

Analysis of the germplasm value chain for dairy in Senegal

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Executive summary

In Senegal, the demand for milk and other dairy products is steadily rising, along with population growth, urbanization and changing dietary behavior of populations. However, national milk production is unable to satisfy the rising demand because of the low productivity of local breeds and the limited number of intensive dairy cattle farms, leading Senegal to import a significant quantity the dairy products it needs for its population.

In fact, the overall cost of dairy products is growing annually, affecting the national economy. To remedy this problem, the Senegalese government is encouraging private initiatives in dairy development and genetic improvement of local cattle breeds with a primary objective to increase milk yield and production. Artificial insemination (AI) is promoted as a tool of choice. Since 1995, the state has funded a number of national AI programmes and set up a legislative and regulatory framework to better control the various interventions on genetic improvement. This study sought to analyse the value chain (VC) of dairy germplasm (semen and breeding livestock).

We carried out surveys of various stakeholders and key informants in the dairy sector and the MEPA. The results of this pioneering study revealed that the germplasm VC is evolving. It is characterised by a form of dualism with a heavy intervention of the public sector coexisting with an emerging dairy business willing to invest to improve their dairy herds.

The germplasm supply market is an oligopoly formed by three private and one public entity, supplying germplasm of various breeds through seven different distribution channels, all leading to the farmer who is either a smallholder or owner of an intensive dairy farm. Some of these channels are more direct, which naturally have a bearing on chain governance. The competitive cost structure of the germplasm was determined using a combination of survey data and secondary information on supplier/importer and AI service provider. Hence, the minimum acceptable rate for the full service is estimate at CFA 30,000 at supplier/importer level and CFA 35,000 at AI service provider level. Note that AI service provider procures all its input from supplier/importer. Hence, the derived cost of AI service alone amounts to a minimum of CFA 9,500, depending on the distance to be covered and the number of animals to be serviced.

The potential for growth is real. The existence of a market for germplasm with privately owned companies providing various services along the value chain, combined with a strong political will, a regulatory framework, and a functioning controlling authority with the required expertise are indicative of a value chain with considerable growth potential. The germplasm VC has taken advantage of these opportunities to emerge as magnified by the increasing number of peri-urban semi-extensive dairy farms in Senegal in recent years. There are limiting factors as well. The primary factor hampering the growth of germplasm value chain is the private demand for AI. It is weak unlike the demand for such a service during the government campaigns. As a result, the success rate for AI is weak. Factors such as high cost of liquid nitrogen, insufficient equipment, undependable seed quality, overall lack of genetic improvement plan with a clear direction on what to do with the resulting genotypes, and insufficient application of regulatory texts have a negative impact on AI success rate, hence on germplasm value chain growth. Despite these weaknesses, it is undeniable that the exploitation of dairy genotypes is on good track as it is generating significant economic benefits for actors along the germplasm value chain, including the farmers as illustrated by the development of peri-urban dairy belts promoted by private initiative.

Keywords: *genetic improvement, artificial insemination, dairy cattle, semen, value chain*

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Table of contents	
I. Introduction	8
II. Background and objectives of the study	9
III. Methodological approach	10
IV. Genetic improvement: the experience from several decades	11
IV.1. Policy, legal and regulatory framework	12
IV.2. Achievements	12
IV.3. Benchmarking	16
IV.4. Prospects	16
V. Analysis of the value chain	17
V.1. The actors and their relationships	19
V.1.1. Suppliers of dairy germplasm	20
V.1.1.1. The status	20
V.1.1.2. The nature of the germplasm	20
V.1.1.3. The volume and variety of imports	21
V.1.1.4. Other services provided	22
V.1.2. Occasional suppliers of live animals	22
V.1.3. Suppliers of other inputs of artificial insemination	23
V.1.4. AI service providers	23
V.1.5. Facilitators	24
V.1.6. Users	24
V.1.7. Distribution channels for germplasm	25
V.1.8. The cost of insemination	25
V.2. Gender aspect	26
V.3. Opportunities and growth constraints in the value chain	27
V.3.1. Opportunities	27
V.3.2. Constraints	28
V.4. Discussion	30
V.5. Strategies for the development of the value chain	32
VI. Recommendations for public authorities	34
VII. Conclusion	35
VIII. References	36

List of tables

Table 1: Methodological approach of the study	11
Table 2: Cost of Insemination by Service Provider Type	26

List of figures

Figure 1: Evolution of imports of dairy products (tons) in Senegal (Source: CEP, DIREL/MEPA, 2014)	8 8
Figure 2: Evolution of Dairy Production (million litres) in Senegal	9
Table 1: Methodological approach of the study	11
Figure 3: Timeline of Different Artificial Insemination Programmes in Senegal	15
Figure 4: Calving Rate achieved under three programs in Senegal relative to the benchmark	16
Figure 5: Estimations of Dairy Cattle Semen in Senegal	18
Figure 6: Evolution of Imports of Dairy Cattle Semen by Breed in Senegal	18
Figure 7: Visual Representation of the Value Chain for Dairy Cattle Germplasm in Senegal	19
Figure 8: Mapping the Actors in the Dairy Cattle Genetics Value Chain	20
Figure 9 : Movement of Dairy Animals in Different Dairy Production Systems	23
Table 2: Cost of insemination according to the type of provider	26
Figure 10: Constraints in the Value Chain for Dairy Cattle Semen in Senegal	29
Figure 11: Interventions for the development of the dairy genetics	32

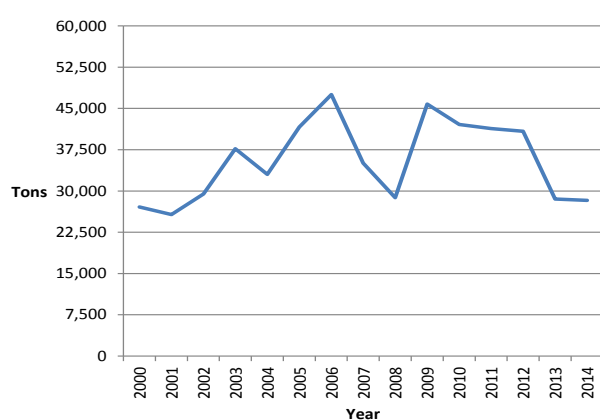
List of abbreviations and acronyms

AI	: Artificial Insemination
AINP	: Artificial Insemination National Plan
ANCAR	: National Agency for Agricultural and Rural Support
ANIPL	: National Agency for Increased Dairy Production
ANSD	: Statistics and Demographics National Agency
CEP	: Surveys and Prospective Unit
CIMEL	: Livestock Development and Modernisation Centres
CNAG	: Genetic Improvement National Centre
DIREL	: Livestock Directorate
EISMV	: Interstate School of Veterinary Sciences and Medicine
FA	: Farmers' Associations
FONSTAB	: Support Fund for Stabling
GI	: Genetic Improvement
GIP	: Genetic Improvement Plan
GOANA	: Great Agricultural Offensive for Food and Abundance
HU	: Helsinki University
ISRA	: Agricultural Research Senegalese Institute
LDNP	: Livestock Development National Plan
MEPA	: Livestock and Animal Production Ministry
NAP	: National Action Plan
NGO	: Non-Governmental Organisation
ODVS	: Order of Veterinarians in Senegal
PAI	: Private Artificial Insemination
PAPEL	: Livestock Support Project
PDESOC	: Livestock Development Project in eastern Senegal and Haute Casamance
PRADELAIT	: Dairy Industry Development Support Project
PRODAM	: Matam Agricultural Development Project
PRODELAIT	: Development Programme for Local Dairy Industry
PSE	: Plan Sénégal Emergent
PSIA	: Special Programme for Artificial Insemination
VC	: Value Chain

I. Introduction

In Senegal, the demand for milk and other dairy products is steadily rising with the growth of the Senegalese population, an increased urbanization of the country, and the changing dietary behaviour of the Senegalese populations. However, national milk production is unable to meet this demand because of the low productivity of local breeds and the limited number of intensive dairy farms. Consequently, Senegal is a net importer of dairy products, with a dairy cost that increases annually, affecting the national economy (DIA et al. 2008). Indeed, as shown in Figure 1, the partial imports registered by the veterinary services of the Port and Dakar Airport increased from 27,095 tonnes in 2000 to 40,838 tonnes in 2012, with a peak of 45,795 tonnes in 2009 (CEP DIREL / APME, 2014).

Figure 1: Evolution of imports of dairy products (tons) in Senegal

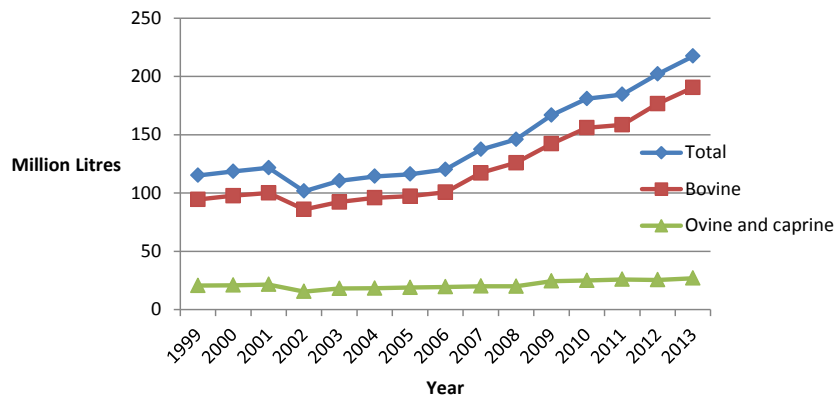


(Source: CEP, DIREL/MEPA, 2014)

Note: these imports only take into account those imports registered at checkpoints at the Port and at Dakar Airport.

National milk production is mainly from bovine sources. Milk from small ruminants is generally not consumed and that from camel is limited to restricted production areas (Figure 2). Bovine milk production was estimated at 94.5 million litres in 1999 and has grown slowly to 190.6 million litres in 2013 (CEP DIREL / APME, 2014). The majority of milk production comes from the extensive farming system that predominates throughout the country. The extensive farming system contributed 76% of the national dairy production in 2013, compared to 24% for semi intensive systems and Intensive farming systems (APME, 2013).

