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Value stream mapping: a comprehensive tool for optimizing sugar agro-industrial value chains

Mapas de flujos de valor: una herramienta integral para la optimización de cadenas de valor agroindustriales azucareras

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ABSTRACT
The optimization of sugar agro-industrial value chains, characterized by their complexity and inefficiencies, requires comprehensive tools such as value stream mapping. The objective is to implement value stream mapping to model the sugar agro-industrial chain of the Boris Luis Santa Coloma agro-industrial company. A quantitative methodology was applied in three stages: selection of a management team, modeling using value stream maps, and identification of improvements through Kaizen events. The initial map revealed a total cycle time of 4969 hours and waiting times of 35 hours. After implementing improvements, significant reductions were achieved, such as a 19,1 % reduction in industrial cycle time. The application of value stream mapping proved to be an effective tool for visualizing and optimizing the chain, generating positive impacts on operational efficiency.
Keywords: value chains; supply chains; sugar agroindustry; lean manufacturing; value stream mapping.

RESUMEN
La optimización de las cadenas de valor agroindustriales azucareras, caracterizadas por su complejidad e ineficiencias, requiere herramientas integrales como los mapas de flujo de valor. El objetivo es implementar los mapas de flujos de valor para la modelación de la cadena agroindustrial azucarera de la empresa agroindustrial azucarera Boris Luis Santa Coloma. Se

aplicó una metodología cuantitativa en tres etapas: selección de un equipo gestor, modelación con mapas de flujo de valor, e identificación de mejoras mediante eventos Kaizen. El mapa inicial reveló un tiempo total de ciclo de 4969 horas y tiempos de espera de 35 horas. Tras la implementación de mejoras, se lograron reducciones significativas, como un 19,1 % en el tiempo de ciclo industrial. La aplicación de los mapas de flujo de valor demostró ser una herramienta efectiva para visualizar y optimizar la cadena, y genera impactos positivos en la eficiencia operativa.
Palabras clave: cadenas de valor; cadenas de suministro; agroindustria azucarera; lean manufacturing; mapas de flujo de valor.

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Introducción

The optimization of material and intellectual resources is considered a natural process in human development, linked to logistics. Its purpose is to organize, arrange, and use inputs or tools based on the ordering, improvement, and/or distribution of specific processes in organizations [1], viewed in turn as a new way of approaching business management that improves quality and is also considered a tool that provides competitive advantage [2, 3].

The organization of the logistical system is the connecting bridge between production and markets, which are separated by time and distance. Furthermore, it directs all efforts to meet customer requirements. Its management has evolved towards integration, aiming to optimize business logistics [4]. Pérez Marroquín [5], from a perspective based on maximizing efficiency, recognizes the complexity and need for a holistic approach in logistical management where the synchronization of marketing, sales, purchasing, finance, and production processes constitutes the first step towards the consolidation of logistical networks.

With the maturity of logistical networks in the early 1980s, a new management approach emerged: supply chains [6], an approach that constitutes the process of planning, executing, and controlling the flows of materials, economic-financial, information, knowledge, and return [7] from the point of origin (suppliers) to the point of consumption in order to meet customer needs. Among its main challenges are [1]: avoiding shortages of essential goods, evolving on the fly with new technologies, waste management in processes, based on risk management, the training of new competent professionals, and a focus on effectiveness.

Supply chains are sometimes confused with value chains, but their conceptualization is different [8]. While supply chains focus on guaranteeing and maintaining an agreed level of service with the customer, value chains focus on generating value for the product or service to be delivered. The value chain is made up of the set of activities that add value to the final product, ranging from its mere conception, through its production, distribution, and commercialization, to collection or recycling after use, generating competitive advantage through the continuous identification of improvement opportunities [9]. Antúnez Saiz and Ferrer Castañedo [10] summarize that it includes all activities that influence the creation of value and that in many cases, without creating it, condition its superior quality.

The relationship between value produced and value perceived constitutes the essence of competitive dynamics and gives the value chain great utility for strategic analysis, something similar to what is addressed in supply chains with customer service. Table 1 shows the main differences between supply chains and value chains.

Table 1 - Conceptual differences between Supply Chains and Value Chains.

Aspects	**Supply Chains**	**Value Chains**
Management Focus	Customer	Value
Objective	Maintain a set service level (SL) for the customer.	Generate value (identify improvement opportunities in C1, C2, C3, C4).
Main Links	• Suppliers • Production • Distribution • Customers	• Suppliers' value chain • Value chain of other business units • Value chain of distribution channels • Customers' value chain
Scope of Management Process	Start: Identification of links and mapping of the supply chain. End: Evaluate customer satisfaction (SL).	Start: Identification of improvement opportunities by value chain links. End: Evaluate the level of added value in the value chain.

As a main similarity, both encompass the logistical subsystems that form the basis of management, business logistics, and the internal supply chain, through their interconnection with other logistical systems, and both are based on enhancing linkages. Therefore, it can be said that a value chain preexists within a supply chain.

