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Ten Years Later: a Comparison between the Results of Early Simulation Scenarios and the Sustainability of a Small-Scale Agro-Industry Development Program

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ABSTRACT

Agro-industrialization promotion is a policy option to aggregate value to a primary product and increase revenues for small farmers. However, experience has shown the vulnerability of small-scale agro-industries (SSAI) when facing a competitive environment with technological, institutional and managerial bottlenecks. A system dynamics model was built to simulate the financial behavior of agrifood processing enterprises promoted by Brazilian SSAI development programs after the mid 1990's. Ten years after the modeling exercise, an assessment of selected enterprises supported by distinct programs largely confirmed the simulation results. Modelling suggested conditions for long-term SSAI sustainability were corroborated and the importance of the promotion programs was further evidenced.

Keywords*: system dynamics; food processing; agro industry; small and medium enterprises – SME; rural non-farm economy - RNFE*

1 Introduction

Small-scale agro-industrialization is a policy option for small farmers to add value to a primary product and increase their revenues. However, experience has shown the vulnerability of small agro-processing enterprises to the pressures of their competitive environment: many fail in their early years of operations. As proposed by Wilkinson and Rocha (2009), agro-industry comprises postharvest activities involved in preparation, preservation and transformation of agricultural, fisheries and forestry raw materials for intermediary or final consumption. Within agro-industry, food-processing and beverages are by far the most important sub-sector in terms of added value, accounting for more than 50% of the total formal agro-processing sectors in developing countries (FAO and UNIDO, 2009).

Since the 1970's, official bodies, international governmental and non-governmental organizations raised their interest in small rural enterprises. Many development agencies established a variety of programs and pilot projects with a general concern about the lack of income distribution and the need to improve livelihoods,

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particularly targeting the rural poor (Fernandes, 2004; Haggblade, S. et al., 2002). Experiences in Brazil, Chile, Kenya, Mexico, South Africa, Taiwan and Thailand have demonstrated the potential of agro-based small and medium enterprises - SME for improvement of farm and non-farm income and the living standards among rural poor more generally (FAO and UNIDO, 2009).

Moreover, programs designed to promote food security, poverty reduction and sustainable development in rural areas often include activities supporting the creation and consolidation of **small-scale agro-industries - SSAI**. The opportunity for many micro entrepreneurs, or for farmers - limited to primary production - to move into higher-value processing or manufacturing, inspired several kinds of interventions. However, the need to ensure competitiveness and long term sustainability constituted a particular challenge for small and medium scale agro-industrial enterprises and family farmers.

In addition to the limitations of their small scale of production, the difficulties faced by these businesses include as well technological, institutional, managerial and marketing challenges. They often find problems in procuring inputs in small quantities and many of them are not able to meet the quality standards required by supermarkets (Fernandes, 2011). Typical problems of SSAIs comprise also the lack of conformity (attendance to quality standards and sanitary rules, homogeneity of raw material and products); irregularity in raw material supply; inappropriate logistics and cold-storage chains; short product shelf life; weaknesses in labeling and product's image and low portfolio diversification, among others.

The ability of SSAIs to access markets usually starts with the local commerce and gradually expands to more complex and distant market outlets. The unsatisfactory conditions of these enterprises work against the establishment of contracts with the fast growing supermarket chains and thus reduces the opportunities to expand market access, increasing product market and price risks.

To cope with such challenges, organizational strategies for SSAIs may involve collective actions such as the creation of community organizations to increase the raw material supply and access to markets (Markelova et al., 2009), creation of joint trademarks, use of quality or production labels, implementation of commercial infra-structures, and promotion of fair trade.

While the promotion of agroindustries can serve several development objectives, the constraints that hamper their development need to be addressed. The degree of risks associated with SSAI should not be underestimated. Indeed, research evidence from Brazil indicates failure rates of up to 50% for SMEs in their first five years of operation. Since agro-industries are a high-risk but relatively low-margin segment of the economy, their success always requires innovative and flexible ways of hedging against risk (FAO and UNIDO, 2009; Kjöllerström, 2004).

Realizing the benefits of agro-industrialization and its challenges, Brazil launched in the 1990s a number of programs with a specific approach to promote SSAIs, focusing on their peculiarities. Policy makers and program

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managers had acknowledged that successful investments in SSAIs must be paired with appropriate technologies, business management assistance and access to value added business networks in emerging markets (Kapila & Mead, 2002). Moreover, to promote higher survival rates, the agro-industrial enterprise should be understood as a system, in which each component affects and is affected by other related components.

In this context, to understand the financial feasibility and operational dynamics of SSAIs immersed in different scenarios, a study conducted under a system dynamics (SD) approach (Fernandes, 2004), encompassed not just internal plant operations, but especially the linkages between the plant and input suppliers, consumers, managerial and technological issues and the wider institutional and market environment. After a decade has passed since this study was concluded, some of the investigated SSAIs succeeded and others failed. This raised the question about which strategic actions were successful, encouraging therefore a comparison of early simulation results with the current situation of some of the investigated SSAIs.

