Socio-economic model for the operation of a solar platform for the conservation and valorization of local milk in the village of Tatki in Northern Senegal

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SUMMARY

Livestock is a strategic sector that occupies nearly 60% of rural households and accounts for 4.3% of Senegal's Gross Domestic Product (ANSD, 2016). The dairy sector plays a decisive role in this sector, given its importance in the food security of the population and the income it generates (Alari et al, 2011). However, national milk production is in deficit; the country relies on imports of large quantities of milk powder, 25,000 tons/year, to cover its consumption needs (MEPA, 2016). These imports weigh heavily on public finances, up to 60 billion FCFA/year, thus accentuating the trade balance deficit, which was 2,977 billion FCFA in 2016 (ANSD, 2018). The analysis of the milk value chain highlights, in addition to the difficulties of securing production in the dry season, the poor access to energy in production areas (Enda Energie, 2015). Thus, in these localities, the milk can neither be preserved nor processed to be valorized and allow producers to earn stable incomes. It is in this context that a milk valorization platform was installed in 2016, in the village of Tatki located in a dairy basin in northern Senegal. After two years of operation of the platform, the financial results showed real difficulties in making the business of selling fresh milk to dairy industries profitable, given the landlocked nature of the area. Indeed, the cost price is 320 CFA francs per liter, for a price proposed by the industrialist set at 325 CFA. According to economic calculations, the floor price of a liter of fresh milk should be set at 550 CFA francs, for a minimum average commercialized volume of 471 liters per day, within the framework of a concessional credit at a rate of 5%. These conditions do not correspond to the reality of the current market and could not be applied without a subsidy. Thus, in order to make the platform profitable, it seems essential to add value to the milk by processing it on site. In this regard, the production of yogurt has given very interesting results that could be replicated in other villages in the northern zone. The financial analysis of the activity, for financing at a subsidized rate of 7.5% per year for a period of 7 years and a deferred repayment of 2 years, shows a rate of return of 18% for a period of 15 years, when local milk is processed into yogurt. The wealth generated (10% NPV) amounts to 227,269,450 FCFA and the time to recover the capital invested is 3.90 years.

Keywords: operation, platform, solar, model, socio-economic

1. INTRODUCTION

The study area is the commune of Fanaye, precisely the village of Tatki, located in the north of Senegal in the department of Podor, with geographic coordinates 16°31'60" N and 15°13'60" W in DMS. It is an area of sandy plain at an altitude of 14 m.

The area is under the influence of the Sahelian climate, marked by low rainfall and recurrent drought waves. The cumulative rainfall recorded in 2017 in the village of Tatki was 155.4 mm. The vegetation is almost everywhere a pseudo thorny steppe on tropical ferruginous soils, with poor or even non-existent pasture during the dry season that lasts 9 months. In this area of Podor, temperatures are high almost all year round, sometimes exceeding 40°c (ANSD, 2015).

Transhumance, once adapted to the environment for the rational exploitation of pastoral resources, is becoming less and less effective, given multiple anthropic and natural factors. The commune of Fanaye is divided into two parts:

- The Fanaye Walo, which is under the influence of the Senegal River where mainly agricultural activities are developed, particularly irrigated and flood recession crops and, exceptionally, rainfed crops.
- The Fanaye Diéri, which is more continental, where Fulani breeders mainly practice extensive livestock farming over vast areas. It is in this part that the study was conducted.

There are no structured markets for livestock products in the Fanaye Diéri zone, despite the beginning of the structuring of the local milk sector in northern Senegal. This is organized by "La Laiterie du Berger" (LDB), an industrial unit based in the town of Richard Toll, which has set up a collection network targeting primarily villages along the Senegal River valley (Broutin et al., 2018). This network does not cover the 13 villages of Fanaye Diéri because of their remoteness.