Figure 2: Evolution of Dairy Production (million litres) in Senegal



Source: CEP, DIREL/ MEPA, 2014

Milk production, transportation, processing and marketing create a large number of jobs and business opportunities along the local milk value chain. Sales of raw milk and derived dairy products (curd, butter, cheese) provide a source of income to producers. These socioeconomic considerations are among others the main reason that the State encourages many initiatives for a sustainable increase of national dairy productivity. Over the last two decades, it is in this context that Senegal, like many African countries, has been willingly adopting policies of intensification of its farming systems and genetic improvement (GI) of the local livestock to boost national dairy production.

While supporting private initiatives through the establishment of intensive dairy farms, the State has opted for the use of artificial insemination (AI) as a tool of choice for genetic improvement. Since 1995, Senegal has gradually set up a legislative and regulatory framework for a better control of GI actions and has financed several AI programmes nationwide in which local cattle breeds are crossed with various exotic dairy breeds. The results of these introductions of exotic germplasm in the form of semen and live animals are the many dairy genotypes, with varying degrees of indigenous bloods, used in Senegal.

II. Background and objectives of the study

How the various genotypes of dairy cattle from the AI campaigns are faring within their production environments is difficult to ascertain in the absence of monitoring and accompanying research. It is recognized, however, that these *exotic animals* may be more demanding in terms of husbandry (nutrition, health, and housing), but may produce more milk than the local breed parents, due to their genetic potential (PROCORDEL, 2001; Keita, 2005; Rukundo, 2009). While there is an expectation that the exploitation of these dairy genotypes would yield economic benefits, for the moment, measuring such benefits would be problematic without benchmarks for the efficient husbandry of such animals in their production environment. Furthermore, the limited information on the dynamics and operating mechanisms of semi-intensive farms, which are in fact a new milk production system, is an additional hurdle to overcome. *Senegal Dairy Genetics Project*, a component of the *Food Africa* programme, is focused on this dynamic and is funded by the Ministry of Foreign Affairs of Finland. This is a collaborative project between the International Livestock Research Institute (ILRI), the Inter-State School of Veterinary Sciences and Medicine in Dakar

(EISMV), the Senegalese Institute of Agricultural Research (ISRA), the Natural Resources Institute Finland (LUKE) and the University of Helsinki (UH). It has set as its main objective the identification and promotion of the use of the most efficient dairy genotypes for low to medium input dairy farms. The three specific objectives of the project are as follows:

1. Farmers and other stakeholders made aware of the most appropriate dairy breed/cross-breed types for selected dairy production systems in Senegal.
2. The germplasm value chain of selected dairy production systems in Senegal, and related policies, characterized and used to inform the development of a strategy for strengthened dairy germplasm production and delivery systems.
3. Local human, institutional and organizational capacity on assessing and promoting different breeds / cross-breeds of livestock for small to medium input production systems in developing countries enhanced.

This present study contributes to the achievement of specific objective 2. It focuses on the analysis of the VC of dairy cattle germplasm. In the context of Senegal, the term *dairy cattle germplasm* refers to the semen (frozen or fresh) from exotic dairy cattle (male and female) and hybrid animals called *improved animals* obtained from the cross of exotic dairy breeds with local breeds. The study of the dairy cattle germplasm VC has the following objectives:

1. Characterize the VC by mapping the actors and their interrelations (the flow of trade and services).
2. Analyse the performance of the production system and distribution of dairy cattle germplasm, artificial insemination services and advisory support.
3. Explore the opportunities and constraints for the development of private entrepreneurship specialized in the production and distribution of the germplasm.

The originality of this study is that it is the first that focuses on the VC of dairy cattle germplasm in Senegal and more specifically, upon dairy cattle semen, which is an important input in AI. A brief overview of AI in Senegal is presented first to foster a better understanding of the context of this study, which is followed by a section on the germplasm VC.

III. Methodological approach

The scope of this study is national (Senegal) with the analysis of the VC essentially based on the following sources of information:

1. Existing documentation on the subject (publications, working documents) from recognised institutions;
2. Statistical data available from the decentralized structures of the Ministry of Livestock and Animal Productions (MEPA) and certain other resources;
3. Interviews with the stakeholders and resource persons along the VC;
4. Initially, a workshop with several key actors and resource persons helped collect general information (an overview of the different links, different actors, traded goods and services, constraints) and to identify the key players, who must be investigated individually. Following this workshop, key informant interviews were performed with 16 key value chain actors.

Thus, the data collection involved different actors, including germplasm suppliers and distributors, heads of regional livestock services, staff of the Directorate of Livestock (DIREL), the CNAG, and the Centre for the Promotion and Modernization of the Livestock sector (CIMEL), AI service providers and other resource persons. On multiple occasions, trips were made within Dakar and to other localities in the regions of Thies, Diourbel, and Louga to interview these actors.

Data analysis focuses on the product, the market, the actors, the policy and regulatory framework that govern trade in dairy germplasm, along with the presence of opportunities for the development of private entrepreneurship specialised in the marketing of dairy germplasm, amongst others. The different stages of the study are presented in Table 1.

Table 1: Methodological approach of the study

Stages	Description
Workshop with key stakeholders and resource persons	Mapping value chain and identification of actors, products and traded services
Focus group discussion	Identify the regulatory and policy framework for the import and handling of dairy germplasm and the identification of performance indicators
Field activities	Development of interview guides and the collection of information from informants
Analysis and transcription	Data analysis and presentation of results for the development of recommendations and prospects from the study
Validation workshop	Presentation of results to various stakeholders for validation, final report is produced

The limitations of the study pertain to the fact that most of the collected data were qualitative. Hence, an economic analysis was not conducted on the value chain due to lack of adequate quantitative data. In addition, the limited of information from the surrounding countries made it difficult to refine the benchmarking and the recommendations. Notwithstanding these conditions, the data collected was sufficient to enhance our understanding of the value chain of dairy germplasm, distribution channels, governance, organization, and factors limiting its growth. These results were validated at a stakeholder workshop.

IV. Genetic improvement: the experience from several decades

Livestock intensification is one of the central pillars used by the Senegalese government to meet a growing demand for animal products (especially dairy) that domestic supply was not able to satisfy. The policy focuses on increasing local dairy production using GI of the local herd implemented by crossing local cattle with exotic cattle breeds, using artificial insemination. Artificial insemination was identified as a suitable tool because of its wide use throughout the world and the satisfactory research results obtained on the reproductive physiology of local cattle breeds (Ndiaye, 1990; Galina and Arthur, 1990; Cisse, 1991; Diouf, 1991; Diop, 1993; Diop, 1995; and Sow, 1997). It is combined with already well-tested heat induction methods (Mbaye and Ndiaye, 1993; Okouyi 2000). The semen used is imported,

although local production has been possible since 2006. Exotic dairy bulls and cows were also introduced into rural dairy farms as live sire. The legal environment was also improved to gain a better control over the interventions while enabling GI to take place and the necessary funds to undertake several AI programmes throughout the country were secured.

IV.1. Policy, legal and regulatory framework

In Senegal, 70% of the population live in rural areas and agricultural activities are their main sources of food and income. The livestock sub-sector contributes about 7.5% of Gross Domestic Product (ANSD, 2009). Hence, the State has opted to make agriculture an engine of economic growth to improve the economic well-being of rural populations, among others. Over the last two decades, the agricultural sector (livestock included) has been promoted as a lever for economic and social development, which led to concrete actions to ensure food sovereignty in the country (APME, 2013). This momentum has resulted in a favourable environment for the development of animal genetic resources by:

1. An institutional change in 2004 that led to the creation of a Ministry of Livestock, which was for a long time under the purview of other ministries;
2. The definition of a National Plan of Livestock Development (PNDE), part of 'Plan Senegal Emergent' (PSE) that describes the developmental priorities;
3. A favourable legal framework through the adoption of laws and regulations on genetic improvement law, agro-forestry-pastoral orientation, forestry code, pastoral code [being written], ratification of several cooperation agreements and other regulatory texts at the sub-regional level; and
4. The existence of producer organizations involved in the management of animal genetic resources (Ba et al., 2005; Anonymous, 2014). The State also has helped finance several national AI and capacity building programmes for the stakeholders to the limits of its allocated budget.

With respect to GI, it is important to mention the following: Law No. 2002-24 of 9 December 2002 related to the GI of domestic animal species in Senegal, Decree No 2007-544 of 24 April 2007 for the application of Law No. 2002-24 of 9 December 2002 affirming the import conditions and handling of animal genetic resources and, finally, the Ministerial Decree 006137 / MEL / DIREL of 9 November 2005 establishing the National Centre for Genetic Improvement (CNAG). All these laws were aimed at improving animal health and production while contributing to the success of the genetic improvement program *albeit* the regulations stemming from these decrees are not yet developed.

However, shortcomings and constraints are noted despite the efforts consented for the revitalization of breeding activities. The following could be mentioned: (i) the non-implementation of existing legislation, (ii) the lack of texts related to conservation and biodiversity, and (iii) the non-harmonization of the various existing sectoral legislation that has an influence on the management of animal genetic resources (MEPA, 2011a; Ly, 2011; Faye, 2011).