This paper briefly revises some of the Brazilian SSAI development programs that took place since the mid-'90s (section 2) and presents an outline of the methodology used in the above mentioned SD study (section 3). Section 4 presents an overview of three selected case studies followed by a comparison among the main results of early simulations and the current situation of the chosen SSAI. Section 5 concludes the discussion.

2 Brazilian small-scale agro-industrial development programs

In 2015 a pioneer Brazilian program driven by a special policy supporting small farmers celebrated 20 years (1995-2015): the "*National Program to Strengthen Family Agriculture – PRONAF*" (Bianchini, 2015). In 2003, the first "*National Program of Agro-industrialization for Family Farmers Production*" (PRONAF-Agro industry) was launched. Before that, PRONAF attended agroindustry initiatives but only through an investment credit line targeting SSAIs, called "PRONAF-Agregar" meant to fund SSAIs, and since 2003, PRONAF-Agroindustry became a larger program for SSAI with several specialized actions (Wesz Jr., 2009).

The actions of PRONAF-Agroindustry comprised: a specific financial credit line for SSAI; strategic discussions about the legal framework; provision of guidelines, documents and technical project profiles; capacity building and training for multiplier (extension) agents; development of appropriate technology; promotion of products from family agriculture (market development); and technical interchange, monitoring and evaluation of information systems. Table 1 shows the goals and results reached by PRONAF-Agro industry between 2003 and 2010.

Table.1 Goals and results reached by PRONAF-Agroindustry between 2003-2010 – BRASIL

Description	Goals (A)	Results (B)	B/A
Funded SSAIs (number)	24.000	23.885	99,5%
Supported Families	191.000	165.584	86,6%
Contracts (BRL$)	1.491.270	953.291	63,9%

Source: Alves (2014)

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While government programs were mainly based on the availability of credit to finance SSAIs, at the federal level the main source of funds was the "Fund for Worker's Support" (FAT) and a constitutional development fund (FNO and FNE)[3], disbursed through PRONAF. Moreover, some state level programs complemented public financial resources with funds from international agreements (e.g. "*Paraná 12 Meses*" and "*Santa Catarina Rural*" programs, involving agreements between these two states and the World Bank; "RS Rural" and "PAMPA", as well as agreements between the Inter-American Development Bank - IDB and the government of the state of Rio Grande do Sul - RS).

Besides PRONAF-Agroindustry, another federal program that had shown great impact in the experiences investigated in the late '90s was the "Appropriate Technology Program" - PTA, driven by the *National Council for Technological and Scientific Development, CNPq*. The PTA program supported social and appropriate technology development to enable *Local Innovation Systems* (SLI) as clusters. The PTA goals included the increase of access to technological information, productivity enhancement support, research, extension, training and credit by small entrepreneurs.

Often, agro-industrial initiatives integrate actions of national and state agencies with municipal counterparts and direct action from international organizations or through technical cooperation with non-governamental organizations - NGOs. State programs, such as PROVE-DF, in Brasília, "*Fábrica do Agricultor*", in Paraná-PR, and "*Desenvolver*", in Santa Catarina-SC, provided qualified professional services through the "EMATER" state level rural extension agencies (e.g. EMATERs for the States of Paraná, Minas Gerais, The Federal District and others). Support could also be provided by research agencies (e.g. EMBRAPA, IAP-PR, among others) and universities (e.g. UFV, IFSC, UNOESC, among others).

Local NGOs often targeted community based organizations and encouraged networks to attract support and services from international institutions such as IAF (Inter-American Foundation); UNDP (United Nations Development Program) and from the Brazilian Agency of Support Services for SMEs – SEBRAE (e.g. Technological Support Program for SMEs (PATME) and the "Sustainable Rural Life" program). The establishment of credit cooperatives has also counted with the active participation of NGOs.

Overall, the Brazilian interventions usually involved investment loans, support regarding the legal framework (regulations on sanitary, tributary and environmental issues, among others), research and technical assistance, and were implemented not only by a single institution, but used to aggregate a variety of actors through agreements between national, state or local governments, councils, NGOs, training and rural extension agencies. The strength of these programs was based on their ability to build innovative networks in a broad sense (Gellynck & Kühne, 2010; Deiters & Schiefer, 2012).

2.1 The case of a SSAI network benefited by Brazilian agro industrial development programs

[3] Constitutional Funds for the Brazilian North– FNO - and Northeast – FNE – regions.

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In order to better show the interaction between the institutional actors in promoting SSAI at several levels, the case of the "Agreco" network is hereby presented. Agreco is an agro-ecological association based in a mountain region of the state of Santa Catarina, in Southern Brazil, assembling 211 family farmers in 1999. Agreco started its SSAI network grouping 27 SSAIs, which included enterprises processing milk, meat (poultry and swine), honey, eggs, vegetables and sugar cane. Each SSAI was owned by a farmer group, varying from 5 to 10 farmers.