This situation motivated the introduction of a solar platform for the conservation and valorization of milk produced in these villages. This is an infrastructure that operates on solar energy. The objective of this platform is to allow the breeders of these localities to have favorable conditions for a better valorization and marketing of their dairy products for the improvement of their incomes and their living conditions.

However, the implementation of such a structure, similar to a dairy power plant, requires several conditions, including:

- a social engineering capable of federating transhumant breeders around this initiative to organize the offer;
- a mastery of technical feasibility for a judicious choice of technology;
- and an entrepreneurial approach guaranteeing the sustainability of the farm.

This study aims to determine for this model of platform :

- The technical conditions of implementation,
- Key profitability indicators,
- A financial model for calculating profitability.

Furthermore, the results of this study should constitute a tool to assist in political decision-making, specifically concerning the development of the milk value chain in Senegal. The results of this study could

constitute a decision support tool for local and political authorities, within the framework of the development strategies of the milk value chain in Senegal.

2. DATA AND METHOD

2.1 Data used

This study is part of the Regional Milk and Solar Energy Value Chain Program called PROGRES-Lait, which is implemented with the support of the European Union and the States of Senegal and Mauritania. The data are from :

- Cooling tests carried out on the tanks of the platform where the milk delivered by the farmers is stored. According to the technical specifications the milk is cooled from 37 degrees to 3 degrees in 3 hours for a good conservation.
- Tests of the quality of the milk received at the Du Berger Dairy from the Tatki platform over a distance of 45 km. The milk was transported in 50-liter cans by a tricycle driven by the platform's collector. The travel time between Tatki and Richard Toll was estimated at 1h30 on average.
- From the PROGRES-Lait project database, with financial and technical information collected every day since the Tatki platform was commissioned in 2016. The data relate to the salary charges, the costs of the energy used and are as follows: the salaries of an administrative staff consisting of a manager, a hygiene and quality manager, an accountant and a janitor, which amount to 330 000 Fcfa/month; the level of energy consumption of the platform estimated at 76 305 Kwh. It is calculated on the basis of the power of the installed equipment, to which is applied the operating time observed with an efficiency of 98% for new equipment. The price of Kwh harmonized at the national level is 90.7 Fcfa/kwh (Commission de Régulation du Secteur de l'Electricité, 2019).

In addition, the databases of the technical services of the Podor department's livestock breeding department, the Senegalese Rural Electrification Agency (ASER) and the Saint Louis Regional Development Agency (ARD) were used.

2.2 Data Collection Methods

The protocol followed is the one proposed by the equipment supplier. It consists in putting a volume of water in the tank, starting it, taking the temperature at the start, and every ten (10) minutes taking the temperature until the tank is stopped. The temperature measurements were taken with a mercury thermometer graduated from 0 to 100 degrees. Before performing another cooling test, the Tank is turned off, and the water is drained, until the Tank returns to normal temperature (ambient temperature). We performed 10 tests on 1 tank with a capacity of 300 liters filled successively with 50 liters and 100 liters of milk. The results presented are the average of the observations on the 10 tests for each volume of milk.

2.2.2 Measurements of the quality of the milk transported from the platforms to the plant

The milk cooled at the Tatki platform was transported in 2 x 50-liter cans to the LDB plant, using tricycles as a means of transport for a distance of 45 km. The LDB uses this means of transport within its collection

radius. Upon receipt at the plant, the milk is directly analyzed in the laboratory. Thus, alcohol, acidity and PH tests are carried out on the milk. In order to avoid prolonged exposure to the sun, the 50-liter cans were transported from 7:00 am and the tricycle conveyors arrived at 9:00 am on average.

2.2.3 Data processing methods for cost-effectiveness and modeling studies

For the profitability study, the data used were collected over an 18-month period of commissioning of the solar milk valorization platform installed in the village of Tatki by PROGRES-Lait. From these data, projections were made over a period of 10 years. A profitability calculation model was developed, based on sensitivity tests of the evolution of the different milk collection factors and the platform's operating conditions. Subsequently, multiple regression methods were used to determine the relationship between profitability and these factors of production.