IV.2. Achievements

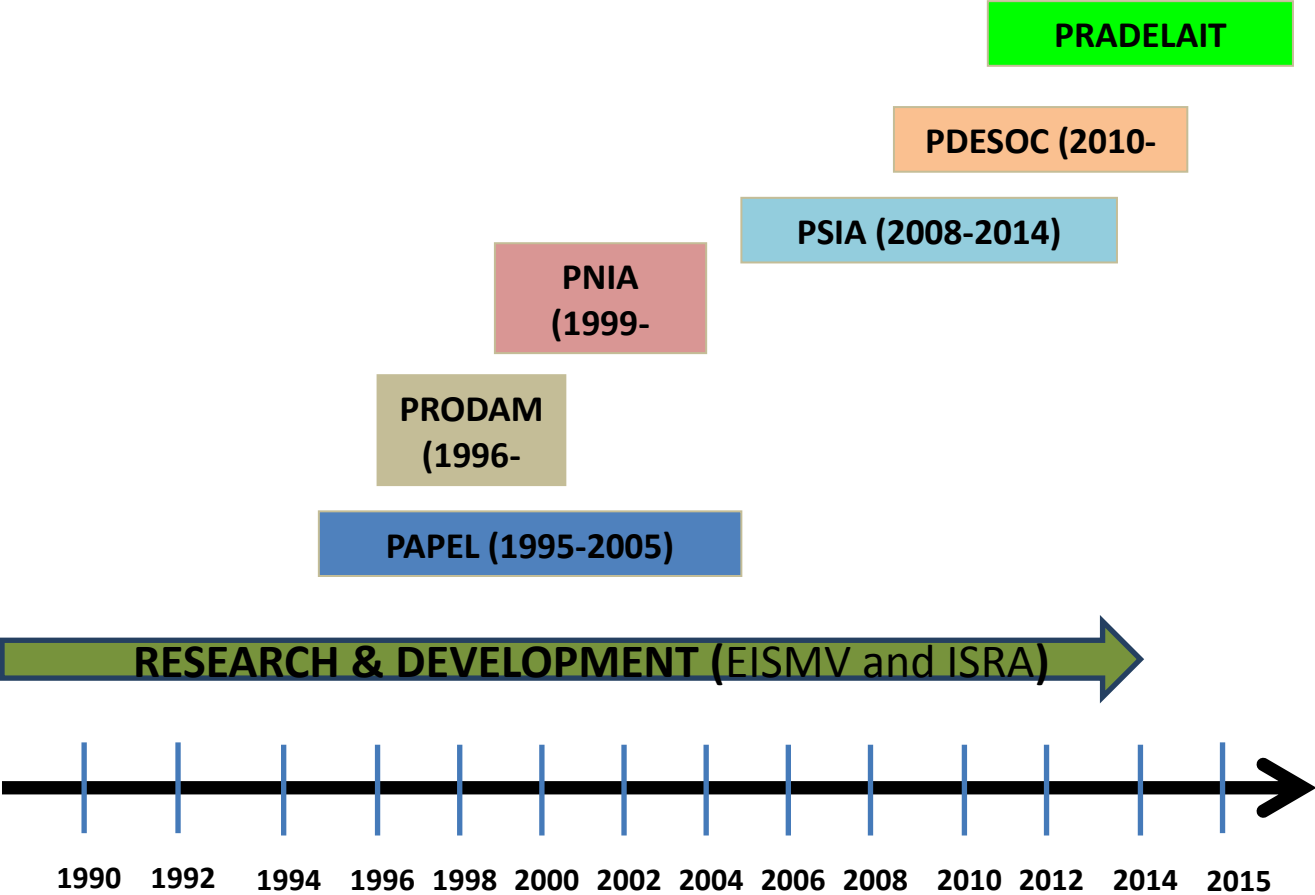
There were many studies conducted on AI and heat induction methods in Senegal. The benefits of these methods are described in detail in Derivaux and Ectors (1989), Twagiramungu et al. (1993). Heat detection is a key factor in AI as the success of AI

technology depends on it. Several factors including husbandry methods, climate, the nutritional and health status and breed of the animal can influence commencement of oestrus. All these factors mean that unlike the exotic breeds, oestrus detection is not easy for most local African breeds, due to their discrete expression, short duration and nocturnal occurrence (Chicoteau, 1989 and 1991). Hence, hormonal induction of heat is essential for an easier detection and for oestrus synchronization and AI planning, especially in rural farms. Different progesterone-based drugs for the induction of heat have been tried in Senegal, including, prostaglandin F_{2α} and PMSG (Thiam, 1989; Faye, 1995; and Diadhiou, 2001). It appears that the cost of induction treatments is the same with the PRID[®] spiral and the Crestar[®] implant (Okouyi 2000). Currently, the method based on the PRID spiral is the most used.

Artificial insemination has been widely popularized by successive dairy programmes following research in Senegal between 1989 and 1992 (Figure 4). First, the Livestock Support Project (PAPEL) from 1995 to 2005, which achieved overall pregnancy rates of 43.4% in the period between 1995 and 1998 and 51.9% during 2003-2005 (Laminou, 1999; PAPEL, 2005 and 2006; and Bouyer, 2006). The following was the Agricultural Development Project of Matam (PRODAM) in Northern Senegal, which was carried out in two campaigns (1996/1997 and 1998/1999) with mixed results (Bouyer, 2006). Both programs stem from the National Artificial Insemination Programme (NAIP), which has an average success rate of 31% and 42% for the first and second campaigns, respectively. Finally, the Special Artificial Insemination Program (PSIA) from 2008 to 2014 obtained the following results: 107,159 cows were inseminated with success rates of 44.2% for the period 2008-2011 (MEPA, 2012a) and 8,865 cows were inseminated in 2014 with a success rate of 41% (MEPA, 2014a). This latter programme was referred to as Great Agricultural Offensive for Food and Abundance (GOANA) for a short time during its implementation. The PSIA is a component of GOANA in its livestock entity known as PRADELAIT (Development Programme for Local Dairy). The evaluation of PSIA showed a steady decline in pregnancy rate from 47.4% to 44.2% and a lack of monitoring of the products, as only 12,280 crossbred were identified in 2012 (MEPA, 2012a). These low statistics could have been detrimental for the continuation of the programme as not much could be said about its profitability and the number of improved animals obtained following the investment (Dakhoumpa, 2003). However, the State decided to continue the genetic improvement effort through the Support Project for the Development of Dairy sector under the National Programme for Livestock Development in the Plan Senegal Emergent.

The Livestock Development Project in Eastern Senegal and Upper Casamance (PDESOC) located in the southeast part of Senegal has been conducting since 2010. Under this initiative, livestock technicians have been trained and equipped along with two well-equipped insemination centres in the cities of Kolda (in 2012) and Tambacounda (expected in 2015) and large-scale AI campaigns were anticipated for 2015. These two AI centres are not yet operational. However, one has to stress that AI was conducted during natural breeding seasons in collaboration with the School of Veterinary Sciences and Medicine in 2014. In addition to the national campaigns, AI services are performed based on demand by rural farmers, semi-intensive and intensive farms. This is a result of the diffusion of AI on a grand scale.

Figure 3: Timeline of Different Artificial Insemination Programmes in Senegal



Under the leadership and organization of the Ministry in charge of Livestock, all dairy GI programmes in Senegal (except two campaigns) have been implemented free of charge. Conducted via induced heats and widely distributed, the AI programmes have benefited many farmers as evidenced by the increase in adoption of *private insemination* performed outside free campaigns (MEPA, 2009a, 2013b; Diop, 2012b). The key actors of the genetic improvement are unquestionably the State, livestock professionals, public services and private structures (veterinarians, livestock engineers and livestock technicians) and the farmers who are the main beneficiaries.

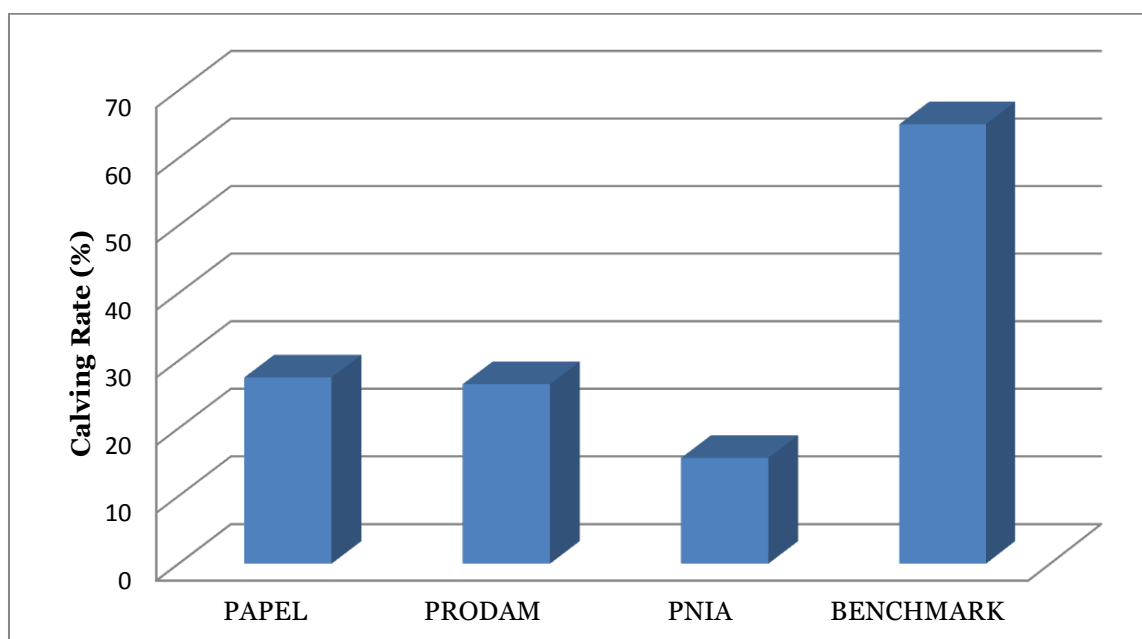
At the sub regional level, smaller scale genetic improvement experiments have been carried out in Guinea (Kamga 2002; Kamga et al., 2005), Cameroon (Bouyer, 2006; Diop and Kamga-Waladjo, 2011), Burkina Faso (Tamboura 1997; Nyanture, 2001; and Pousga, 2002), Mali (Cisse, 1991b, Bouyer, 2006; Diop and Kamga-Waladjo, 2011) and Mauritania (Mankou, 2008). Unquestionably, Senegal has mobilized considerable financial resources and has the deepest AI experience in the sub region. Unfortunately, for lack of data, it is impossible to make a quantitative assessment of the contribution of AI programmes to the increases in national milk production.

IV.3. Benchmarking

The ambitious objectives of the livestock development programmes have not significantly altered the genetic profile of local cattle breeds. Although a slight improvement in milk production is noted, the contribution of different campaigns to the increase of local production and reduction of imports of dairy products are not known. It is the same for the productivity of different dairy genotypes (an issue being addressed by the Senegal Dairy Genetics project).

Indeed, PAPEL has achieved the insemination of 5,000 cows in three phases and PRODAM recorded 768 cows inseminated in two phases. The National Artificial Insemination Programme, which set a goal for the insemination of 500,000 cows in 5 years, hardly achieved 100,000 cows (Figure 4). In comparison, in Kenya, Uganda and Tanzania (three countries in East Africa used as reference) the dairy herd improvement has increased an average of 6% per annum over the past few decades (FAO, 2011). In Kenya, which is the third largest dairy producer in Africa, there is a quality dairy cattle population (European exotic breeds) of over 3.5 million head. Further, the local Zebu breed accounts for 70 percent of the total population of Kenyan cattle, and it contributes less than 20 percent of the total production of cow milk (FAO, 2011).