Sugar agro-industrial value chains are distinguished by their structural complexity, the multiplicity of actors involved (producers, processors, distributors, and consumers), and the need for efficient coordination to maximize the generation of added value. These chains require the integration of activities from the provision of raw materials to transformation and commercialization, where efficiency in the management of product, information, and financial resource flows is fundamental for their competitive performance [11]. Sustainability emerges as a central axis, evaluated through economic, social, environmental, and resource dimensions, which demands multi-criteria evaluation models and continuous improvement strategies, such as process optimization, technology implementation, and institutional strengthening [12].

In this context, risk management and adaptability to market fluctuations are essential to maintain resilience and profitability, requiring the identification and mitigation of risk agents along the chain [13]. Finally, the generation of added value and the equitable distribution of benefits among actors are persistent challenges, where innovation, investment in technology, and collaboration among the links of the chain are determining factors for the sustainability and competitiveness of the sector [14, 15].

The use of Value Stream Mapping (VSM) in modeling sugar agro-industrial value chains allows for the comprehensive visualization of productive processes, identifying inefficiencies, waste, and bottlenecks, as well as opportunities for improvement in sustainability and competitiveness [16]. These maps, which graphically represent the journey of materials and information from origin to final product, have been used to integrate tools such as life cycle analysis, simulation, and Lean management, which facilitates the identification of critical points and the prioritization of interventions in the chain [17]. Their application has proven key to optimizing processes, reducing losses, improving decision-making, and moving towards more sustainable and resilient chains [18].

An analysis of different studies implementing VSM for modeling the sugar agro-industrial value chain [7, 16, 17, 19] allows summarizing that relevant gaps persist: the lack of studies that comprehensively combine different methodologies, the scarce adaptation of maps to specific contexts, the tendency to address only effects and not root causes, the limitations of traditional maps due to their static nature, and the difficulty in modeling complex dynamic behaviors.

Consequently, the research objective is to implement VSM for modeling the sugar agro-industrial chain of the Boris Luis Santa Coloma agro-industrial company.

Methods

The study was framed within a quantitative research methodology with a descriptive approach [20] applied to a specific case study: the Boris Luis Santa Coloma sugar agro-industrial company, in the province of Mayabeque, Cuba. Figure 1 shows the procedure proposed in the research.

Procedure Objective: Establish a systematic methodology to comprehensively visualize, analyze, and model all flows and processes of the sugar value chain, in order to identify waste and improvement opportunities.

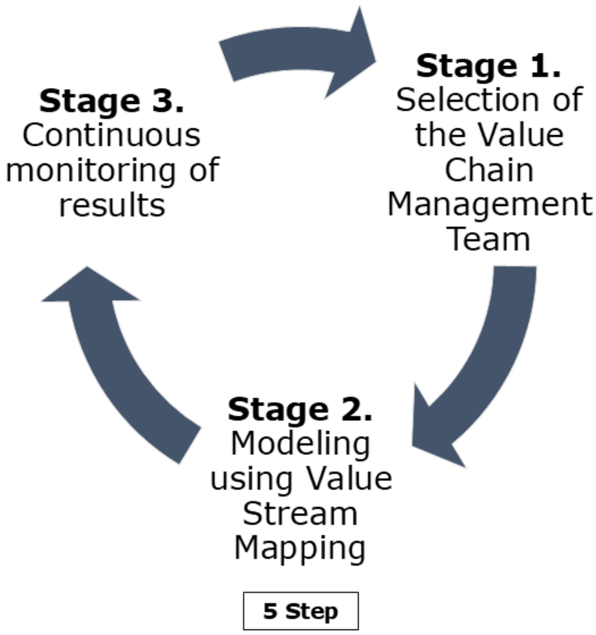

Fig. 1 - Procedure proposed in the research.

Stage 1. Selection of the Value Chain Management Team

The formation of the team was conceptualized not as a simple selection, but as the creation of a "talent cohort." The search prioritized a hybrid profile combining technical knowledge in agronomy, logistics, and industrial processes with transversal competencies in data analysis, systemic thinking, and change management. The premise was that the complexity of the modern sugar chain requires synthesizing diverse perspectives to decipher its integral dynamics.

To objectify this search and transcend mere curricular assessment, the Artola Pimentel Expertise Coefficient [21] was applied. This tool allowed quantifying and balancing a triple profile: procedural wisdom (practical experience), analytical agility (ability to interpret data), and ecosystem vision (understanding of the sector as a whole).

Stage 2. Modeling using Value Stream Mapping

Step 2.1. Collection of primary data in the different links of the chain

The analysis of the value chain, based on its processes, allows understanding its functioning, evaluating its efficiency, and identifying improvement opportunities. Each link fulfills a specific function in the transformation of the product, so it is essential to recognize how these activities interact to understand their contribution to the whole. The main links and indicators to analyze appear in table 2. During this step, all information related to activities, their duration, resources, and main risks is recovered (these were represented in a risk matrix of impact vs. probability).

Table 2 – Main links and indicators for creating the maps.