3. RESULTS

3.1 Cooling tests

The results of the evolution of the temperatures recorded during the cooling tests of 50l and 100l milk volumes, carried out in a real environment, are represented by figure n°1.

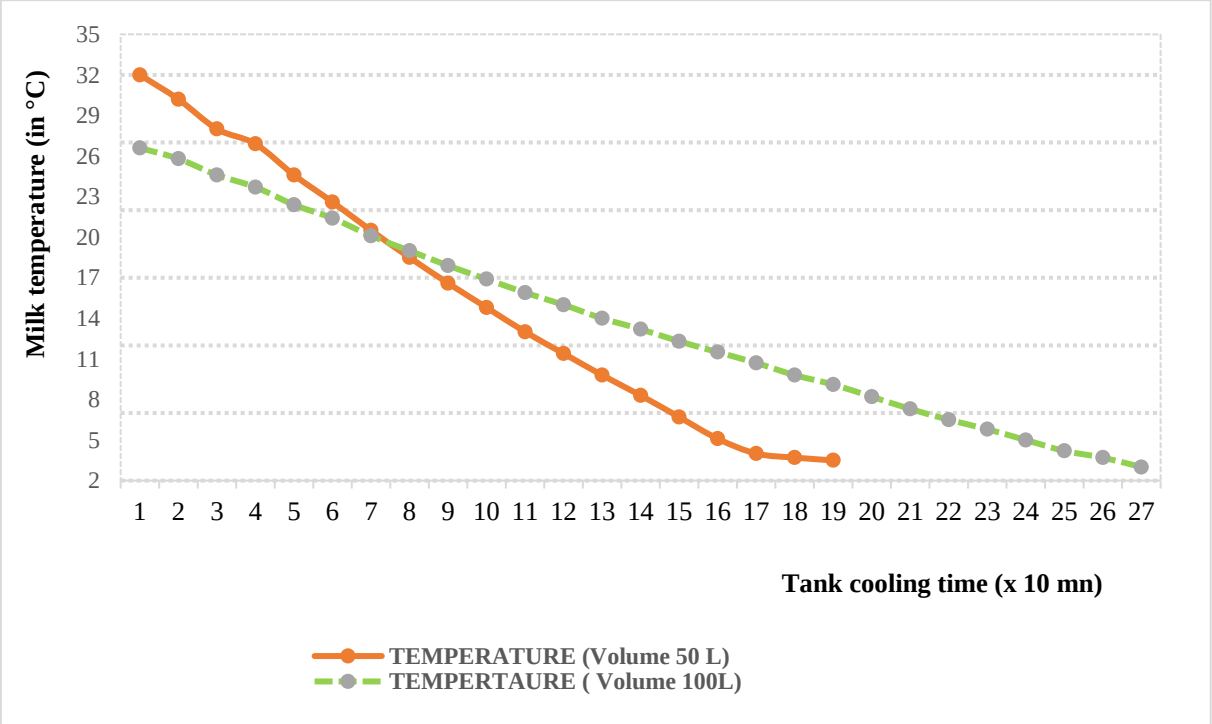

Figure 1: evolution of the drop in milk temperature according to the volume and cooling time of the tank

For the first experiment carried out on a 50l volume, the start and stop times were respectively 18h 08mn and 20h 48mm, i.e. a duration of 2h 40mm during which the temperatures noted fell regularly from 32°C to 3.5°C. This duration is slightly below the supplier's reference value of 3 hours. After shutdown, the tank automatically restarts every 15mm for 2 minutes to maintain the same temperature of 3.5°C.

For the second experiment carried out on a 100l volume, the Tank was started at 14h 12mn at 27°C and stopped at 18h 21 at 3.5°C, i.e. a duration of 4h 09mn; it restarts every 15mn for 2mn. In order to improve

this result which was not conclusive, we changed the protocol by pre-cooling the tank before putting the milk to be preserved. That is to say, put water which is cooled down to a temperature of 20-15°c, then empty the water and immediately put the milk to be preserved. The result was conclusive, with a temperature of 3.5°c reached in less than 3 hours of operation as recommended.