Figure 4: Calving Rate achieved under three programs in Senegal relative to the benchmark



Source: Pursley et al (1998) and Kouamo et al.(2009)

IV.4. Prospects

Artificial Insemination is irrefutably a widely popularized technology by the State and adopted by rural farmers, despite the mixed results of some campaigns. Evaluations of AI programmes, as well as numerous studies, have highlighted the main constraints to overcome and the strategic changes to consider for the desired results (MEPA, 2009, MEPA, 2012a, Diop, 2012a; Diop, 2012b). The major constraint is that a holistic approach was not envisaged in the programmes. Indeed, improved breeding conditions, along with the establishment of a monitoring system (AI service delivery, performance of inseminated cows and number of improved animals) and the revision of the evaluation criteria for national

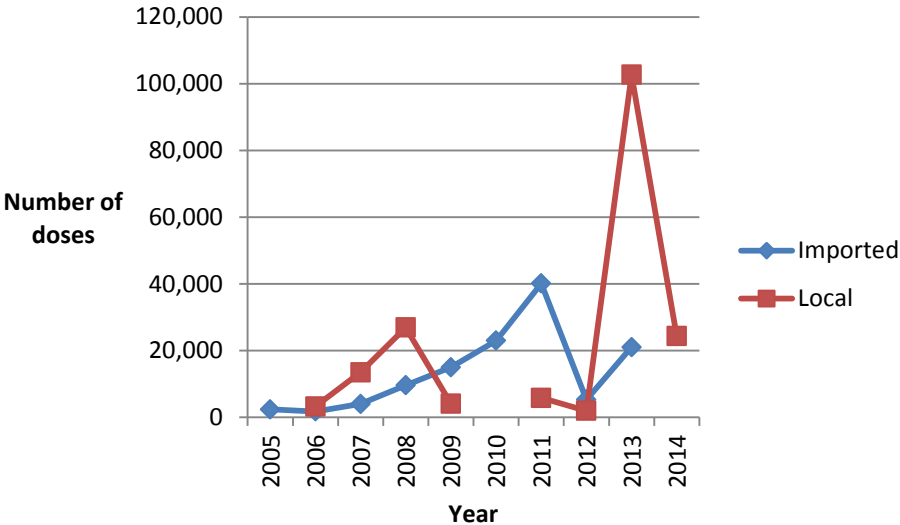
programmes are important in achieving the objectives of genetic improvement. The lack of an operational Genetic Improvement Plan (GIP) is also a major failure. There are multiple solutions listed through the literature such as:

- Reorient and strengthen the existing programmes with corrective measures such as monitoring and evaluation of performance (of both the AI program itself, as well as of the animals created by the program).
- Develop and adopt a GIP in order to adapt the breeds and system of crossing according to agro-ecological zones, objectives of livestock keepers and others within the livestock value chains, and the livestock systems in which animals are raised.
- Organise training sessions for pastoralists and agro-pastoralists to build capacity on appropriate management strategies for new breeds or crossbreeds of livestock.
- Ensuring the quality of inputs for AI, especially the semen, and strengthen the expertise of some AI practitioners.
- Promote a continuous, convenient AI service to meet demand, outside of the national campaigns.
- Increase investment and operating budgets for the CNAG technical personnel to enable them to carry out their assigned tasks, especially in semen production, training of AI service providers, awareness of beneficiaries etc. In addition, a strengthening of the capacity of their technical staff should be considered.
- Grant the request from farmers for semen production from local cattle breeds. Despite the request, the Authorities have not developed a programme for the conservation and genetic improvement of local breeds.

V. Analysis of the value chain

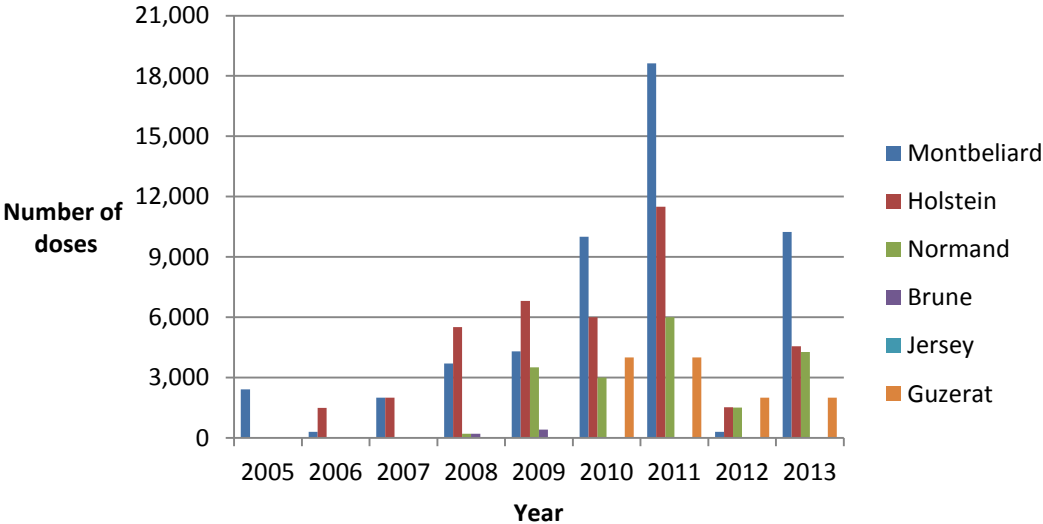
The genetic improvement programme relies more upon imported frozen semen from exotic dairy cattle than upon the introduction of live exotic dairy cattle when taking into account the volume of imports and the widespread use of artificial insemination. Therefore, semen imports far exceed that of exotic dairy animals. The quantity of semen introduced varies from one year to another, depending on the demand from the national and sub-regional market as shown in Figure 5. The semen doses presented in this figure include animal semen used during national campaigns subsidized by the MEPA, but are underestimated because the figures do not take account the imports by intensive farms and NGOs. However, the chained saw-like profile reflects the reality because imports are not constant from year to year. There is no record over a period of 10 years (1995 to 2005) due to the absence of a database for semen imports at MEPA. For the same reason, the evolution of exotic dairy cattle imports is not recorded. The imports were mainly from the following breeds Montbeliard, Holstein, Normandy and Guzerat (Figure 6).

Figure 5: Estimations of Dairy Cattle Semen in Senegal



Notes: Due to the failure of the nitrogen generator in 2010, CNAG produces fresh semen only from 2011 to 2014. The data presented in this diagram do not take into account the direct imports by private farms and other associations.

Figure 6: Evolution of Imports of Dairy Cattle Semen by Breed in Senegal

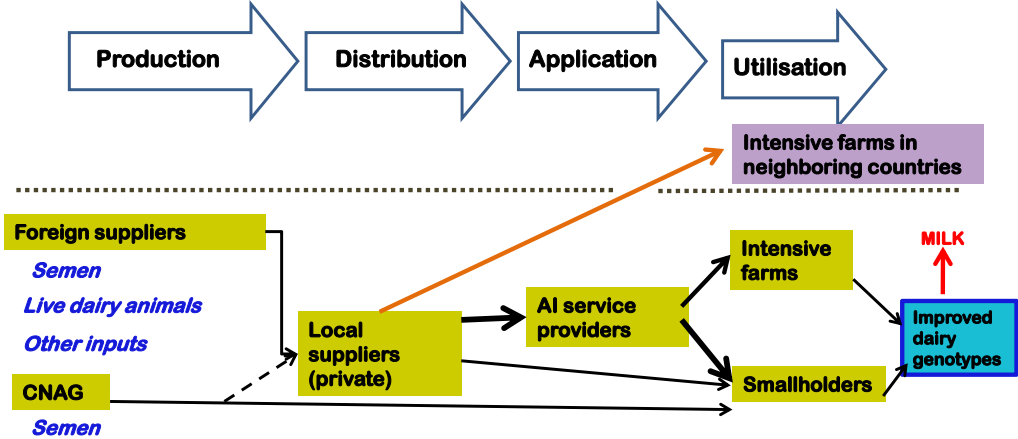


In recent years, the importation of exotic dairy cattle is increasing with the growth of peri-urban intensive and semi-intensive farms, which benefit from the dairy cattle subsidies provided by the state in line with its new strategy. Indeed, in order to accelerate the achievement of the objectives of the breeding policy, particularly the increase in national milk production, the State imports more and more adults, productive animals to sell to producers at subsidized prices. Thus, in this context, the MEPA has imported the following through *private providers*, 36 purebred Gir (5 males and 31 females) from Brazil in 2006, 75 pregnant Guzerat x Montbéliard cross-bred heifers from France and 216 Guzerat x Montbéliard cross-bred cattle (40 bulls and 176 pregnant/with a calf cows) from Brazil in 2013 and 2014. These exotic dairy animals are sold to selected farmers within the semi-intensive system at subsidized price. The CNAG, as part of its activities, has also imported 11 bulls as sperm stocks between 2005 and 2014.

The Links in the VC:

The same structures and actors are involved in the VC in both types of genetic improvement options; in this case, the semen and the imported live animals. The generic names for the links in the VC are as follows: *production*, *distribution*, *processing*, and *use*. More specifically, *Production* (importation of germplasm, although the CNAG ensures local production), *Distribution* (refers to private companies performing AI with the imported germplasm or locally produced semen), *Processing* (the manipulation of germplasm in order to create added value, which is represented by the birth of an improved animal) and *Use* (primary beneficiary from the improved animal). The chain structure is presented in Figure 7.