Between 1998 and 2000, the "*Desenvolver*" state program provided business development services (BDS) to support the "*Inter-municipal Project of Modular Agro industries Network*" (PIAMER) enabling farmers to access funds from the federal program PRONAF, particularly improving their agro-industrial investment projects. PIAMER also had a contribution from the local municipal government with the provision building materials during the stage of SSAI construction.

As soon as most SAAIs started up operations, Agreco established a partnership with SEBRAE to receive strategic, tactic and operational business management support, covering even the costs of their administrative work force. At the beginning, Agreco SSAIs would market their products through direct sales, but with the advancement of the agro-industrialization process, the Agreco network established two SMEs to access market outlets and benefit from SIMPLES – an especial taxation scheme for small businesses.

Presently, 22 SSAIs are active and Agreco's network comprises sixteen units focusing on products with extended shelf life and certified organic production. Six of the early SSAIs are now dissociated from the Agreco network and five others failed working with perishable products (minimum processed vegetables). Since 2009, Agreco established a cooperative, reinforcing its sales in institutional and traditional retail markets (Guzzatti, 2012; Weber, 2013). The institutional market grew with support from the national Acquisition Food Program (PAA), which promotes the purchase of products from family agriculture, and the National Program of School Meals (PNAE) that also favors the purchase of food from small farmers and rural SSAIs.

From an annual gross revenue in 2002 of around BRL$ 0.7 million, the "Cooperagreco" reached proceeds of BRL$ 2.8 million in 2012 (Fernandes, 2004; Guzatti, 2012). Recently, the network approved a project of BRL$ 406 thousand through the World Bank funded SC Rural program to expand its activities, including a new head office and the acquisition of frozen chambers, trucks, and other equipment (SC Rural, 2016). The expectation is to reach an annual growth revenue above BRL$ 5.0 million.

The Agreco network also promotes and interacts with other rural non-farm activities (RNFA). The "CrediColônia" is a credit cooperative essential to guarantee microcredit for small farmers. The "Acolhida na Colônia" is an association of agro-tourism, another symbiotic activity that promotes their SSAI products. In addition, the "Formation Center" (CFAE) granted by the 2011 FINEP Innovation Premium with BRL$ 500 thousand to conduct experiments with small farmers and develop the production chain of essential oils in the region (Heidemann & Lunardi, 2013). FINEP is a Brazilian federal funding agency for science, technology and innovation.

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Table 2 summarizes the conditions of Agreco in 2002 in comparison with its situation in 2012 and Table 3 summarizes the main support actions received by Agreco network.

Table.2 Summary of Agreco network conditions in 2002 and in 2012.

Description	2002	2012
Business Model	Two Agreco SMEs and the "Credicolônia"	Agreco Organic Production Ltd. (SME) and the CooperAgreco
Family Farms	220	82
Farmers	500	177
Municipalities	4	9
SSAI	27	16
Product Portfolio	120	44
Annual Gross Revenue	BRL$ 777 thousand	BRL$ 2.778 thousand

Source: Adapted from Fernandes (2004); Guzzati (2012) and Weber (2013).

Table.3 Main support actions received by Agreco Network.

PROGRAM/AGENCY	2002	Recently (2012-2015)
PRONAF – Agroindustry (MDA)	Investment funding	Working Capital
Local municipality (donation)	Building Materials	---
DESENVOLVER (EPAGRI, CNPq, FUNCITEC[4])	BDS	---
PATME - VRS (SEBRAE)	BDS	---
INNOVATION PREMIUM (FINEP)	---	Research and Development
FOOD ACQUISITION - PAA (MDA)	---	Institutional Market Access
SCHOOL MEAL - PNAE (FNDE/MEC)[5]	---	Institutional Market Access
SC Rural (World Bank)	---	Incremental Investment
Universities (UFSC, CEPAGRO[6], etc)	• Strategic Planning • Agro-ecological production systems • Other rural development researches	

Source: Adapted from Fernandes (2004); Guzzati (2012) and Weber (2013).

3 Methodological approach

A comprehensive analysis was needed to understand the operational dynamics and identify success factors for the long-term financial sustainability of SSAIs targeted by the development programs that took place in Brazil after the mid'90s. For that, a rapid appraisal was conducted through structured interviews with 35 owners of targeted SSAIs and another 27 key stakeholders at different Brazilian regions. It brought out the diversity of the institutional environment around each particular case, showing how an earlier concept of "*verticalization of small scale agricultural production – PROVE-DF*" (Carvalho, 2001; Sulzbacher, 2009; Fernandes, 2004; Gellynck & Kühne, 2010), experienced in the city of Brasilia in 1995, evolved and was reproduced in many Brazilian regions.