Milk conservation technology must be adapted to the degree of aridity of the environment. For the Fanaye-Diéri area, where the daily temperature can reach peaks of 45°C during the summer, it is more desirable to install tanks of reduced capacity (300 liters) and to pre-cool the tank to reach a temperature of 15°C before pouring the milk into it if the volume to be preserved exceeds 100 liters.

3.2 The quality of milk supplied to the LDB from the Tatki platform

The milk supplied to the LDB, stored in two 50-liter cans, meets the plant's standards with normal pH, acidity and density. The results of the analyses performed by the LDB are presented below:

- Canister1 : Weight of 49.2 kg; Alcohol negative; pH of 6.73; Acidity of 18; Density of 1025 and temperature of 21°.
- Canister2 : Weight of 48.9 kg; Alcohol negative; pH of 6.72; Acidity of 19; Density of 1025 and temperature of 21.1°.

Through this experience, we can see that despite the large distances (up to 45km) between the milk production areas and the areas where the dairy plants are located, breeders can supply quality milk to these processors.

3.3 Profitability of the milk collection platform activity

The amount of the platform's investment has been evaluated at 131 660 000 FCFA. This cost includes, as presented in Table 2, the various headings related to the constructions that will house the solar and cooling equipment (200-liter tank), the offices, the installation of the rural electrification network, and the operating and collection equipment.

Most of the investment is related to solar equipment and the installation of the rural electrification network (78%). The buildings to house the platform require a minimum surface area of 200 m² and represent 14% of the investment. Collection and operating equipment and furniture represent only 7% of the investment.

Table 1: Investment costs of the Tatki platform

Designation	**Amount (Fcfa)**
Construction	17 923 000
Solar equipment	76 550 000
Cold equipment	1 205 000
Installation network electrification	15 932 000
Installation materials for households	9 900 000
Collection materials (tricycle, motorcycle, and materials)	3 300 000
Small operating equipment	4 250 000
Studies	2 600 000
Total investments	**131 660 000**

It should be pointed out that the cost of the land where the infrastructure is installed was not taken into account in the investments, because the platform was built as part of a community project, with the support of the local community of Fanaye. Thus, the land was made available free of charge by the town hall as part of its contribution to the implementation of the project.

The commissioning of the platform requires a working capital requirement (WCR) which, in Tatki's current conditions, must cover a period of six months. This period is necessary to ensure continuity of operations (especially the payment of fixed expenses). Indeed, at the beginning of the commissioning of a platform, the volumes of milk collected from the breeders may be low and may not allow the platform to be profitable. Indeed, during these first months, farmers are not yet used to the job of milk producer.

Table 2: Structure of working capital requirements (WCR) (in CFAF)

Loads	**Quantities**	**PU**	**Total price (Fcfa)**
Purchase milk breeders	10800	290	3132000
Collector remuneration	12	50000	600000
Water	6	30000	180000
Electricity	9085	91	824005
Cleaning products	6	5000	30000
Platform staff salaries	6	330000	1980000
Transmission and distribution network	51750	24	1242000
Monthly package contingencies	6	55000	330000
Total WCR			**8318005**

This WCR covers expenses related to :

- The purchase of milk from the breeders (90 l/d) for 4.5 days/week,
- To the remuneration of the collectors (2 times/month) and to the payment of the salaries of the platform staff,
- To the payment of the current charges of water, electricity, and cleaning materials,
- Contingencies and coverage of transport charges on the LDB.

The aggregation of the technical data collected after 18 months of operation of the platform, supplemented by financial and collection volume projections, made it possible to determine the actual and projected operating accounts in year 1 and over the next 3 years. Profitability levels are thus calculated.