General Link	Description	Indicator to Analyze
Agricultural Link	Cultivation - harvest - collection -	• Cycle time per hectare

	transport to mill	• Yield (ton cane / hectare) • Mechanical / manual harvest index • Waiting time at collection point
Industrial Link	Reception - milling - clarification - evaporation - crystallization - centrifugation - drying - packaging	• Process capacity per stage • Operational cycle time • Intermediate inventories • Extraction rate and efficiency
Commercial Link	Storage - distribution - customers	• Delivery times • Stock levels • Order fulfillment rate

Step 2.2. Mapping of the current value chain and analysis of stakeholder groups

To map the value chain, the precepts defined by Hernandez Nariño et al. [7] were considered. An analysis of the main actors and their relationships was carried out based on their classification into: (1) suppliers, (2) producers, (3) distributors, (4) marketers, and (5) customers. The implementation of a supplier selection technique that optimizes the operational management of production systems and strengthens customer relationship management is proposed [22].

Step 2.3. Construction of the current value stream maps

For the construction of the current VSM, Microsoft Visio software was used, starting from the integration of the information obtained from the mapping. The procedure proposed by Sánchez Suárez et al. [17] was used for its creation.

Step 2.4. Identification of improvement opportunities

To identify improvement opportunities, an approach based on Kaizen bursts (Kaizen events) was used, allowing the prioritization of problems according to their severity and urgency. Through brainstorming sessions, potential solutions were generated by considering three key axes: market studies to analyze the environment and sector trends, innovation and optimization of the production system, and strategic investment in development.

Each improvement proposal was evaluated based on three fundamental questions:

1. How to make processes more efficient and fluid?
2. In what way can actors collaborate to optimize production and distribution?
3. How to ensure that resources are used strategically to improve the system's profitability and sustainability?

Step 2.5. Construction of the future value stream map

The future VSM aims not only to visualize an improved model but also to transform the structure of the production system to make it more efficient, sustainable, and competitive. It is not enough to make superficial adjustments; it involves rethinking how processes, actors, and resources are integrated, ensuring that each improvement introduced has a real impact on the value chain's performance.

Stage 3. Continuous monitoring of results

Quantitative assessments were carried out based on the efficiency index per link [17], which relates the current times in each of the activities and the projected future value from corrective actions. For corrective actions that have a direct influence on time reduction, the criteria of the management team and members of the AZCUBA group's board of directors were taken into account. These analyses were complemented by qualitative assessments of the economic, social, and environmental benefits for the sector.

Results

From the application of the proposed methodology, the following results are obtained:

Stage 1. Selection of the value chain management team

The value chain management team was composed of nine experts, all with a competence level between 0.89 and 0.97. Of these, four are from the AZCUBA business group, three are from the Boris Luis Santa Coloma sugar agro-industrial company, and two are researchers and academics (one from the University of Matanzas and one from the Havana Agricultural University).

Stage 2. Modeling using value stream mapping

Step 2.1. Collection of primary data in the different links of the chain

Table 3 shows the collection of primary data from the links of the sugar agro-industrial value chain of Boris Luis Santa Coloma. Figure 2 shows the risk map.

Table 3 - Collection of primary data from the links.

Link	Number of Activities	Duration (time)	Resource Type
Primary prodution	8	12 – 24 months	Material Resources Human Resources
Distributor 1 (TRANSMEC)	5	24 – 72 hours	Material Resources Human Resources
Industrial production	10	24 – 72 hours	Material Resources Human Resources
Distributor 2 (ENCARGA)	5	2 – 4 hours	Material Resources Human Resources