[4] Science and Technology Foundation of Santa Catarina State - SC
[5] National Fund for Education Development/Ministry of Education
[6] Study Center for Group Agriculture Promotion

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Acknowledging the complexity of reaching a successful SSAI's survival rate, the investigated programs comprised one or more strategic actions addressing the institutional environment; organizational structure; funding; legalization; technological and entrepreneurial capacity building; and commercialization and marketing. Armendàriz *et al.* (2015) argue about how a complex-systems perspective can shed light on the analysis of complex food-systems. To build the best capacity for agro-industrial entrepreneurs to continue sustainable after the promotion project support ceases, the SSAI should be seen as a system with a "*complex combination of activities (production, handling, storage, transport, process, package, wholesale, retail, etc.) operated by dynamic agents, enabling cities to meet their food requirements*" (Aragrande & Argenti (2001)).

The traditional financial feasibility evaluation of projects does not take under consideration the interaction between variables used as basis for building financial cash flows, nor between them and the business competitive environment (Lourenzani, 1999; Fernandes et al., 1999; Avellar, 2002; Fernandes, 2011). Especially, they do not consider the possible mechanisms of feedback and delay (time gaps) as results of the business actions in its relation with the supply and distributive systems, nor the mechanisms related to internal operations (technological choices; operational procedures etc.). A system dynamics (SD) approach instead can encompass not just internal plant operations, but especially the linkages between the plant and input suppliers, consumers, managerial and technological issues and the wider institutional and market environment. In comparison with other complex system methodologies (e.g. agent-based models, social network analysis), applying SD while dealing with food supply and distribution systems is a worthwhile approach for policy evaluation, providing an assessment of long-term effects and it is useful for the understanding of a phenomenon based on the causation of variables (Armendàriz et al. (2014); Giraldo et al. (2011)).

Following SD concepts and procedures (Hannon & Ruth, 1994; POWERSIM CO., 1996; Richardson, 1996; Sterman, 2000) and a classical agro-industrial system conceptualization, the sub-systems of supply, processing and distribution, as well as their relation to the competitive and institutional environment were considered (Austin, 1992). In brief, the study followed the basic steps presented in Figure.1.

Based on the collected data, causal looping diagrams (also referred to as influence diagrams) were designed to shed light on the dynamics between financial variables and critical success factors that include **production mix diversification, product differentiation, level of production capacity utilization and networking**, among other determinants of competitiveness. After investigating the patterns of behavior through the **influence diagrams**, the main sub-systems and variables able to give a financial answer were selected to build the **stock and flow diagrams**.

The modeling process relies upon financial models available on the software "Vensim", as its molecules (i.e. building blocks of good system dynamics models) and other structures proposed by Avellar (2002) and Lourenzani & Silva (1999). The previous models represent the financial behavior of firms through its cash inputs and outputs in order to obtain its cash flow and payment capacity. Since the focus of the study was on the SSAI financial performance, the new model had to be flexible enough to allow its application to different cases at a

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time. In each case, a firm was considered to have its own product mix, requiring the use of vector variables and ranges structured in worksheets describing the initial system status. The traditional cash flow used to calculate the financial feasibility indicator (payment capacity) was modified with the additional consideration of critical variables for SSAI sustainability.

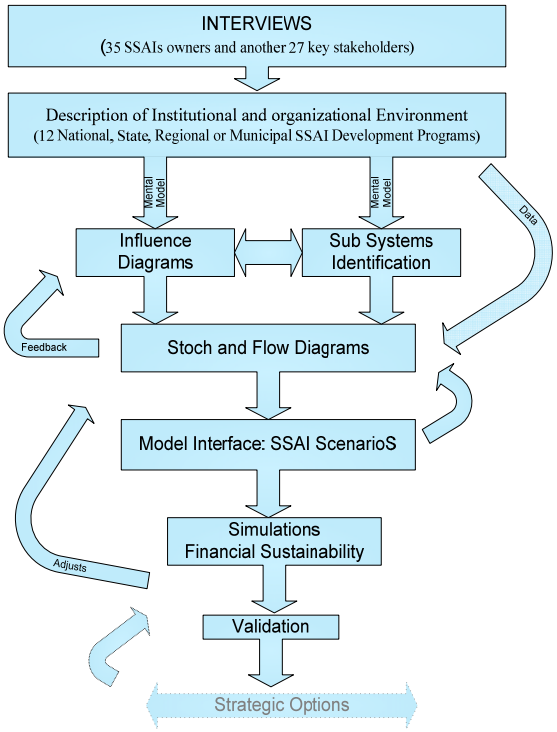

Figure.1 Methodological steps

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Figure 2 presents the production dynamics and its costs affected by the choice of distribution channels, raw material production system (conventional or alternative (organic; hydroponic; etc.)) and raw material supplying (SSAI owners; network; and, or others).