The collection was carried out with a price level of 290 FCFA /l from farmers, the resale of milk is carried out at the LDB price, i.e. 385 Fcfa/liter. The platform hired two collectors paid 50,000 FCFA/month and equipped with tricycles. This system made it possible to collect, on average, in the first year 168 l/d, 323 l/d in the second year, 471 l/d in the third year, and 717 l/d in the fourth year, with a very high variability according to the season.

The revenue of the solar platform is made up of revenue from the domestic energy distributed to rural households and from the sale of preserved milk. The village of Tatki has 63 households that have requested and obtained an energy connection. Similarly, the project has proceeded with the public

electrification and the electrification of community buildings (1 mosque, 1 school and 1 health post). Revenues from energy supply are very low and represent 1.6% of the platform's revenues.

Table 3: Platform Forecast Operating and Cash Flow Accounts

Designation	**Year1**	**Year2**	**Year3**	**Year4**
Purchase of milk	11 745 000	22 475 000	32 770 000	49 880 000
Collector and staff salaries	5 160 000	4 080 000	5 160 000	4 200 000
Water	360 000	360 000	360 000	420 000
Electricity	1 648 010	2 096 636	2 491 503	2 940 128
Cleaning input	100 000	120 000	140 000	150 000
Transmission and distribution network	780 000	1 080 000	1 200 000	1 380 000
Technical amortization	8 507 038	8 507 038	8 507 038	8 507 038
Financial expenses	-	-	-	-
Unexpected	660 000	660 000	660 000	700 000
Office automation	60 000	70 000	80 000	80 000
Under total operating expenses	**29 020 049**	**39 448 674**	**51 368 541**	**68 257 167**
Fresh milk	15 280 650	30 938 600	50 558 200	70 932 400
Domestic energy	1 134 000	1 134 000	1 134 000	1 134 000
Sub-total operating revenues	**16 414 650**	**32 072 600**	**51 692 200**	**72 066 400**
Results of Operations	12 605 399	7 376 074	323 659	3 809 233
CAF	4 098 360	1 130 964	8 830 697	12 316 272
Amortization capital invested	-	-	-	-
Cash flow	4 098 360	1 130 964	8 830 697	12 316 272
	4 098 360	2 967 396	5 863 301	18 179 572

Under current operating conditions and in the context of a total subsidy that bears the cost of the investment, the platform's activity is not profitable. The shortfall must be borne by the project over the first two years, which thus bears part of the operating costs. At the end of the project, there is a real risk of the platform ceasing operations if collection does not reach at least 471 l/day, which represents the break-even point. This will require a significant change in the production system, which is marked by seasonality and the abandonment of transhumance by a large number of farmers in the Fanaye Diéri area.

To achieve a minimum profitability of 5%, in order to remunerate the capital invested under a concessional credit, a milk transfer price of 550 Fcfa/l must be applied. This price would put the platform out of the market, as the LDB manages to collect at a price of 385 Fcfa in its current collection radius.

This is why tests of valorisation of the fact have been carried out in order to bring an added value to the platform to ensure its sustainability.

4. DISCUSSIONS

4.1. The added value provided by the milk processing activity

Yoghurt milk processing activities have been undertaken at the platform level, in order to improve the platform's profitability and to have a solvency to support operating costs.

The prerequisites for the launch of these activities were :

- The animation of training modules on hygiene and quality for farmers, collectors and staff of the platform, and training sessions dedicated to the staff for processing: It is thus not only to work with farmers to increase the volumes of milk produced and sold to the platform, but also to limit milk losses related to quality problems and technical control of processing into yogurt.
- The definition and application of quality control levels at each stage of the process, from collection to processing, including the equipment of collectors and the technical manager of the platform with milk test kits to ensure good quality milk or yogurt produced.
- And the obtaining of the FRA approval before the release of the product on the market; this approval is a release attesting the conformity of the product to the sanitary, microbiological and organoleptic standards of consumer goods on the Senegalese market. This authorization is the responsibility of the Ministry of Trade and more specifically the Directorate of Internal Trade through the Division of Consumption and Consumer Safety (Ministry of Livestock, 2005). It will facilitate the marketing of the platform's products.