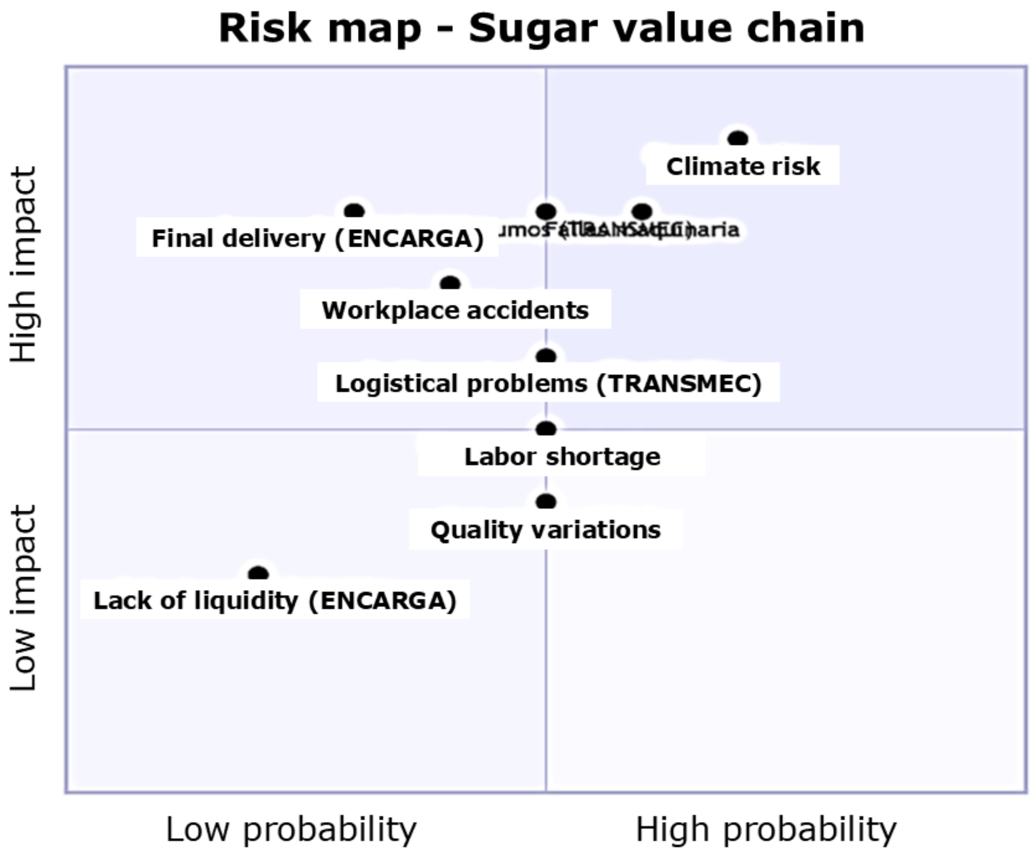

Fig. 2 – Risk map of the sugar value chain.

Step 2.2. Mapping of the current value chain and analysis of stakeholder groups

Table 4 shows the relationship matrix of the main stakeholder groups of the Boris Luis Santa Coloma sugar agro-industrial company. Once the value chain links, the involved actors, and the interaction between the different system components were defined, the current value chain was mapped, representing material, financial, and information flows (Figure 3). The chain was presented to experts, where 100% approved the proposed value chain by affirming that it describes their current real operation.

Table 4 - Stakeholder relationship matrix.

Stakeholder Groups	1	2	3	4	5	6
1. General Manager	-	x	x	0	x	0
2. Cane Compensation Manager	x	-	x	0	0	0
3. Brigade Chief, Collection Center	x	x	-	x	0	0
4. Mill Administrator	0	0	x	-	0	0
5. Commercial Department	x	0	0	0	-	x
6. TECNOAZUCAR	0	0	0	0	x	-

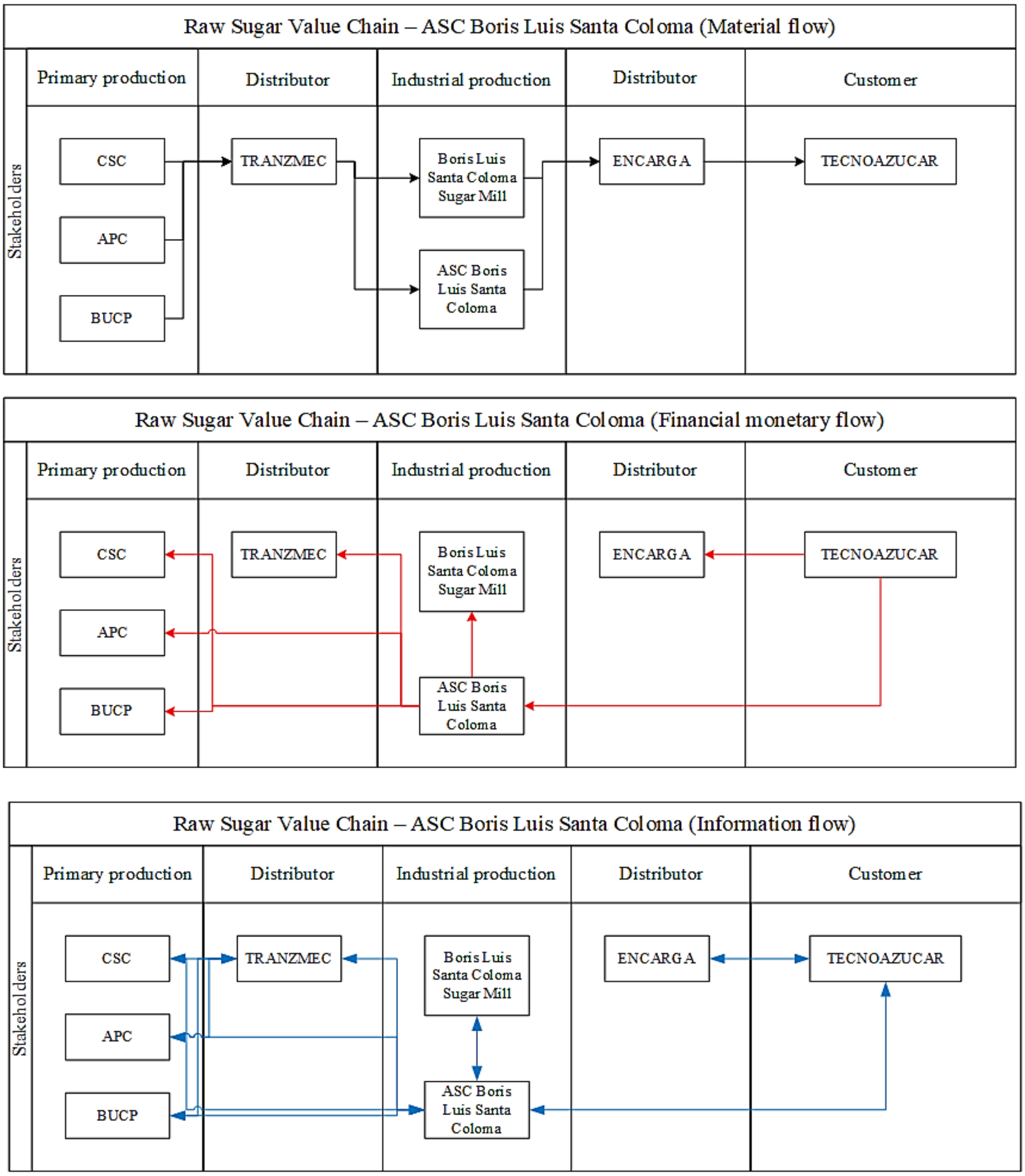

Fig. 3 – Current value chain map.