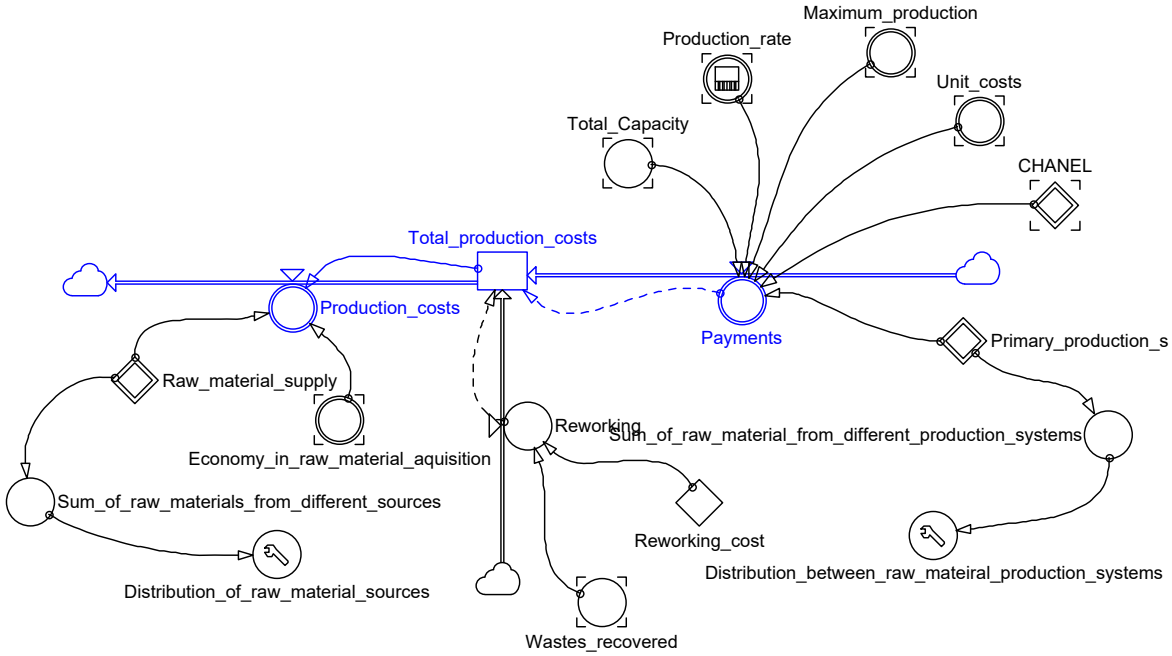

Figure 2. Production Dynamics – Stock and Flow Diagram

The production cost outflow varies according to the source of raw material and with economies in its acquisition. It balances the total production costs resulting from the payment and reworking inflows. The payments reflect the amount obtained of each product in a more or less diversified product mix and the correspondent unit processing costs. The unit cost comprises the variable costs – agro-industrial inputs (water, energy), ingredients, packing, laboratory analysis, storage, maintenance and repairing of equipment, commercial costs, taxes, labors, and transport, depending on the **diversification of product portfolio** - as well as fixed costs – office expenditures, administrative work force, security rates, rents, certification, depreciation, costs of opportunity. The **networking** process also reduces the fixed costs by group efforts to buy inputs or sell the products collectively. Furthermore, the changes in the **distribution channel (fair trade, retail or institutional market)** affect the variable costs, since the value added tax varies according to the respective product sale price.

The production costs connect other stock and flow diagrams capturing the investments and the cash balance over time, as well as the physical production. It is not the objective of this paper to delve deeply into the discussion of those diagrams. The intention is to remark how the consideration of critical variables improved the traditional models of financial analysis. Among others, factors such as the “seasonal effects on raw material production”, “waste recovering”, “product innovation” and “level of production capacity use” were considered, as they affect the SSAI payment capacity and its sustainability.

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The model was presented by an interface with several panels. Each panel groups control buttons and bars (panels) focusing on specific issues, in order to enable the definition of distinct scenarios to simulate the SSAI financial behavior under shocks on: “production capacity utilization”; “sales planning”; “raw material supply planning”; “product differentiation”; “production and sales”; “diversification of production mix”; “incremental investments and capacity acquisition”; “fiscal and credit incentives”; and “institutional incentives”.

The initial simulation tests were validated with reference models showing similar behavior, taking into account two years of monthly production and earnings. A series of simulations under different optimistic, conservative and pessimistic hypotheses related to the operations and environment of a selected SSAI indicated some conditions for the long-term financial sustainability associated with each case. Some of the main insights brought about by the simulations could be now (ten years after the modeling exercise) contrasted with the current situation of and trajectory followed by of some SSAIs, as we discuss in the next section.

4 Presentation of selected case studies and early simulation results

Previously the system behavior was tested for three SSAI case studies, being two small agro-industries (A6 and A12) from the Agreco network supported by the “*Desenvolver*” program and one independent SSAI (A26) from Paraná state supported by “*Fábrica do Agricultor*”. A26 is similar to A12 in size, investments and raw materials, but with an institutional environment that is completely different. The selection was based on available data and on the critical success factors that could be compared and tested (diversification, differentiation, market share, etc.). Following is a brief description of their status in 2002:

A6: an SSAI from Agreco network with a production capacity of 48 tons/year of minimally processed vegetable (MPV). The A6 project (BRL$ 38,500) was funded by PRONAF covering 100% of investments in equipment (BRL$ 10 thousand) and 71% for construction (BRL$ 20 thousand). A6 was processing 28 different raw materials supplied only by its family farm owners (five brothers) obtaining 42 products in different weighted packs (salads and cuts). In 2002, A6 was using 25% of its production capacity but had reached levels of 68%, before facing the entry of strong market competitors. The Agreco network products adopted an "*Agreco Quality of Life*" seal, which was helpful to obtain the Brazilian organic certification.

