be on quality and not on the number of head (more and better quality meat from the same

number of live animals exported or even fewer head of animals). Interventions will be needed along the value chain. On the other hand, herders can benefit if they can adjust to changing demand requirements in the markets.

References

- Aker J. (2008). Does Digital Divide or Provide? Information Technology, Search Costs and Cereal Market Performance in Niger. BREAD Working Paper No. 177, 61 p.
- Alary, V., Corniaux, C., & Gautier, D. (2011). Livestock's contribution to poverty alleviation: How to measure it? *World Development*, 39, 1638–1648.
- Ancey V. (2016). Comment se construit l'invisibilité des populations pastorales au Sahel: l'expérience de la crise alimentaire de 2005 au Niger. *Cahier de l'Agriculture*. 25: 55003
- Bizimana J.C., Angerer J.P., Bessler D.A., Keita F. (2015). Cattle Markets Integration and Price Discovery: The Case of Mali, *The Journal of Development Studies*, 51:3, 319-334, DOI: 10.1080/00220388.2014.963564
- Butt T. A., McCarl B. A., Angerer J., Dyke P., Stuth J. W. (2005). the economic and food security implications of climate change in Mali. *Climate Change*, 68 355-378.
- CNIA, 2017 : Deuxième session ordinaire du conseil d'administration du centre national de l'insémination artificielle animale: Rapport annuel 2017 ; 28P
- CNIA, 2018 Troisième session ordinaire du conseil d'administration du centre national de l'insémination artificielle animale (CNIA): Rapport annuel 2018 ; 24P
- Cook, Richard, 2003. "Increasing Livestock Sector Contribution to Economic Growth in Mali"; Concept Paper."
- Dembele, Amadou, 2017. Revue des filieres betail/viande & lait et des politiques qui les influencent au Mali "*Revue of livestock and milk value chains and influencing policies in Mali*", FAO and ECOWAS.
- Direction Nationale des Production et Industries Animales (2018). Rapport annuel "*Annual Report*"
- Direction Nationale des Production et Industries Animales (2014). Rapport annuel 2014 "*Annual Report*"

ECOWAP "Regional Agricultural Policy for West Africa", 2008. Make Agriculture the Lever of Regional Integration." (http://www.diplomatie.gouv.fr/fr/IMG/pdf/01_ANG-COMCEDEAO.pdf)

ECOWAS "Regional Agricultural Policy for West Africa", 2011. Strategic Plan for the Development and Transformation of Livestock Sector in the ECOWAS Region – 2011 – 2020." ECOWAS Commission press release. Bamako.

Fuka, Y. (2011) Chef d'Equipe. "Etude sur la Conservation of Niger Delta."

Government of Mali (2004). "Program Support with the Durable Development of the Breeding in the Sahel Occidental (P.A.D.E.S.O). Ministry of Livestock and Fisheries (PADES0)".

ILCA (1998) "Livestock Production in Central Mali." INRZFH-ILCA publication. August, 1988.

Magesa M.M. (2015). Linking Rural Farmers to Markets Using ICTs, CTA Working Paper 15/12, Series: ICTs for agriculture, November, 21

Ministère de l'Élevage et de la Pêche (Mali), (2004) : *Politique nationale de développement de l'élevage au Mali, Volume 1 : Diagnostic et analyse critique de la situation actuelle du sous-secteur élevage au Mali*, Bamako, Mali, Ministère de l'Élevage et des Pêches, 114 p.149

Ministère de l'Élevage et de la Pêche (Mali), (2004) : *Politique nationale de développement de l'élevage au Mali : Volume 2 : Enjeux et stratégies*, Bamako, Mali, Ministère de l'Élevage et des Pêches, 30 p.

Ministry of Livestock and Fishery 2017 and 2018, Annual reports.

Malian Office for Livestock and Meat (OMBEVI), Annual report 2016, 2016.

Ministère de l'Élevage et de la Pêche (Mali), (2004) : *Politique nationale de développement de l'élevage au Mali : Volume 3 : Cadre d'orientation politique*, Bamako, Mali, Ministère de l'Élevage et des Pêches, 16 p.

Recensement General de la Population et de l'Habitat. Census of Population and Housing, 2009.

Seo S and Mendelsohn R. (2006). "The impact of climate change on livestock management in Africa: a structural Ricardian analysis." CEEPA Discussion Paper No. 23, 2006 Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Texas AgriLife Research/Texas A & M University, 2010. "Mali Livestock and Pastoralist Initiative – Phase II.

Texas AgriLife Research/Texas A & M University (2011). "Mali Livestock and Pastoralist Initiative – Phase II.

The World Bank (2017) Mali Livestock Sector Development Support Project (PADEL-M) (P160641), Nov 2017

Toure, A.M. and Coulibaly, A. (2007). "Rapport d'Evaluation du Programme Tako de la New East Foundation." Programme Evaluation report.

UNDP, 2015. "Gestion durable du betail ruminant endemique d'importance mondiale en Afrique de l'Ouest." Sustainable management of endemic ruminant cattle of global importance in West Africa PIMS 1119.

USAID (2011) – West Africa. USAID/West Africa Feed the Future Strategy. March, 2011.

US Government. CIA World Fact Book. Washington, D.C.

USAID, 1990. "Final Evaluation – The Mali Livestock Sector II Project (688-0218)."

Van Campenhout, B. (2012). Market integration in Mozambique, a non-parametric extension to the threshold Model (IFPRI Working Paper No. 4). Washington, DC: International Food Policy Research Institute.

Williams, T.O., S. Ehui, and P. Kormawa, 2001. "Implications of Changing domestic policies and globalization for crop – livestock systems development in West Africa."

Williams, T.O., B. Spycher, and I. Okike, 2004, "Improvements of livestock marketing and regional trade in West Africa." CFC Project no. CFC/FIGM/06. ILRI.