Step 2.3. Construction of the current value stream maps

The current VSM was constructed, identifying as main problems: non-compliance with production plans due to low crop yields, deficient pest control systems, deficiencies in production demand planning, unnecessary movements due to poor organization and route optimization, unnecessary internal movements of operators in the mill, increased rework due to poor quality control systems, increased queues in cane reception at the mill, and non-compliance in payments. The modeling yielded total cycle times of 4969 hours and total waiting times of 35 hours.

Step 2.4. Identification of improvement opportunities

A working session was held with 100 % of the experts where the current conditions of the value chain were presented, as well as the current models and the deficiencies detected during their implementation, to jointly propose improvement opportunities. Among the main ones are:

- Use of private transport for moving sugar cane in support of state transport.
- Creation of a collection center to streamline reception and weighing processes before factory processing.
- Define a collaborative demand planning model to adjust inventory levels in the factory.
- Implement a customer relationship planning system focused mainly on optimizing contracting processes.
- Implementation of a customer-centric payment management system with the implementation of electronic payments.
- Conduct a capacity study in the factory to reduce queues caused by bottlenecks.

Step 2.5. Construction of the future value stream map

Based on the improvement opportunities, an action plan was created and implemented from July 2024 to July 2025, with two measurements: one in January 2025 and the second in July 2025. With the latter, the future value stream map was modeled (figure 4).

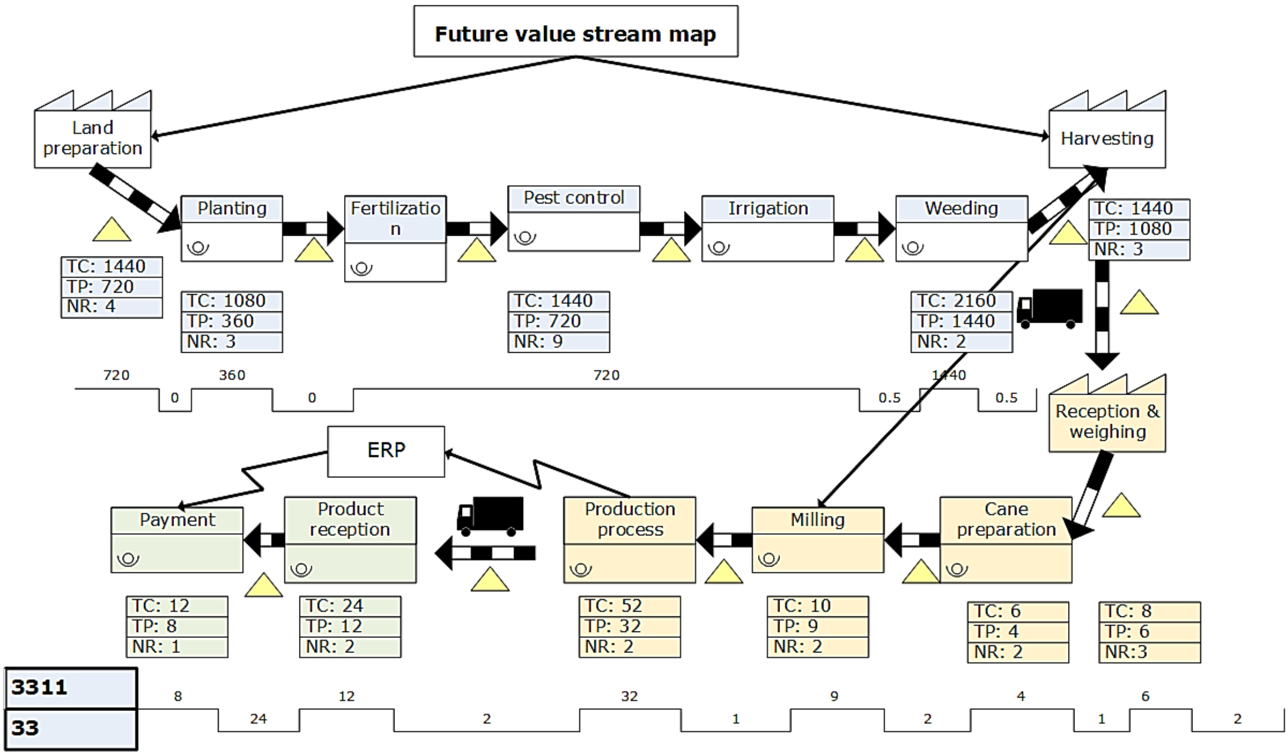

Fig. 4 – Future value stream map.

Stage 3. Continuous monitoring of results

Table 4 shows the impact analysis and its evolution in the two measurement periods.