A12: an SSAI from Agreco network with a production capacity of 120 tons/year of “colonial” cheese (≈ 4,500 l/day of raw material). Three farmer brothers owned this SSAI and they adopted the "*Voisin System*" of rotational grazing management, which applies intensive management to forage crops on pastureland and is considered an ecological practice for milk production (Murphy at al., 1986; Schvarz Sobrinho et al., 2007). They provided 50% of raw material and expected to obtain 50% from Agreco partners under an organic production network. The total investment was BRL$ 110 thousand. PRONAF financed 100% for equipment (BRL$ 60 thousand) and 30% of its construction costs (BRL$ 30 thousand). In 2002, A12 used 17% of its production capacity, but it had reached peaks of 38% in earlier months (seasonal effects).

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A26: an independent agroindustry, out of the Agreco network, with a production capacity of 140 tons/year of dairy products such as traditional cheese, ricotta and buttermilk (≈ 4,800 l/day of raw material). A26 total investment was BRL$ 110 thousand, being BRL$ 55 thousand from a PRONAF refundable loan and BRL$ 35 thousand from a non-refundable grant from the "Paraná 12 meses" program, supported by the World Bank. The local municipality provided an older building school to be transformed in a processing unit and an additional BRL$ 10 thousand for working capital. This SSAI started procuring 24% of their raw material needs from its 24 associated farmers and the remaining from non-associated local producers. In 2002, A26 used 83% of its production capacity, but achieved full capacity utilization before one year of operations. With the support from "*Fábrica do Agricultor*" program, A26 was part of a soft network allowed to use the seal of "Southeast Tastes" from Paraná. Table 4 and 5 below summarize the initial investments, production capacity and current situation of the three-selected SSAI.

Table.4 Initial SSAI investment and production capacity

SSAI	Owners	Products	Initial Investment (BRL$)	Raw Material RM/Day	Production Capacity (Tons/year)	Arrangement
A6	5	Minimally Processed Vegetables	38,250	500 (kg)	48	Formal Network
A12	3	Cheese	110,000	4,500 (l)	120	Formal Network
A26	24	Cheese, Ricotta, Buttermilk	110,000	4,800 (l)	140	Soft Network

Source: Adapted from Fernandes (2004).

Table.5 SSAI performance in 2002 and situation in 2012.

SSAI	2002				2012	
	RM Supply	Sales (tons/year)	Revenue (BRL$)	Production Capacity Use	Status	Capacity (RM/Day)
A6	100% Owners	12	28,000	25 %	Stopped Processing	N.A.
A12	50% Owners 50% Agreco Network	20	86,000	17 %	Incremental Investments. New business model	30,000 (l)
A26	22% Associated 78% Local producers	116	385,000	83 %	Incremental Investments. Same business model.	100,000 (l)

Source: Adapted from Fernandes (2004) and data provided by recent interviews (2016).

The basic simulations indicated a low sustainability for these three SSAI maintaining their initial conditions. For A6 and A12, the low use of production capacity was a major constraint. Distinctly, the A26 reached its full capacity in one year of operation, but its production cost was too high, with seasonal impacts over its revenues. The adoption of strategic actions to overcome these barriers was imperative. The simulations indicated a need for incremental investments to improve the A6 cold storage capacity and the distribution logistics. Otherwise, it should acquire new equipment allowing the production of vegetable conserves with extended shelf life.

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In the case of A12, the formal networking for the organic production was a challenge, but essential to reach the minimum use of its production capacity and obtain a financial feasibility. Alternatively, A12 could increase its raw material supply buying from other local producers including non-associated to Agreco network. A26 also could make incremental investments to have a more diversified product portfolio. Nevertheless, even working under full capacity the simulations showed the importance of product differentiation (quality standards, cultural value, innovativeness, etc.) to obtain a proper profit and secure the financial feasibility.

A26 was working with high costs and it was vulnerable to seasonal price effects. It needed to reduce its production costs by improving the productivity of its suppliers and enlarge its profit margins by searching for product differentiation and diversifying its product portfolio. Once it was able to increase its raw material supply easily reaching 100% of its capacity, the simulations showed it could make incremental investments to at least double its production capacity.