Figure 7: Visual Representation of the Value Chain for Dairy Cattle Germplasm in Senegal

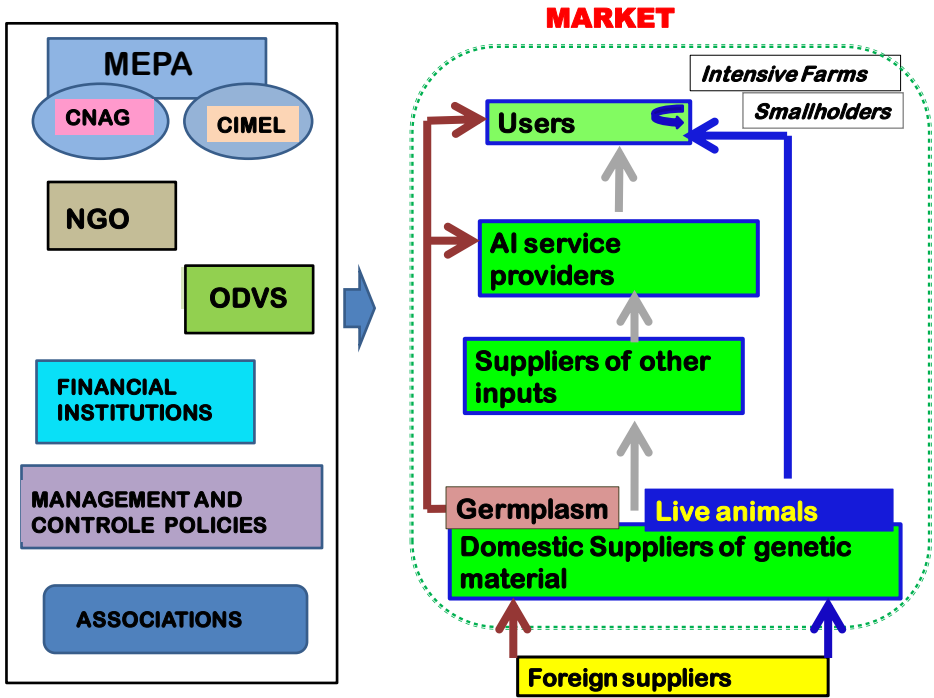


As shown in Figure 7, the chain is relatively simple in its structure and organization but complex when traded products are considered, especially the manner to which they are traded. Indeed, it is rare for dairy germplasm to be solely exchanged. Generally, the exchange is as a package (*bundle*) consisting of the germplasm along with the other inputs necessary for handling (liquid nitrogen, hormones, spirals, and implants) and the AI service. This may include support or advisory service. Distribution channels described in section V.1.7 are numerous but relatively short between the producer/semen provider and the recipient, in this case the end user.

V.1. The actors and their relationships

The actors involved in the dairy germplasm value chain are *germplasm suppliers* (semen and live exotic cattle), *other input suppliers*, *AI service providers* (service providers), *facilitators* (the State and Banking Institutions) and *end-users* (intensive dairy farms, rural semi-intensive farms). Some players are involved more than one node in the chain, denoting the lack of specialization and diversification of activities of the actors. The different relationships that actors have with each other are shown in Figure 8.

Figure 8: Mapping the Actors in the Dairy Cattle Genetics Value Chain



V.1.1. Suppliers of dairy germplasm

In accordance with the vision of the Senegalese government, the option of improving dairy genetics has led to the importation of: 1) frozen semen, 2) live stud bulls, 3) females or pregnant females, and 4) the promotion by the CNAG, of local semen production from imported stud bulls. In the entire country, there are four (4) suppliers of germplasm: *AFRIVET SARL*, *SOPRODEL*, *VETO HORIZON*, and CNAG. As mentioned before, only CNAG produces semen; hence it could also be referred as suppliers/producers while the other three, which are privately owned import germplasm, store, and distribute to users. For these three, the term *wholesalers/distributors* could be attributed to them, as well as that of suppliers/importers. This select group of *suppliers* is not homogeneous as there are variations in their legal status, nature of the germplasm, volume, frequency and diversity of germplasm and, finally, in other services and benefits offered.

V.1.1.1. The Status

The importers/suppliers are private enterprises created through the initiative of founding professionals who are involved in other income generating activities in the veterinary/animal science field while CNAG is a public institution attached to MEPA. Its mission and its functions are described in Decree No. 2007-544 dated 24 April 2007, implementing Law No. 2002-24 of 9 December 2002 on the genetic improvement of domestic animal species.

National professionals trained in the animal science/veterinary field with expertise in AI practice are heading these structures. Veterinarians who have acquired additional training related to livestock and business management head all, except one.

V.1.1.2. The nature of the germplasm

The State has no vocation to import germplasm and other AI inputs required for its genetic improvement campaigns. This function has been devolved to the private sector with the CNAG controlling who is in charge of the introduction and handling of all the germplasm in

Senegal, as stipulated in the Decree No. 2007-544 mentioned above. Note, however, that this control is not always effective. Consequently, the State issues calls for tender in order to acquire the germplasm necessary for its programmes. The *private providers*, by bidding, comply with the specifications defined by the MEPA, which among others include specifications on which exotic dairy breeds to import.

Many dairy breeds were introduced into Senegal, including Montbeliard, Holstein, Normand, Brune, Abondance, Jersiaise, and dairy Guzerat, to name a few. The interviews show that the most popular dairy breeds for farmers are Montbeliard, Holstein, and dairy Guzerat. The criteria considered when choosing the breed are the level of adaptation to local farming conditions (climate and endurance), production, and quality of milk (fat percentage). The color of the coat is also important for many farmers due to social considerations. For example, *Peulh (Fulani)* farmers prefer animals with light hides (white to gray) and are not attracted by the dark or black hides, unlike *Serere* farmers. The dairy germplasm is used in various forms: frozen semen (imported and locally produced), fresh semen and live exotic cattle (bulls and females, whether pregnant or not).

Imported frozen semen

The *private suppliers* are predominantly importing semen from European countries, with France having been the main providing country for many years. Currently, with business growth and wider contacts, they are sourcing from many countries with partners varying from one year to another. Thus, Belgium, Brazil, the Netherlands and Morocco can now be listed as countries of origin regarding imported semen, in addition to France. The semen is used for AI campaigns and *private artificial insemination (PAI)*. Private artificial insemination is on demand and is fully paid by rural farmers, semi-intensive dairy farms and peri-urban intensive dairy farms contrary to AI campaigns financed by the government.

Frozen semen produced locally

This comes from the collection of semen from exotic dairy sires raised by CNAG. It is packaged and preserved *in situ* for use during national campaigns, along with other AI inseminations outside of the campaigns. Frozen semen production has been interrupted since 2010, due to the failure of the liquid nitrogen generator.

Fresh semen

Like frozen semen, CNAG also produces fresh semen from exotic sires for farms near the Centre for Zoo-technical Research in Dahra. Despite its short shelf life (for immediate usage, or at the latest two days after the harvest), fresh semen is available and accessible from CNAG throughout the year.

Live animals (sires and pregnant heifers)

In addition to frozen semen, the *private suppliers* are importing live exotic cattle for sale to semi-intensive farms and on request from the State for its development activities (sold at subsidized prices to semi-intensive farms). The import of these animals is mainly for natural breeding, so the current inclination of MEPA is toward the introduction of productive females (pregnant cows or heifers).

V.1.1.3. The volume and variety of imports

Import volume and diversity of the introduced germplasm depend on the abilities of *private suppliers* to provide customer satisfaction. In addition, they are indicators of the proportion of the market (demand) that the supplier tends to satisfy at the national and sub regional level, along with the accessibility to bank credit (credibility with domestic financial institutions).

V.1.1.4. Other services provided

In addition to the supply of dairy germplasm, the importers/distributors are involved in other activities in the value chain. Indeed, they operate as: 1) retailers and distributors for ensuring the transport of semen to the AI service provider, 2) extra equipment suppliers for transport (appropriate cylinders) and liquid nitrogen, 3) AI service providers in Senegal and the countries of the sub region (Mauritania, Mali, Cameroon, Chad etc.), and 4) Suppliers of other inputs required for AI, such as implants, spirals, extra hormones and other small equipment.

All *private providers* undertake other income generating activities such as veterinary clinics, sale of veterinary products and advisory support. Therefore, the supply of dairy germplasm is only one activity among many others.

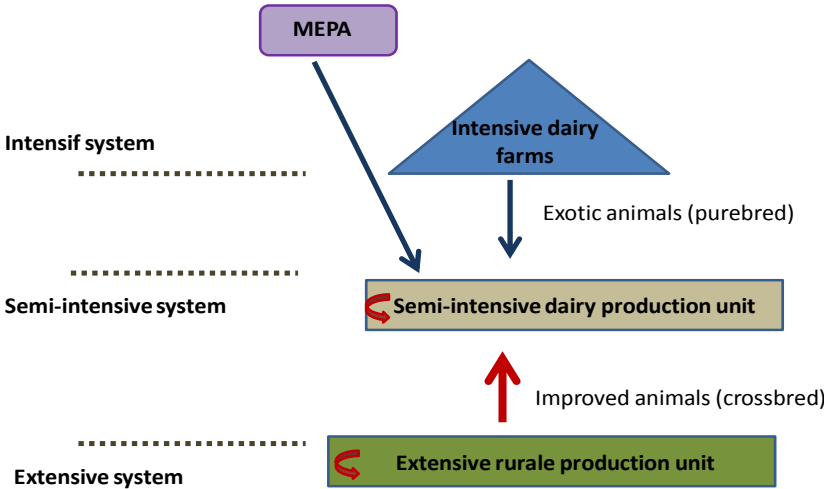
V.1. 2. Occasional suppliers of live animals

Although trade volume is very low, it is important to note the transfer of dairy animals between intensive dairy farms and other lower-input dairy keepers. The *private veterinarians* play a facilitating role in this movement of animals. Indeed, purchase intent and sales of animals are declared in veterinary clinics/pharmacies that serve as platforms for exchanging information between stakeholders. However, transactions are directly between the stakeholders, as the *private veterinarian* is unpaid.

Animal movements are between rural farms, semi-intensive farms and intensive dairy farms as shown in Figure 9. Indeed, for a better herd management, intensive dairy farms occasionally sell exotic dairy cattle. Destocking also occurs with male calves that are often not kept due to the use of AI. For economic reasons, the *improved animals* are sold between the rural farms and especially for semi-intensive farms. Reasons for sale include the need for cash flow and management challenges of improved animals (food, and health).

The current dynamic is that after many campaigns, some areas have now specialized in the birth of *improved animals* (the Groundnut Basin, the pastoral zone and the south), while others use or do both improved and standard animals (generally near large cities such as Dakar, Touba, Thies, and Louga).

Figure 9 : Movement of Dairy Animals in Different Dairy Production Systems



V.1.3. Suppliers of other inputs of artificial insemination

Along with the semen, other inputs are necessary for the act of insemination in Africa. These include implants, spirals and extra hormones, which are mainly supplied by *private providers* and by some veterinary pharmacies, which serve as *retailers* for these inputs. The CNAG also supplies insemination inputs as part of its regulatory activities to users in close proximity.

V.1.4. AI service providers

In Senegal, animal Scientists or veterinarians (Doctor of veterinary medicine) who operate private practices (pharmacies and clinics) provide insemination service. They are called *private veterinarians* as opposed to the veterinarians employed in the public and para-public institutions who are civil servants. They have received the same training in veterinary schools and additional training on AI for those interested. Both public and private veterinarians belong to the board known as the *Ordre des Docteurs Veterinaires* (Veterinarian Doctors Medical Board) (ODVS), which adjudicate over conflicts and defend the interests of the profession. The AI service providers also have their own associations in the geographical zones where they intervene to deal with matters specific to their businesses, especially when negotiating rates with importers/distributors during national campaigns.