Tabla 4 – Measurement of the impact of the implemented improvement solutions.

Link	IEa (January 2025)		IEa (July 2025)		Evolution	
	TCT	WT	TCT	WT	TCT	WT
Primary prodution	28,4 %	35 %	31,6 %	50 %	3,2 %	15 %
Distributor 1 (TRANSMEC)	40 %	-	50 %	-	10 %	-
Industrial production	35 %	28,5 %	19,1 %	33,3 %	-15,9 %	4,8 %
Distributor 2 (ENCARGA)	0 %	-	0 %	-	0 %	-
Customer	26 %	0 %	28,6 %	0 %	2,6 %	0 %

Where: TCT (Total Cycle Time) y WT (Wait times).

The application of the procedure allowed identifying and eliminating activities that do not add value (waste), all of which results in impacts in the economic, social, and environmental spheres.

Economic Impact

- Optimization of transport routes influences the distance traveled and reduces fuel consumption. The reduction of inter-link transport time from 2 to 1 hour represents substantial savings in logistical costs.
- The 19.1% reduction in cycle time and 33.3% in waiting times implies greater machinery availability, more efficient use of energy (steam, electricity), and a reduction in the cost per ton of sugar produced.
- Clarification of roles through the responsibility assignment matrix avoids duplication of functions and time lost in inefficient coordination. Personnel are assigned to value-added activities, increasing apparent labor productivity.
- Increases the volume and quality of sugar production and its derivatives, and creates exportable surpluses or for the national industry, reducing the need to import sugar or finished products that could be manufactured locally.

Social Impact

- Strengthening of local capacities through training, raising the technical and managerial competencies of professionals and technicians in modern management tools, fostering local innovation.
- Empowers actors by giving them the tools to analyze and improve their own processes.
- Contributes to farmers and cooperatives integrating more fairly and efficiently into the chain. The possibility of using their own transport and streamlining reception and payment processes improve their income and economic stability.
- Fosters local development by strengthening primary and logistical local links; innovation retains more value within the Mayabeque territory, generating indirect jobs and stimulating the provincial economy.

- Contributes to food security by guaranteeing stable production of food, strengthening national sovereignty by reducing dependence on sugar imports or other products that can be substituted by cane derivatives.
- Contributes to the preservation of the sugar cultural and productive heritage of the territory, which is a source of identity and pride for sugar communities.

Environmental Impact

- Optimization of transport routes, efficient load planning, and reduction of truck travel and waiting times lead to a direct decrease in greenhouse gas emissions, contributing to Cuba's national and international commitments in climate change mitigation.
- The reduction of stops and bottlenecks in the industrial process entails more stable and efficient consumption of steam and electricity, decreasing the carbon footprint of production.
- Contribution to the circular economy through the utilization of by-products such as bagasse, which can be efficiently used as fuel for renewable energy generation (biomass), reducing dependence on fossil fuels.
- Integration and collaboration among actors for the processing of filter cake as organic fertilizer, closing the nutrient cycle and returning them to the cane fields, thus impacting waste reduction and optimization of resource use to promote significantly more sustainable circular business models.
- Contribution to more efficient and monitored agricultural practices derived from better chain management contribute to the long-term conservation of soil and water resources, which are the basis of agro-industrial production.

Discussion

The VSM implementation in the sugar agro-industrial value chain of the Boris Luis Santa Coloma company proved to be an effective tool for comprehensively visualizing flows and processes, allowing the identification of inefficiencies, waste, and bottlenecks. The results obtained reflect a significant improvement in efficiency indicators, especially in the reduction of cycle and waiting times in productive and logistical links, validating the usefulness of VSM as a diagnostic and continuous improvement instrument in complex agro-industrial contexts [17, 18]. However, the study also evidenced limitations inherent to traditional maps, such as their static nature and the difficulty in modeling complex dynamic behaviors, which coincides with that indicated by El Kammouni et al. [19].

One of the main contributions of this research was the integration of a multidisciplinary approach in the formation of the management team, through the application of the Artola Pimentel Expertise Coefficient [21] to guarantee a balance between technical knowledge, analytical agility, and systemic vision. This approach facilitated not only the identification of operational problems but also the proposal of solutions aligned with the economic, social, and environmental dimensions of sustainability, as proposed by Yani et al. [12] and

Asrol and Yani [14]. Nevertheless, important gaps remain that open new lines for future research.

First, it is necessary to develop dynamic or adaptive VSM, capable of incorporating uncertainty variables and seasonal fluctuations typical of the sugar agro-industry. The integration of tools such as agent-based simulation or dynamic system modeling, like the approach explored by Sumadi and Ardiani [11], would allow anticipating scenarios and evaluating the impact of interventions before their implementation, thus overcoming the rigidity of conventional VSM.

Another promising line is the integration of VSM with other optimization and sustainability assessment methodologies. Although this study conducted a qualitative assessment of impacts, future research could formally incorporate life cycle assessment (LCA) or the use of multi-criteria indicators, as suggested by Masudin et al. [15], to more precisely quantify the environmental and social footprint of the proposed improvements. This would be especially relevant in the context of the circular economy, where the utilization of by-products like bagasse and filter cake acquires a strategic role.