4.1 Current status in comparison with early simulations results

According to the status presented in Table.5, A6 was not able to make incremental investments to increase its production capacity use and reduce wastes. The A6 owners returned to agricultural primary production. A12 changed to conventional dairy products in view of the difficulties to obtain organic raw material. In this context, A12 made incremental investments, started to buy raw material from other local producers to increase its production capacity use and changed its business model working independently from the formal Agreco network. On the other hand, A26 grew beyond expectations. We describe next the alternative strategies to overcome the performance bottlenecks followed by A26 and by the Agreco network.

The municipal program “Bom Pasto” (Good Pasture) supported A26, promoting improvements in milk production and quality. It is noteworthy the fact that before this SSAI was implemented, local farmers used to produce milk only for self-consumption. Earlier the milk sector was not seen as an attractive economic activity, because of the buying conditions offered by traditional dairies. Expanding their raw material acquisition after 2006, A26 accessed new funds from PRONAF, thus increasing in 30% its production capacity and reaching one thousand local milk producers and employing 75 workers in 2008. A26 also adopted a diversified portfolio with 30 dairy products including different sliced cheese (mozzarella, provolone, etc.) and new format and flavored cheese (twisted, wined, oregano, etc.). In 2012, A26 was processing 100 thousand liters a day with 100 workers and designed an expansion project to process 250 thousand liters a day, which was approved by the Federal Inspection Service (SIF), allowing them to sell all over the country.

On the other hand, the Agreco network adopted strategic actions to reach more sales flexibility promoting extended shelf life products and improving its logistics and regular offerings. Agreco began producing and marketing minimally processed vegetables as a novelty, when they reached 68% of their production capacity. However, new entrants in the major urban market (state capital) drove the prices down based on scale economies and more proximity to the sales points. As shown in Table 6, in 2002 there were six SSAIs designed

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to minimally process vegetables and most of them were working twice a week only, well below their installed capacity. Thus, this market opportunity was overestimated.

Table.6 SSAI Agreco Network – production and sales comparison from 2002 to 2012.

	2002					2012		
SSAI GROUP	**SSAI**	**Capacacity Tons/Year**	**UC (%)**	**Sales Tons/Year**	**Value BRL$ 1.000**	**SSAI**	**Sales Tons/Year**	**Value BRL$ 1.000**
Honey	3	27	37%	10,0	50	3	40	398
Sugar-Cane	4	50	26%	13,0	26	3	34	138
Pickles Vegetable	3	180	2%	4,0	22	1	103	413
Jelly, sweets jams	2	336	1%	4,0	27	1	58	291
Read to use products	---	---	---	---	---			
Tomato products and dried bananas	1	N.A.	N.A.	N.A.	N.A.	2	26	260
Poultry slaughterhouse	1	n.a.	n.a.	0,5	2	1	4	31
Minimally Processed Vegetable	6	598	25%	153,0	241	2	N.A.	1.247
Bakery and Pasta	3	72	39%	28,0	56	3		
Eggs (*)	1	180	6%	11,0	21			
Other products	---	N.A.	N.A.	100,0	176	N.A.		
Dairy products	2	240	20%	20,5	86	(**)	N.A.	N.A.
Pig slaughterhouse	1	86	7%	6,0	70	(**)		
TOTAL	**27**	**1769**	**---**	**350,0**	**777**	**16**	**265**	**2.778**
Anual Gross Revenue	**BRL $ 777.000**					**BRL $ 2.778.000**		

Source: Adapted from Fernandes (2004); Guzzati (2012); Weber (2013) and data provided by recent interviews. (*) In transition for biscuit production. (**) Dissociated from Agreco network.

Considering 27 SSAIs in 2002, Table 6 shows a 60% survival rate in the context of the Agreco network, with 16 SSAI active in 2016 generating positive impacts in terms of the network's annual gross revenue. This result is a reflex of the strategic action turned to add value through an extended shelf life of the marketed products. The Network prioritized efforts to reach full capacity utilization of some SSAI, while closing the redundant units (pickled vegetable, bakery, jelly and sweet jams units) in accordance to the market demands and the network raw material supply, optimizing their production capacity use and the respective sales to the retail market. Recently, the network adopted *retort pouch* techniques in order to diversify its portfolio with differentiated products like ready-to-use beans. In addition, as mentioned in section 2.1, Agreco is making incremental investments to expand its logistic infrastructure with new trucks and improvements in the cold chain, including the network storage capacity.

The establishment of CooperAgreco increased its capacity to cater to institutional markets (public bidding and school meals supply). According to the CooperAgreco's commercial manager, "*the supermarket chain is more perennial than the school meals market. For school meals the products are generally "in natura" (fresh without processing) comprising a large diversified amount with low added value and a high logistic cost. On the other side, the retail market requires a production mix previously established with a regular offering*". In order to

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keep diversified market opportunities and tax advantages, the network kept two business model including the SME ("Agreco Organic Production Ltd") and the cooperative (CooperAgreco).