For national AI campaigns, service delivery and all inputs of AI (semen included) are paid for by the State. The *AI service providers* are selected on tenders; they sign a contract with MEPA, which takes into account the campaign specifications. All inputs, including semen, are available from *private providers* approved by MEPA. The latter is in charge of planning and coordinating campaigns (implementation schedule, site selection, definition of the number of inseminations). In addition, the MEPA, through its decentralized services, provides logistical support for *AI service providers* if necessary. For the campaigns from 2000 to 2007, a contribution of 7,000 to 10,000 FCFA was requested from the farmer for each candidate

cow to cover the cost of deworming before AI. It has now been removed under the GOANA campaign.

Apart from the national campaign for PAI, AI service providers are paid by the farmer for the service along with the provision of all inputs of AI, including frozen semen and pregnancy diagnosis. They obtain their supplies from *private suppliers*. Investigations revealed constraints on the delivery system of the semen and a lack of containers (cylinders) suitable for transportation and storage of the semen. The floor price for PAI amounts to 30,000 CFA francs (46 euros) and the price of the semen represents one fifth of the fee of the service. The price of PAI has decreased, it was 50 000 FCFA (76 euros) during the PAPEL Programme (Diao, 2005).

For national campaigns and PAI, farmers choose a dairy breed from the panel of races proposed by the AI service provider. The majority of inseminations are performed during the national campaign, so the peak of use of semen is at that period. However, it appears from this study that a steady increase in PAI is noted and, increasingly, the PAI are made during natural ovulations, thus reducing the cost of insemination. Furthermore, some farmers prefer the PAI because the success rate is higher than during the campaigns.

V.1.5. Facilitators

The State, through the MEPA, provides a facilitating institutional support to the germplasm VC to promote its development. This includes the following:

- Building the capacity of the different actors;
- Promoting private investment;
- Disseminating AI throughout the country;
- Providing financial support
- Implementing support programmes as an accompanying measure to the success of the AI and enhancement of production (FONSTAB, Health, small-scale dairies),
- Enacting the legislation governing the import and manipulation of germplasm and finally
- Establishing a germplasm control structure, in this case CNAG.

Financial institutions are involved as facilitators in the VC as many participants require credit to operate. Some non-governmental organizations (NGOs), producer organizations (POs) and ODVS are also facilitators by funding AI as part of their developmental programmes.

V.1.6. Users

Dairy farms and livestock producers are the main beneficiaries of AI because of the direct financial benefits accrued from milk production and/or sale of live animals. The intensive dairy farms that raise exotic dairy cattle (pedigrees and crosses between exotic breeds) on the outskirts of large cities (especially in the region of Dakar and Thies) form a *peri-urban dairy belt*. The National Association for the Intensification of Dairy Production (ANIPL) includes 20 intensive dairy farms raising 1,600 dairy cattle. The main breeds used are the *Holstein*, the *Girolando*, *Jersey cow*, *Monbeliard*, *Normand*, *Brune des Alpes*. Artificial insemination is widely used. The semen comes from *private suppliers/distributors* and imports. The produced milk is generally sold in the nearby cities.

Semi-extensive farms are less equipped than their intensive counterparts. They are located on the outskirts of towns and raise local, local by exotic cross-bred, and also some pure-bred exotic dairy cattle. They benefit from exchange of animals with traditional intensive and extensive dairy systems. The reproductive methods can be by AI or natural service, depending on the production goals of the farmer.

In rural farms, local breeds predominate but some local x exotic cross-bred breeds are raised in the traditional extensive system but exposed to risks such as their difficulty to adapt to the conditions (herding movements, lack of feed, and supplements), susceptibility to disease (decreased hardiness) and risks linked to climate changes (impact on diet and health).

In summary, the State, as the bankroller of the national AI campaigns, plays a major role in the germplasm value chain. Through tender processes, it selects its main contractors, which can be an importer/distributor or occasionally a well-connected private veterinarian. These contractors then subcontract the AI service to the AI service providers. The system also operates outside the national AI campaigns where the relations between the different actors in the VC vary, depending on the distribution channel. In any case, the supplier market is an oligopoly dominated by two major players (SOPRODEL and AFRIVET). As for providers, they act individually or as part of collective action. Collective action is generally designed to better negotiate with contractors during campaigns financed by the state.

V.1.7. Distribution channels for germplasm

Seven different distribution channels were identified (Figure 7). They all lead to the end user, in this case the farmer. Among these channels, 4 start from *private suppliers* that can sell directly to: (1) farmer, (2) AI service provider who inseminate at the farmer's request, and (3) public and State entities (MEPA), NGOs, and development projects, which in turn contract a service provider who inseminates at the farmer's facility. Occasionally, public entity such as NGOs employs its own inseminator. The fourth circuit identified represents the localized intensive farms, especially in the regions of Dakar and Thies that may be importing semen for their own activities. The fifth circuit consists of the provision of services as carried out by the *private supplier* in the other countries of the sub region. Finally, the last two circuits begin with CNAG, which directly supplies the farmer with semen and administers insemination (*proximity insemination*) or by linking with an AI service provider who will do the inseminations for the farmer.

V.1.8. The cost of insemination

The analysis of price and cost represent a major step in understanding the competitive structure within a value chain. Unfortunately, this study has encountered difficulty with the collection of certain information, particularly with respect to price and cost data at the private veterinary practitioner (i.e., retail) level. For instance, we encounter some difficulties gathering information on the applicable fees for insemination or price of hormones at retail level. However, we could use the focus group discussion data to derive this information. As stated earlier, AI service is offered in package that includes semen straw, hormones, and the insemination itself for those using hormonal induced ovulation, and semen and insemination for those seeking natural oestrus. On average, the overall package costs CFA 30,000 based at supplier/importer (i.e., wholesaler) based on the survey while for the private the minimum they are willing to accept for the package is CFA 35,000. Price of semen straw was also

collected from the suppliers/importers and the AI service providers, which are on average CFA 7,500 and CFA 8,000, respectively (Table 2).

Table 2: Cost of insemination according to the type of provider

Products and Services	Price Per Type of Provider (FCFA)	
	Supplier/Importer	AI Service Provider
Semen, hormones, and insemination*	30,000	35,000
Semen (straw)	7,500	8,000
Semen and insemination**	-	17,500
Hormones	14,700	17,500
Insemination	7,800	9,500

Notes: *Insemination via induced ovulation and **Insemination during natural ovulation

Regardless of the type of actor, the cost of insemination varies depending on the location of the animal and the number of services requested in the farm or proximity. The prices of semen shown in Table 2 above are averages, which vary depending on the genetic value of the bull (pedigree) and its geographical origin. For example, among *private providers*, semen from a Brazilian-born breed is sold at 8,000 CFA francs (12.2 euros), while that of a European race is 7,000 CFA (10.6 euros).

In addition to semen type, distance and whether the insemination is based on natural or induced ovulation are important factors to consider. They affect the cost of service. By distance, we are referring to whether it is performed in the same municipality as the residence of the AI service provider or in another more remote location. Insemination during natural ovulations vary between CFA 15 000 and CFA 20 000 (23 and 30.5 euros), depending on the distance the provider travels to perform the service. Based on the collected data and the average mark-up between wholesaler (i.e., supplier/importer) and retailer (i.e., AI service provider) in the industry, it was possible to deduce that the cost of insemination and hormones at the providers' level, bearing in mind that the importer/supplier sometimes contracted out these operations to individual practitioners as well.

Therefore, on average the act of insemination alone costs CFA 7,800 (11.8 euros) at the supplier/importer level and CFA 9,500 CFA francs (14.5 euros) at AI service provider level. Note that these costs were determined based on the lowest price the providers are willing to accept for the service; hence, they could be higher. In addition, the number of animals to be inseminated is also an important incentive for the AI service providers and the farmer. The farmer benefits if several inseminations are performed with each visit from the AI service provider. This explains why in localities that are remote from the AI service providers, inseminations are exclusively conducted via induced ovulation in order to reduce costs. In addition, some farmers who require these services enter in collective action before calling the AI service provider to achieve some economies of scale. Inseminations on natural ovulations are often made in the immediate environment of the AI technician for practical purposes.

V.2. Gender aspect

The players in the VC are essentially men, although there are three female veterinarians that provide AI services. The veterinarians are at the top of the pyramid with regard to health or

AI service providers. Those providing AI service undergo additional training to become operational. The training was dispensed by the veterinary school, under the national program for artificial insemination paid by the government. Livestock technicians offering AI service do undergo training on individual basis offered by their private employers who are veterinarians. Hence, by the time they start providing such service, they are already beyond 27 years of age, which explain why young people are not in this category. For females, their limited presence stems from career choice as males are traditionally more represented in veterinary school than females. Furthermore, after training, the majority of females that go into private practices tend to operate in the area of clinical services and veterinary pharmacies. Overall, the number of females offering AI service has historically been lower than that of men. For these considerations, young people and women tend to operate only as farmers in the VC. Regardless, it must be recognized that a functional germplasm value chain requires good knowledge about breeding, availability of funds and refresher training for the AI service providers although diligent practice and dexterity are also necessary.

V.3. Opportunities and growth constraints in the value chain

V.3.1. Opportunities

The germplasm VC has real potentials for its development. Indeed, as described in Section IV, the existence of a national and sub-regional market, along with a strong political will and financial backing from the state and a favourable legislative and regulatory environment are all conducive to growth. In addition, the existence of national expertise, private companies that specialised in genetics, financial institutions, a national centre for genetic improvement (CNAG), and a centre specialised in the promotion of livestock (CIMEL) are important enabling factors.

Over the last ten years, the inflow of exotic dairy cattle genes has increased as imports of semen and live animals have increased. In addition to the increase in numbers and quantities, changes were noted with the diversity of breeds and origins of biological material (MEPA, 2012b; Anonymous, 2014). These dairy gene inflows have caused the following positive effects:

- Coexistence of three systems of rearing cattle differentiated by production targets, breed, workforce, and the livestock management system of the animals: 1) an intensive system using exotic breeds of purebred animals, 2) a semi-intensive system with increasing use of local x exotic cross-breed animals, and 3) a traditional extensive system largely utilising local breeds of animals.
- Use of improved management practices (animal health-care, feed and housing) to support the non-local breeds, so a trend towards modernization.
- Development of processing units, packaging, and marketing of animal products, especially milk. This is a corollary of the efforts on farm management designed for a better utilization of production (value addition) .
- Development of private initiatives, as evidenced by the increase of actors in the germplasm value chain.