Additionally, the need to explore the potential of digitalization and Industry 4.0 technologies in the mapping and management of sugar value chains is identified. The incorporation of IoT sensors, big data, and real-time collaboration platforms could transform VSM into living, automatically updatable tools, facilitating continuous and proactive monitoring, as envisioned in the approaches of Morosini Frazzon et al. [6] and Burinskiene et al. [2].

Finally, it is recommended to extend the application of VSM to other critical, less explored links, such as financing systems, knowledge management, or interaction with public policies. The complexity of agro-industrial chains, as pointed out by Pérez Pravia and Vega de la Cruz [8], requires a holistic approach that transcends operational optimization and addresses the institutional and governance determinants that condition their performance and resilience.

Conclusions

1. The effectiveness of VSM is segmented and critically depends on inter-link governance. Although the application of VSM allowed reducing the total cycle time by 19,1 % in the industrial link, the improvement in the primary production link was only 3,2 %, evidencing that Lean tools alone do not overcome structural disconnections. The absence of formal collaboration mechanisms between producers, industry, and distributors limits the systemic impact, confirming that technical optimization previously requires a collaborative governance architecture.
2. The quantitative identification of waste through VSM reveals critical inefficiencies, but its elimination demands multifaceted interventions. The initial mapping quantified 4969 hours of total cycle time and 35 hours of waiting, identifying operational bottlenecks. However, correcting these problems was not resolved solely with flow adjustments but demanded structural interventions such as the creation of a collection center and the

redefinition of planning models, demonstrating that VSM data must be translated into organizational and investment changes to materialize improvements.

3. The sustainability of the documented improvements requires continuous and adaptive monitoring, beyond the static future map. Although the future value map projected a 33,4 % reduction in cycle times and a 5,72 % reduction in waiting times, the disparate evolution between links—such as the 10 % advance in the TRANSMEC distributor versus 0 % in ENCARGA—underscores that implementation is heterogeneous and subject to local factors. This highlights the need to complement VSM with real-time monitoring systems that allow dynamic adjustments and ensure the permanence of efficiency gains.

Referencias

1. Sánchez Suárez Y, Pérez Castañeira JA, Sangroni Laguardia N, Cruz Blanco C, Medina Nogueira YE. Retos actuales de la logística y la cadena de suministro. Ingeniería Industrial. 2021;XLII(1):1-12. [cited: October 08, 2025]. Available at: https://rii.cujae.edu.cu/index.php/revistaind/article/download/1079/992

2. Burinskiene A, Daškevič D. Digitalization in Logistics for Competitive Excellence: Case Study of Estonia. Tehnicki Glasnik. 2024;18(3):486-96. [cited: October 08, 2025]. Available at: http://doi.org/10.31803/tg-20240502090609

3. John IB, Adekunle SA, Aigbavboa CO. Adoption of Circular Economy by Construction Industry SMEs: Organisational Growth Transition Study. Sustainability (Switzerland). 2023;15(7). [cited: October 08, 2025]. Available at: http://doi.org/10.3390/su15075929

4. Salas Navarro K, Meza JA, Obredor-Baldovino T, Mercado-Caruso N. Evaluación de la Cadena de Suministro para Mejorar la Competitividad y Productividad en el Sector Metalmecánico en Barranquilla, Colombia. Información Tecnológica. 2019;30(5):25-33. [cited: October 08, 2025]. Available at: http://doi.org/10.4067/S0718-07642019000200025

5. Pérez Marroquín RD. Automatización de Procesos y Eficiencia Operativa mediante Inteligencia Artificial en la Administración. Business Innova Sciences. 2024;5(1):85-113. [cited: October 08, 2025]. Available at: http://doi.org/10.5281/zenodo.13308399

6. Morosini Frazzon E, Taboada Rodriguez CM, Meireles Pereira M, Cardoso Pires M, Uhlmann I. Towards supply chain management 4.0. Brazilian Journal of Operations & Production Management. 2019;16(1):180-91. [cited: October 08, 2025]. Available at: http://doi.org/10.14488/BJOPM.2019.v16.n2.a2

7. Hernández Nariño A, Sablón Cossío N, Sánchez Galván F, Bautista Santos H, Acevedo Urquiaga AJ. Supply chain mapping: Analysis of processes, flows and actors in Latin-American case studies. Kasetsart Journal of Social Sciences. 2025;46(1):460102. [cited: October 08, 2025]. Available at: https://doi.org/10.34044/j.kjss.2025.46.1.02

8. Pérez Pravia MC, Vega de la Cruz LO. Gestión de riesgos en encadenamientos productivos sostenibles. Revista Venezolana De Gerencia.