Table 6 also shows that both dairy SSAIs became independent of Agreco network. Notice that in 2002 the other dairy SSAI was already dissociating from Agreco network and A12 was having difficulties to keep the formal organic network conditions to induce new milk producers in the adoption of an alternative ecological milk production system ("Voisin system", Murphy, 1986). A12 is still partner of Agreco for some territorial development actions. The case shows how value added by product differentiation suffered a negative compensation by the low production capacity use due to difficulties with ecological raw material supply and the network conditions highly affecting the SSAI sustainability. According to Gusatti (2012) 44% of Agreco farmers have 100% of organic production, while 35% produce in both systems (conventional and organic) and 21% are starting the conversion to organic production.

Overall, the comparison of the current situation discussed here with the early simulation results mentioned in section 4 shows that the outcome of strategic actions taken by SSAI leaders revealed similar SSAI behavior in accordance with the expectations of the previous analysis and were able to produce even more satisfactory impacts than the insights provided by the simulation results.

5 Lessons Learned and Conclusions

Agro-industrialization is a dynamic activity where several critical factors act simultaneously demanding a streamlined decision-making process as a pre-requisite for sustainability. The higher the understanding of the agroindustrial system, the larger are the chances of successful decision maker's interventions leading to business survival and growth. Small-scale agro-industries - SSAI - are vulnerable to the pressures of their competitive environment and are specially challenged to reach financial feasibility. Nevertheless, institutional arrangements involving networking stakeholders as well as the adoption of certain strategic actions can create optimistic growth and sustainable scenarios.

The system dynamics approach proved to be workable in designing and testing alternative scenarios and managing the factors leading to their behavior more efficiently, avoiding pitfalls when simulation long-term effects are indicative of undesirable outcomes. The comparison between early simulations and the current situation of selected cases of SSAI has shown that there is no single approach to reach the desirable sustainability of this particular class of agro-enterprises. Each case is embedded in a scenario in which behavior is based on the causation of multiple variables. Far from being exhaustive, the following critical factors can nonetheless be highlighted, due to their stronger relevance and impact on SSAI sustainability:

- **Production Capacity** – being dependent on the raw material supply and the amount that the SSAI unit is able to process, the production capacity must be carefully defined in agro-industrial project design.

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There is a need to carefully identify the break-even point and ensure that underutilization is avoided by careful marketing and raw material procurement strategies;

- **Product Differentiation** – a product can be designed to target a specific group of customers by choosing a different package, taste, quality standards or incorporating technological innovations, among others. New market trends will eventually bring new competitors. Entrepreneurs must consider the costs and benefits of offering a new product and the SSAI ability to provide and sustain the innovation in its production system;
- **Product Diversification** – a diversified product mix can bring over new contracts, but a portfolio that is over-diversified also can make management difficult. Decision makers need to define a portfolio that takes in to account, inter alia, avoiding wastes before the expiration of shelf life and the ability to meet the needs of potential consumers.
- **Diversified Sales Channels**: a diversified distribution system increases the SSAI resilience and reduces the impacts of external shocks on sales. Institutional and retail markets, as well as special channels such as organic and fair trade products, offer distinct profit margins and conditions. The sales policy should balance the pros and cons of different channels, bearing in mind that institutional markets can warrant a reasonable market security through their contracts, even with lower profit margins, while the retail and fair trade markets can be more profitable but require a better prepared, professional commercial staff.
- **Business Model** – the organizational structure, firm size and the legal framework into which the SSAI is embedded can favor its financial feasibility with advantages such as tax breaks and access to credit. The adoption of more than one business model can produce redundant administrative costs and tasks, while on the other hand it can offer more flexibility in commercial deals.
- **Networking** – the partnerships established by the SSAI owners or associated farmers can provide business advantages. Cooperative actions can affect in a beneficial way the investments, production costs, sales and other sustainability indicators. On the other hand, agro-industrial projects taking into account the establishment of new networks should be prepared to cope with greater complexity in organizational issues and a typically slower investment pay-back period.
- **Institutional arrangements** – the complexity of inter-institutional relationships is caused by factors such as the associated bureaucratic processes and the dependence between institutions supporting the SSAI activities. The partnership development may be emphasized with a clear definition of executive responsibilities, avoiding the duplicity of resources and effort requirements. Institutional development and good governance between partners should induce to a more simplified tasks and promptness in replying to SSAI requests.

All these critical factors need to be well balanced, since they also can yield negative impacts in certain scenarios. The improvement of efficiency and resilience of food systems at every scale requires comprehensive

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governance, at every level (local, national, regional and international). It shall involve all stakeholders, farmers, agro-industry, retailers, consumers and public authorities.

Governments can play a crucial role in providing public funding, research, technical expertise, support for new technology adopters and the adequate regulatory framework. Finally, concerning that future food production will be constrained by environmental issues as well as energy, land and water scarcity, technological and innovation efforts are highly necessary to support sustainable SSAI development and enhance the competitiveness of agro-industrial value chains. Well designed and implemented small-scale agro industrial development programs with components covering some of the elements hereby discussed can undoubtedly play a key role in the promotion of sustainable SSAIs, particularly in developing countries.

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