In summary, the germplasm VC has not only taken advantage of the existing opportunities to emerge, but it has created changes that are favourable to its growth: with the increase in the number of suburban semi-extensive dairy farms as a good illustration.

V.3.2. Constraints

Several constraints hinder the proper functioning of the VC: they are economic, technical and institutional (Figure 10). Due to the cluster effect, constraints are common to germplasm VC and local milk VC; however, the focus will be on the constraints that specifically affect germplasm VC development.

The limited nature of the market: All stakeholders ranked the small size of the market as a major constraint. Indeed, although they are all unanimous on the increase in private AI (i.e., fully paid by the user), importers/distributors and private service providers argue that the current demand for semen is still low to induce VC growth. It must be stressed that the State, through national AI campaigns it funds, is the main customer of germplasm importers/distributors and AI service *providers*.

The high cost of liquid nitrogen: it is a constraint noted by all stakeholders. This substance is required for the conservation of semen and has an impact on its price and quality, especially in the tropics. The liquid nitrogen level should be raised regularly every 10 days in the hot season, and every 15 days during the cold season, to avoid the effects of evaporation and preserve the quality of semen (Bouyer, 2006). In addition, the quality, of the storage area of the bottle and its management affect the aforementioned periods. Liquid nitrogen supply in Africa is one of the major constraints in the provision of AI programmes. In Senegal, the two current providers are located in Dakar; availability and accessibility problems throughout the country are decried. The price per litre of liquid nitrogen varies. It is set at 5,000 FCFA (7.6 euros) for a supplier who is an actor in the germplasm VC and up to 13,000 CFA francs (20 euros) without taxes to other industrial users.

Transport and conservation equipments for semen are insufficient: AI service providers noted the lack of appropriate cylinders in terms of quality (isothermal) and the capacity and usage (for transport and storage) of the semen. This has an impact on the quality of semen and therefore on the AI success rate.

The inefficient distribution system for semen: The AI service providers within the region of the Dakar are supplied directly from the semen of private providers, but this is not the case with their colleagues who operate more remotely in the country. Their semen orders are often conveyed by public transport and subject to all associated risks (weather, delays, dirt, etc.). This distribution method affects the quality of the semen.

Semen breed-type: Whilst semen from a number of exotic breed-types is imported or locally produced, dairy keepers are not able to access local x exotic cross-breed semen. Availing the latter could be advantageous in providing access to dairy sires that are both productive and locally adapted. In terms of stabilising, the cross-breed type (as currently the F1 progeny of a local by exotic mating) would need to be mated back to either of these parental types, resulting in a backcross with 75% of one breed and 25% of the other. Whereas mating the F1 progeny to a cross-bred sire would result in an F2 with 50% of each breed-type.

Semen quality: it was mentioned based on the success rate of AI and the current distribution system (tracking the semen from the suppliers to the insemination of the animal). Several respondents blame the quality of the semen at the time of insemination for low AI success

rates. The success rate of AI depends on several factors: those intrinsic to the animal (health, age, and general condition), the technical ability of the AI technician, the semen quality (viability, motility, biochemical and microbiological quality) and, finally, the environment (farm management system, climatic factors, etc.).

Delays in payment by the State: the timeframe for payment of actors in national campaigns is quite long, leading some to quit the business

Information sharing: sharing information between different actors is neither complete nor continuous. The information flow is discontinuous and horizontal, as it is done sequentially (in the preparations of AI campaigns) and between actors who share the same activities.

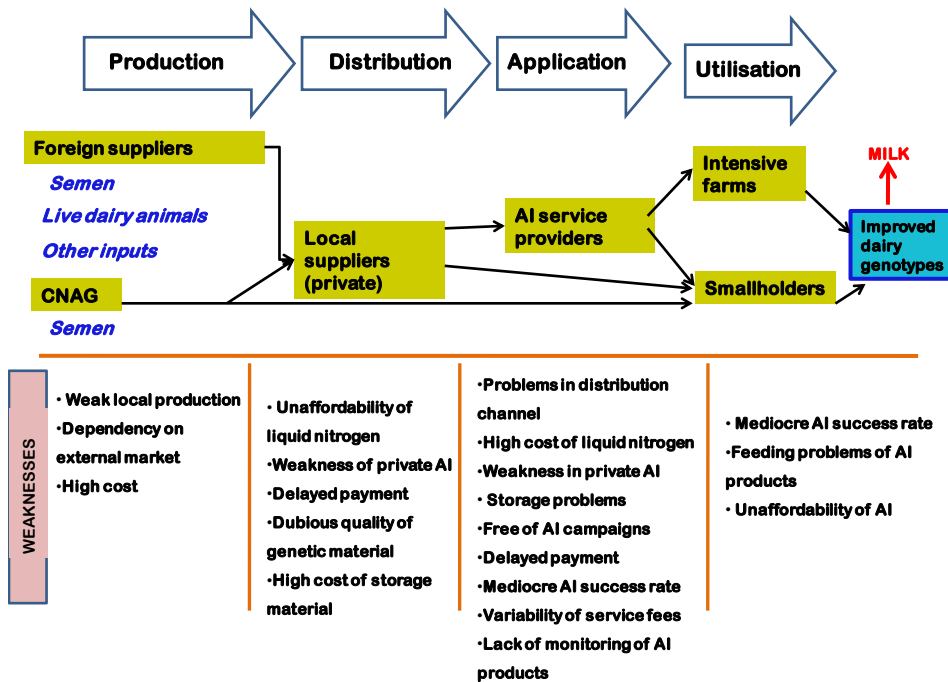
Low promotion of improved animals: not only are the performance of dairy genotypes underutilized (as limited inputs, particularly feed, mean that their genetic potential for milk production is not expressed)), but there is little added value in locally produced milk (little processing, poor labelling and ongoing marketing constraints). This issue has been well documented in several studies on AI (Diao, 2005; and al Dia 2008. MEPA, 2009; Diop and Kamga-Waladjo 2011; Diop , 2012b). This constraint partly explains the narrowness of the market and why business opportunities are not developed.

Low success rate of AI: it discourages the use of AI and consequently has a negative impact on the development of the VC. Success depends on several factors as mentioned above.

Free national campaigns AI: While it is undeniable that the AI campaigns have been beneficial to the growth of the germplasm VC, the fact that they are entirely bankrolled by the State is a hindrance to the emergence of private AI service providers capable of operating based on the fees charged to and paid for by farmers. Indeed, farmers who are motivated and willing to pay for the service will positively affect the germplasm VC, especially in terms of sustainability. This is an investment and its return posits on the best promotion of improved animals and / or of their production by the farmer. In national campaigns, the high rate of inseminated cows that did not show up during pregnancy tests reflects the lack of motivation of some farmers , who are not optimizing the opportunity that the free national campaigns is presenting to them.

Insufficient implementation of existing legislation In some cases, the law regulating genetic improvement plan (PAG) are not applied at all; in others, there is a lack of implementation: an example is the law on genetic improvement as discussed in section IV.

Figure 10: Constraints in the Value Chain for Dairy Cattle Semen in Senegal



V.4. Discussion

In Senegal, the development of the germplasm VC for dairy has been driven by the State and it has gained in popularity among farmers. It has acquired some attractiveness in the national campaigns over the years, at the national and sub regional levels. The private sector is at the heart of the process, with *private suppliers/importers* having market shares in AI programmes in the West African sub region. A right dosage of public-private partnership is desirable, especially financially, as too much of public authorities' implications could slow VC development. This scenario is akin to that of Senegal where the state, through its national AI campaigns, is deeply involved in the VC governance. What would happen if the State decided to stop national AI campaigns for some reason such as lack of funds or policy change? A withdrawal, if abrupt, would substantially weaken the germplasm VC. Hence, to ensure sustainability, stakeholders involved in germplasm VC need to have a prospective stand and view this eventuality as a real possibility. In doing so they would be able to prevent the collapse of germplasm VC should the State, their major partner ceases to bankroll the national AI programs.

The requirements of the national market are sufficiently respected. Indeed, the existing law and the legal dispositions taken by the MEPA in the specification of the orders ensure compliance between product/market and quality assurance. In fact, marketing adequate and predictable volumes, fluidity (i.e., ability to deliver on schedule), and rapid execution of transaction are required. It is imperative to improve the current system of distribution in order to ensure the quality of semen.

Evidence should be provided on the various trade-offs of keeping the different dairy breed-types, so dairy keepers can make informed choices on breed-use. Production of local by exotic cross-bred semen should also be strongly considered, as this would provide a further option to dairy keepers and would help to stabilise the cross-breed type.

For VC sustainability, farmers should be encouraged to financially contribute to national AI campaigns. This analysis shows that the supply of semen is higher than demand.

Sexed semen may be available if demand is expressed with *private suppliers*. It is more expensive has lower AI success rate than unsexed semen. These costs have to be accounted in the decision of choosing one over the other semen type.

The importers/distributors and the AI service providers have the expertise to acquire, distribute, and use germplasm. The relationships between vertically linked actors are relatively good, despite the quasi-monopoly power of the importers/distributors who at times exercise it at the detriments of AI service providers. During the survey, the AI service providers have lamented the rates at which these importers/distributors contracted out by the government were willing to pay them. The relationships, however, are of horizontal nature whereby actors who are at the same level exchange information. Conflicts between these actors are rare because of the policing by the veterinary board, which delineate each service provider zone of intervention although encroachments happen at times. The vertical information flow requires improvement for a smooth flow of information within VC. Competition exists because of actors' heterogeneity and lack of specialization leading some to operate at several levels of the VC. This does not always cause major bottlenecks in the functioning of the system although it is often criticised by the service providers who are claiming that the importers/distributors are supplying products to them and compete against them at the same time. With respect to horizontal relationships, the agreed rate during the government program is obtained after concertation between service providers and distributors/importers. This prevents unfair competition, which can have a negative impact on the VC. It was noted that all actors had other sources of income. This diversification has not only helped seize business opportunities, but also to manage the risk posed by an economically unpredictable business venture.