Processing requires an additional level of investment, such as the acquisition of freezers (2) essential for preservation, and means of transport (refrigerated vehicle in the cruise year) essential for the preservation of finished products. The global investment for the installation of a platform is on average 156 million Fcfa. The WCR must be strengthened for a period of 6 months taking into account the cost of packaging, inputs or lactic ferments and the transport of the finished product from Tatki to Dakar, the main target market. This WCR is 13.4 million Fcfa.

The major constraints for this processing activity can be summarized as follows:

- The collection of milk from farmers: despite general assemblies at village level and training sessions, farmers have been slow to adhere to the organizational scheme proposed by the platform. The volumes collected did not exceed 100 liters/day for the first 6 months, despite the application of a rather high price of 290 Fcfa/liter and the guarantee of payment at the end of the month at the platform. It is this long delay that justifies the duration of at least 6 months of the WCR for a recovery platform in rural areas. The expenses related to collection and the remuneration of collectors represent 52% of the platform's operating expenses.
- Transport of finished products to market: the isolation of the production zone has made it difficult to transport the dairy product to urban centers (Dia, 2009). The distribution of the product (yogurt) was carried out in the city of Dakar, 400 km away, where there is a wider demand for 100% local and more solvent yogurt. Indeed, consumers can buy the 1 kg pot of yogurt at 1200 Fcfa (Gret, Enda Garf Sahel, 2006). This price is in line with the market price. The level of activity had not yet necessitated the investment in refrigerated trucks, so the product was transported using ten or so coolers with a capacity of 100 l each. Thus, a special organization was

set up using tricycles to take the finished products out of the production area (Tatki) to Dagana (the nearest town). And from this city to Dakar, the products are transported by public transport buses at a cost of 3000 Fcfa/glaciere. The return of empty coolers from Dakar to Dagana is done by means of public transport buses at a cost of 1000 Fcfa/cooler. The area where a development platform is to be set up must take into account the landlocked nature of the area in order to avoid an overly complicated and costly transport organization.

- The cost of packaging: The costs of packaging in Senegalese dairies can be heavy and can compete with local dairy products (Ferrari S, 2017). At the platform level, in order to market the yogurt, the product must be labeled and presented in plastic jars made in factories located mainly in Dakar. These jars with the product label cost 177 FCFA per jar when the order exceeds 5000 jars at the factory and between 225 and 250 FCFA per unit if purchased at the market level. When buying at market level, the cost of buying labels must also be taken into account, as it is not possible to market food products in anonymous packaging. On average, a label can cost 120 francs per unit. The platform has adopted a factory sourcing strategy to achieve economies of scale. Packaging accounted for 26% of operating expenses.

4.2. The cost of yogurt production

The revenues of a dairy platform are mainly made up of the sale of dairy products such as yoghurt in Tatki (98%), but also the monthly payment of electricity bills provided by the solar network.

The selling price of milk applied by the platform is 950 francs per liter for the distributors. This price, from year 3 of operation, covers the production cost of one liter of yogurt, which is valued at 873 FCFA. Indeed, production costs vary between year 1 and 4, from 1323 FCFA to 774 FCFA, for respectively total volumes processed per year of 48,600 liters and 280,800 liters and operating costs of 64,319,332 FCFA and 217,317,447 FCFA.

This price of yogurt (100% local) was determined to allow distributors to align themselves with market prices which is 1200 FCFA per 1 liter pot. Under these conditions, the distributor achieves a gross margin of 250 FCFA per pot and Tatki's platform obtains a margin of 237 FCFA per pot in a cruising year. The distribution of the margins on this new yoghurt sector, per liter of product, is as follows:

- Breeder's margin: 145 FCFA
- Platform margin: 176 FCFA
- Margin of the yogurt distributor : 250 FCFA

Preliminary surveys of farmers before the platform started its activities made it possible to determine the production cost of a liter of milk at 145 Fcfa, while the platform applies a collection price of 290 Fcfa/l.