2021;26(96):1396 [cited: October 08, 2025]. Available at: http://doi.org/10.52080/rvgluz.26.96.25

9. Cáceres R, Martínez-Román JA, Romero I. Las dependencias funcional y productiva en el análisis de las cadenas de valor global. Revista de Economía Mundial. 2013(35):87-101. [cited: October 08, 2025]. Available at: https://www.redalyc.org/pdf/866/86629567004.pdf

10. Antúnez Saiz V, Ferrer Castañedo M. Hacia un enfoque de encadenamientos productivos en Cuba: una propuesta metodológica para su análisis. cofin Habana. 2014;8(3). [cited: October 08, 2025]. Available at: https://revistas.uh.cu/cofinhab/article/view/1317/1170

11. Sumadi J, Ardiani F. Supply chain brown sugar agroindustry in Banyuwangi district: Analysis study with a dynamic system approach. International Journal of Supply Chain Management. 2020;9(1):626-32. [cited: October 08, 2025]. Available at: https://core.ac.uk/download/pdf/288291209.pdf

12. Yani M, Asrol M, Hambali E, Papilo P, Mursidah S, Marimin M. An adaptive fuzzy multi-criteria model for sustainability assessment of sugarcane agroindustry supply chain. Ieee Access. 2022;10:5497-517. [cited: October 08, 2025]. Available at: https://doi.org/10.1109/ACCESS.2022.3140519

13. Asrol M, Yani M, Taira E. Risk management for improving supply chain performance of sugarcane agroindustry. Industrial Engineering & Management Systems. 2021;20(1):9-26. [cited: October 08, 2025]. Available at: https://doi.org/10.7232/iems.2021.20.1.9

14. Asrol M, Yani M. A multi-criteria model of supply chain sustainability assessment and improvement for sugarcane agroindustry. Heliyon. 2024;10(7). [cited: October 08, 2025]. Available at: https://www.cell.com/heliyon/pdf/S2405-8440(24)04290-7.pdf

15. Masudin I, Alfarisi S, Suhartin E, Restuputri DP, Shariff SSR. Hotspot Identification for Improving Cane-Sugar Sustainable Supply Chain Through the Integration of Life Cycle Assessment and Value Stream Mapping. Process Integration and Optimization for Sustainability. 2025;9(2):605-24. [cited: October 08, 2025]. Available at: https://doi.org/10.1007/s41660-025-00486-y

16. De Steur H, Wesana J, Dora MK, Pearce D, Gellynck X. Applying Value Stream Mapping to reduce food losses and wastes in supply chains: A systematic review. Waste management. 2016;58:359-68. [cited: October 08, 2025]. Available at: https://bura.brunel.ac.uk/bitstream/2438/13116/3/FullText.pdf

17. Sánchez Suárez Y, Sánchez Castillo V, Gómez Cano CA. Implementación de mapas de flujo de valor en la mejora de trayectorias intrahospitalarias de pacientes. Revista Cubana de Salud Pública. 2025;51:e_19273. [cited: October 08, 2025]. Available at: http://doi.org/10.58763/rc2023115

18. Ahmad R, Amin RFM, Mustafa SA. Value stream mapping with lean thinking model for effective non-value added identification, evaluation and solution processes. Operations Management Research. 2022;15(3):1490-509. [cited: October 08, 2025]. Available at: https://doi.org/10.1007/s12063-022-00265-9

19. El Kammouni R, Kamach O, Masmoudi M, editors. Value stream mapping 4.0: a structural modeling approach. 13ème CONFERENCE INTERNATIONALE DE MODELISATION, OPTIMISATION ET SIMULATION (MOSIM2020), 12-14 Nov 2020, AGADIR, Maroc; 2020. [cited: October 08, 2025]. Available at: https://hal.science/hal-03192847/

20. Sánchez Suárez Y, Marqués León M, Hernández Nariño A, Suárez Pérez M. Metodología para el diagnóstico de la gestión de trayectorias de pacientes en hospitales. Región Científica. 2023;2(2):2023115. [cited: October 08, 2025]. Available at: http://doi.org/10.58763/rc2023115

21. Artola Pimentel MdL. Modelo de evaluación del desempeño de empresas perfeccionadas en el tránsito hacia empresas de clase en el sector de servicios ingenieros de Cuba [Tesis presentada en opción al grado de Doctor en Ciencias Técnicas]. Matanzas, Cuba: Universidad de Matanzas "Camilo Cienfuegos"; 2002.

22. García Alcaraz JL, Alvarado Iniesta A, Maldonado Macías AA. Selección de proveedores basada en análisis dimensional. Contaduría y administración. 2013;58(3):249-78. [cited: October 08, 2025]. Available at: https://doi.org/10.1016/S0186-1042(13)71229-4

Conflict of Interest

The authors declare no conflict of interest.

Contribution of each author:

Yasniel Sánchez Suárez: Project leader and administrator, participated in drafting the introduction and defining the differences between supply chains and value chains. He also modeled the value chain and drafted the first version.

Darian Samá Muñoz: Participated in drafting the introduction regarding sugar agro-industrial value chains. He participated in applying the results of the procedure and in the research discussion.

Dasiel Calzadilla Adan: Participated in designing the procedure and applying phase three, impact assessments. He participated in collecting field data to support the modeling. He participated in drafting the manuscript's conclusions.

Arialys Hernández Nariño: Participated in drafting the introduction, specifically the sections related to value chains. He participated in the design of the methodology for the stakeholder analysis and improvement opportunity identification section. He also participated in the initial drafting of the discussion and in the manuscript review.

Gianny David Quesada Martínez: He participated in adjusting the introduction and preparing the abstract. He also participated in the final manuscript review, value chain modeling, and processing of field data.