Semen is the largest (measured by quantity and by distribution area) source of germplasm and the most sustainable. The import of live animals is still necessary during the establishment of intensive dairy farms. For semi-intensive farms, the introduction of *dairy Guzerat* cattle by the state at subsidized prices, aims to promote a dairy genotype adapted to local farming conditions (heat tolerance, walking ability with phenotypic characteristics accepted by farmers such as the presence of horns and the colour of the robe (APME, 2013). Importing animals for production to ensure, within a short time, milk production and milk products while justified may not be sustainable unless when extended for breeding purposes. Indeed this is a costly strategy with a positive aspect in that it allows dairy keepers to access the breed or cross-breed types they desire. Semen is convenient to use, so a business opportunity is created for those involved in its imports, distribution, and use. Live sire is also an option used by some farmers with its risks (health) and cost of maintenance.

In order for CNAG to produce the semen of local x exotic cross-bred or exotic dairy cattle, and to control imported semen, it must be provided with logistics, financial and human capacity for the consistent achievement of the stated objectives. For genetic variability, it is important to renew the sires used by the CNAG Centre on a regular basis to avoid a limited number of bulls servicing a large number of cows. With the variety of exotic dairy breeds introduced in Senegal, it is important to have a genetic improvement plan (GIP) based on agro-ecological zones, including an operational crossing plan for the genetic improvement of

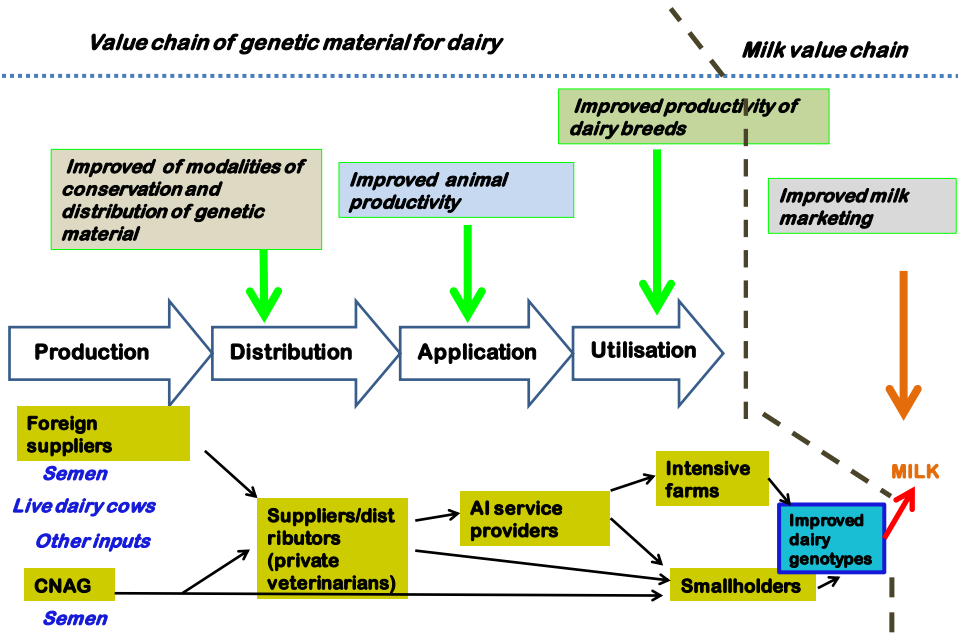
local breeds as mentioned by Diop (2001; 2012a) and, where required, a local breed preservation programme (Anonymous, 2014). Note that the production of local cattle breeds semen is part of the mission of CNAG. Like the GIP, the need for a national action plan (NAP) is acknowledged, as it is a useful tool for governance guidance, planning and monitoring and evaluation of actions to achieve the objectives of the indicated policies.

Recommendations have been proposed for several constraints listed in section V.3.2 following the proposals made in various studies on AI (Thiam, 1996; Byugura, 1997; Diedhiou, 2002; Nishimwe, 2008; Kouamo et al., 2009; Sawadogo, 2011, Diop and Kamga-Waladjo, 2011); further proposals to improve the semen distribution system are made in section V.5 section below.

V.5. Strategies for the development of the value chain

Growth in the dairy genetics largely depends upon that of the local milk VC; so all actions for the promotion of local milk benefit the germplasm VC. For the development of the germplasm VC, it is necessary to expand the local milk market. To do this, dairy productivity (including via the use of more appropriate dairy breed-types) must increase followed by a better marketing of local milk and milk products. Interventions will therefore be on both VCs (Figure 11).

Figure 11: Interventions for the development of the dairy genetics



Response to the increase in productivity:

- **Ensuring the semen quality by improving the current distribution system.** Semen is a fragile biological material that requires care during handling and transport. The creation of secondary depots that comply with the conditions for handling biological material would reduce the risk of damage due to transport. Semen should be transported in appropriate containers and as quickly as possible. This proximity of the semen to the AI service provider should also be subject to the use of appropriate cylinders for transport on the ground and its conservation for a limited time. Widespread geographic accessibility to semen will

contribute to the increase of AI on natural ovulation, which is less expensive than that with induced ovulation.

- **Improve the success rate of AI** in order to increase the numbers of dairy animals. Many factors influence this success rate so, including correct oestrus detection (if natural ovulation), body condition of the animal at time of insemination, AI technique and semen quality. The measures to be taken include:
 - Training of farmers on oestrus detection
 - Improving husbandry conditions so that the animals have a good general state of health for AI. Farmers must make the most of public programmes implemented by the MEPA such as FONSTAB, making fodder reserves and promoting agricultural by-products in feed and enjoy the facilities provided to producer organizations (cooperative purchase of food, etc.)
 - Raising awareness and capacity building amongst farmers so that they benefit the most from development programmes (the AI campaigns, FONSTAB, etc.)
 - Strengthening the capacity of AI service providers who need good technical skills (through regular practices) and ensure customer loyalty (trust between actors)
- **Promote higher PAI** reflecting the motivation of farmers to increase the number of dairy animals. It is necessary that farmers contribute financially to the programme during the campaigns.
- **Educate farmers** to the use of breed or cross-breed types adapted to the farming conditions prevailing in their area of operation. Information should be available via the GIP, which must be commissioned by MEPA for its dairy improvement policy.
- **Increased use of sexed semen, which is available on the market.** Two suppliers including SOPRODEL and AFRIVET have sexed semen (which is used in PAI on demand) and embryos. The dissemination of sexed semen could be a great advantage in intensive and semi-intensive farms, despite its cost and noted low success rate, which calls for pilot test to have a better idea under what conditions success rate improve and whether there will be need for better targeting.

Improve local milk marketing:

The increase in production by dairy animals, achieved through use of the most appropriate breed or cross-breed types coupled with appropriate management practices (animal health-care, feeding, and housing). Such an increase should be followed by an increase in the share of local milk to the overall demand of milk in Senegal. The financial benefits resulting from this scenario should incentivise farmers to use AI to close the productivity gap and increase production. Access to reliable and remunerative markets is required (which may necessitate additional milk processing plants), and adding value to local milk processing by producing other dairy products (yogurt, cheese) and by labelling, etc.

Other Actions:

- A requirement for the development of the VC is the sustainable integration of semen users (intensive dairy farms, semi-intensive farms and rural farmers) and semen importers/producers. Trust and cooperation between all actors is essential. In addition, opportunities and compensation for risks and effort must be fair.
- A platform for innovation, which would allow for an increase in information flow between actors, for exchanges to remove constraints and for innovations that increases the efficiency of the various links in the chain.

VI. Recommendations for public authorities

The state, has promoted the introduction of AI throughout the territory for more than two decades via its campaigns. This has resulted in the development of the private sector in activities and services in the field of breeding, an enrolment of farmers in genetic improvement, and business opportunities with trade in different breed or cross-breed types of dairy animals and their products. Despite the shortcomings, there have been many achievements. The recommendations below are formulated to consolidate the gains made and to propose future directions:

- Evaluation of all campaigns initiated from 1995 to the present, in order to learn lessons that will guide the new AI programmes and the breeding policy in general.
- Improving breeding statistical data, including information on the different breeds/cross-breeds of dairy animals. Specifically, for this study it was challenging to collect the information on imports of germplasm. In the absence of data centralisation, it was necessary to collect partial information from various departments of MEPA. It is a strong recommendation that a database be created to centralize and record all information relating to the importation and exportation of germplasm (species, type of material, origin, destination etc.). This database should be updated regularly or in real-time and would contain reliable statistics and have better traceability of introductions. Also, it will be an important animal genetic resource management tool to ensure awareness of threats to local breeds and erosion of their viability
- Monitoring the performance of the different dairy breed/cross-breed types by the relevant services (MEPA and ANCAR). Data collection, such as on milk yield, reproduction and survivability would be very informative for the development of baselines on milk production of each dairy genotype in a given production environment. These measures would also help to assess the contribution of these animals to the satisfaction of the national demand for milk.
- A financial participation of farmers in national AI campaigns combined with other technical actions (semen quality and technical capacity of the AI technician) will help increase the success rate of AI. Farmers who are willing to pay for the service are more likely to perceive it as an investment for which they would expect a return. Thus, they would be more likely to prepare animals for AI, hence increasing AI success rate. Moreover they tend to provide the necessarily levels of inputs (animal health-care, feed, and housing) for the improved dairy genotype to be expressed. Once farmers start paying for the service, the state should gradually reduce its funding for national campaigns to promote the development of the VC. These funds, which were for AI campaigns could be directed into financing the development of livestock support programmes that positively influence the germplasm and milk VCs.
- Strengthening of CNAG capabilities and ensuring staffing, financial and logistical means to carry out its sovereign duties of semen production and semen import control. In addition, CNAG should produce local by exotic cross-bred semen, as an alternate semen option for dairy keepers, and consider piloting the use of sexed-semen.
- Development of a GIP that reflects the results of the evaluation of AI campaigns, the monitoring data collected for dairy genotypes and climate change.

- Implementation of a National Action Plan (NAP) would be a useful governance tool for orientation, planning, and monitoring and evaluation of actions to achieve the objectives in livestock policies. It would allow the private sector to seize business opportunities.

VII. Conclusion

The germplasm VC is growing in Senegal, as it has benefited from various opportunities that public authorities have set up as part of their policy of intensification of dairy production. Despite the lack of statistics, it is undeniable that the exploitation of dairy genotypes generates significant economic benefits, as illustrated in the development of peri-urban dairy belts promoted by private initiative. This pioneering study shows that the germplasm value chain is developing. Its development is based on the expansion of the domestic market by increasing private artificial insemination solicited by farmers and through better promotion of locally produced milk.

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