4.3. Profitability indicators of the milk to yogurt processing platform

In order for this model to be replicated by private individuals, we studied the profitability of the activity with financing at a subsidized rate of 7.5% per year and a deferred repayment of the invested capital of 2 years for a total duration of 7 years. Under these production conditions, with 5 workdays/week, control of the transformation process (2% loss rate) and prices applied to collection and distribution, the profitability of the platform for the transformation of local milk into yogurt is 18%, for a period of 15 years. The wealth

generated (10% NPV) amounts to 227,269,450 FCFA and the time to recover the capital invested is 3.90 years.

To support the local milk sector and improve the income of farmers, it is important that the State encourages the installation of solar milk processing platforms in the production basins. The example of Tatki defines the conditions of technical feasibility and the levels of performance and financial profitability expected. The definition of a good policy in this field should allow private promoters to invest in it. The contours of this policy would take into account the need to put in place three conditions, namely :

- An interest rate subsidy mechanism of up to 7.5% per year, as is the case in Senegal for the financing of major crops such as groundnuts, cotton, rice and industrial tomatoes;
- A line of credit for medium-term investment financing repayable over 7 years and short-term working capital and inventory requirements over 24 months.

A support strategy to sustain the cost of packaging, which weighs quite heavily in operating expenses.

4.4. Modeling the financial profitability of a milk processing platform

The technical results obtained at Tatki and the observation of the various indicators that influence the platform's profitability allowed sensitivity tests to be carried out. They can be summed up by varying the 4 main performance indicators of a transformation platform that we call the 4Ps:

- Labour productivity materialized by the number of working days,
- The processing performance or quality illustrated by the loss rate,
- The collection price of milk from farmers,

And the price or cost of packaging.

Profitability levels, according to the project financial analysis approach, were thus calculated based on the observed variations in these indicators, as shown in Table 4.

Table 4: Determination of IRR based on project financial analysis with variation in parameters (specify parameters)

IRR (in %)	Breeder price	Packing price	Number of working days	Loss rate (in %)
18	290	177	6	10
21	290	177	5,5	5
18	300	195	5,5	5
5	300	195	5,5	15
11	325	195	6	10
5	325	195	5	10
10	290	195	5	10
15	290	204	6	10
8	290	212	5	10
8	290	251	6	10
4	290	177	6	20
9	290	177	4,5	10

The analysis showed that the correlation coefficients are all close to 1 (see Table 5, with a low standard deviation of 0.4%, showing a close relationship between these parameters and profitability.

Table 5: Presentation of the results of the multiple regression between the different profitability parameters

	Coefficients	**Standard Error**	**Statistical T**	***Probability***	**Limit (SC=95%)**	**Upper Limit (SC=95%)**	**Lower Limit for Confidence Threshold = 95.0%**	**Upper Limit for Confidence Threshold = 95.0**
Constant	5,70E-01	3,68E-02	1,55E+01	1,14E-06	4,83E-01	6,57E-01	4,83E-01	6,57E-01
Breeder price	-1,31E-03	1,06E-04	-1,24E+01	5,09E-06	-1,56E-03	-1,06E-03	-1,56E-03	-1,06E-03
Packaging price	-1,25E-03	7,00E-05	-1,79E+01	4,26E-07	-1,42E-03	-1,09E-03	-1,42E-03	-1,09E-03
Number of work days	5,72E-02	2,85E-03	2,00E+01	1,92E-07	5,05E-02	6,40E-02	5,05E-02	6,40E-02
loss rate	-1,33E+00	3,71E-02	-3,59E+01	3,38E-09	-1,42E+00	-1,24E+00	-1,42E+00	-1,24E+00

Under these conditions, where several factors interact with profitability, the analysis allows to model the profitability of the activity of milk to yogurt processing for a solar platform installed in a landlocked rural area with an extensive production system as in the case of the villages of Fanaye Diéri. The financial model is presented as follows; it comes from the results obtained by statistical analysis from multiple regression simulations.

IRR = (-1.31304E-03*Collection price) +(-1.25072E-03*Packaging price) + (5.72037E-02*Productivity) + (5.72037E-02*Productivity) + (-1.3319E+00 *Performance transformation) + 0.5696797

This financial model was tested and the levels of profitability obtained, by varying the four parameters of which it is composed, coincide exactly with the IRR results of the financial analysis presented in Table 4.

5. CONCLUSION

The characteristics noted in our study area (13 villages of Fanaye Diéri), reflect the reality of the dairy basins of Senegal. The sites are landlocked, marked by a significant deficit in infrastructure. Very few roads and tracks connect these production centers to urban markets where there is a solvent demand for dairy products. In periods of milk overproduction, such as during the rainy season, herders are sometimes forced

to waste fresh milk because they have no conservation infrastructure and cannot take their products to these markets. The difficulties in the milk sector are quite profound.

The study made it possible to define the technical conditions for the installation of solar platforms in landlocked areas, in order to provide solutions to the problem of dairy product conservation. To enable these investments to be sustainable, these platforms must operate activities to enhance the value of milk such as processing into 100% local yogurt. Profitability criteria and conditions are defined with the control of four key performance indicators, referred to here as the 4Ps. The private sector will be able to invest in the sector with institutional support for interest rate subsidies and the necessary support to reduce the cost of packaging. The approach has been tested in the village of Tatki and could be replicated in large, landlocked dairy centers. The proposed financial profitability model is a decision-making tool for investors, enabling them to measure the performance of this activity each time and to make adjustments. In addition to the dairy storage and processing aspect, such a platform provides other benefits, such as public lighting and access to domestic energy for the populations of the villages concerned. In Senegal, the rural electrification rate remains too low. It rose from 8% in 2000 to 33.7% in 2016 (ASER, 2017).

Taking into account the energy dimension in the definition of agricultural and pastoral policies in Senegal should facilitate these transformations for an increase in income and improved living conditions for 350,000 families living from livestock activities (Ministry of Agriculture and Rural Equipment, 2015).

6. References

National Statistics and Demography Agency (ANSD). 2015. Regional Economic and Social Situation Saint Louis.

National Statistics and Demography Agency (NSTAD). 2018. Economic and Social Situation of Senegal in 2015.

Alary V, Cornials C, Gautier D. 2011. Livestock's contribution to poverty alleviation: How to measure it? World Development.

National Agency for Statistics And Demography (ANSD). 2016. Transport Sector Report.

Broutin C, Levard L, Goudiaby M. 2018. What Trade Policies for the Promotion of the "Local Milk" Sector in West Africa. GRET Synthesis Report.

Commission of Regulation for electricity sector. 2019. Official Bulletin No. 27/28.

Dia D. 2009.” dairy farming territories under the test of political and economic dynamics: elements for a geography of milk in Senegal”. PhD thesis

ENDA Energy. 2015. Study on the diagnosis of the milk value chain in the regions of Saint Louis, Louga and Kolda.

Ferrari S. 2017. PhD thesis report on the viability of industrial dairy chains in Senegal: an analysis in terms of governance.

Gret, Enda Graf Sahel. 2006. Etat des lieux de la filière lait et produits laitiers au Sénégal.

Ministry Of Livestock and Animal Production (MEPA). 2016. Sector Review Report.

Ministry of Livestock. 2005. Quality Control in Dairy Processing Guide to Good Hygiene Practices.

Departmental Service of Podor Livestock. 2018. Annual report

Spintech. 2018. Technical data sheet of the 1000 liter milk tank.