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DESIGN OF A SCOR MODEL AS A TOOL FOR IMPROVEMENT IN THE HORTICULTURAL SUPPLY CHAIN IN COLOMBIA

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ABSTRACT

The horticultural sector plays a crucial role in the economy, contributing significantly to the supply of fresh and healthy products to the community. However, supply chain efficiency in this sector can face challenges that affect both producers and consumers. This research project was developed with the main objective of analyzing and improving the supply chain in the horticultural sector of Duitama, identifying areas of opportunity and proposing strategies to optimize the flow of products from production to the final consumer, a mixed approach methodology was implemented where the Participatory Rural Innovation (IRP) method is applied with an intentional sampling for small horticultural producers in the province of Duitama.

KEYWORDS: SCOR Model, Horticultural Sector, Supply Chain, Duitama.

1. INTRODUCTION

Global vegetable production has experienced significant growth in recent decades. According to an FAO report, global vegetable production grew by 65% between 2000 and 2019, reaching 1,128 million tons in 2019 (AenVerde, 2021). In 2021, tomatoes were the most produced vegetable globally, with approximately 189 million metric tons (Most Produced Vegetables Globally in 2021, n.d.). Mexico was positioned as the ninth largest producer of vegetables worldwide in 2023, with a production of 14.1 million tons, with tomatoes, green chiles, onions, corn and cucumbers standing out as the five main vegetables grown in the country. Overall, global production of fresh fruit and vegetables has remained stable in recent years, standing at 1,882 million tonnes in 2020.

The production of vegetables in Colombia is diverse and is distributed in different departments of the country, adapting to the needs of the country.

agroclimatic conditions of each region. According to the Statistical Yearbook of Fruits and Vegetables, in 2009, the departments with the highest vegetable production were Boyacá (26%), Cundinamarca (21%), Antioquia (10%), Norte de Santander (10%), Santander (7%) and Nariño (6%), which together accounted for 80% of vegetable production in Colombia. (Industry and Commerce, 2022) In addition, it is estimated that the vegetable chain in Colombia generates about 350 thousand total jobs annually, of which approximately 117 thousand are direct jobs and around 233 thousand are indirect jobs (Ministry of Agriculture and Rural Development, 2022)

In terms of harvest and production areas, it is noteworthy that horticultural crops are reported in 32 departments and more than 1,000 municipalities, with 55% of the total horticultural harvested area concentrated in the departments of Cundinamarca (18%), Boyacá (15%), Antioquia (11%) and Nariño (11%). The main products and destinations of production vary according to the department, with crops such as lettuce, carrots, bulb onions, tomatoes, among others, mainly destined for fresh consumption.

The municipality of Duitama stands out for its horticultural production, being an important supplier of fresh products to the region. Despite this crucial role, the supply chain in the horticultural sector faces challenges that affect the efficiency and profitability of the actors involved, from producers to end consumers, among the existing problems can be identified the lack of effective coordination between producers, distributors and retailers in the supply

chain Duitama's horticultural system, leading to redundancies, delays and product loss, low implementation of information technologies and adequate tracking systems hinders real-time visibility and monitoring of the supply chain, contributing to inefficiency and product loss. (González, 2020.)

The main challenges in the horticultural supply chain in Duitama include poor post-harvest infrastructure, logistics, product availability, resilience, and adaptation to market changes. The scarcity of post-harvest infrastructure has affected the added value of horticultural products in the region. Logistics is another major challenge, as moving food from one place to another requires a complex network of transportation and storage infrastructure, and any failure in this system can cause delays and shortages. Product availability, resilience, and adaptation to market changes are also critical challenges facing the horticultural supply chain in Duitama.

In addition to this, the horticultural sector is strongly influenced by external factors such as climate, seasons and market demand. The lack of strategies to anticipate and mitigate these impacts results in fluctuations in supply and demand.

Likewise, the lack of adequate storage and transport conditions is evident, contributing to the deterioration of the quality of horticultural products, resulting in economic losses for both producers and distributors.

Supply chain optimization in Duitama's horticultural sector is essential not only for the economic profitability of those involved, but also to ensure a consistent and quality supply of fresh produce to the community. In addition, improving efficiency and sustainability can strengthen the competitiveness of the sector at local and regional levels.

This research is developed through a mixed approach methodology, where a research-action-participation method is implemented since researchers are involved with the object of study and a descriptive method at the time of identifying the shortcomings of the supply chain with the survey instrument applied.

2. THEORETICAL REFERENCES

2.1. Supply Chain

To understand the operational particularities of the supply chain, it is necessary to take into account the most important events in the context of its evolution (Table 1). Although the transition from physical distribution management using logistics to

current supply chain models has been happening for a while, it has only recently gained momentum and supply chain models have become more complex.

Board 1: Evolution of the Supply Chain.

Date	Event
1940 - 1950	Using machinery to improve labor-intensive material handling processes and utilize storage design
1960	The term "Physical Distribution" arises as a result of the change from railroad to truck for freight transport
1963	The National Physical Distribution Management Council (NCPDM) was created with the aim of meeting the needs of the logistics industries
1970	Advent of computers: led to the creation of Georgia Tech's Production and Distribution Research Center and Columbia University's Center for Computational Optimization, focused on supply chain innovation, logistics and distribution, inventory optimization, and route tracing
1970 - 1980	Material requirements planning (MRP) systems were developed in an attempt to integrate multiple databases of companies that exist in companies and encourage them to communicate with each other
1985	The National Physical Distribution Management Council (NCPDM) changed its name to the Logistics Management Council (CLM), reflecting the evolution of the discipline, including the integration of inbound, outbound, and reverse flows of products, services, and information
1990	Logistics and supply chain management became more widely accepted in the industry and increased with the emergence of enterprise resource planning (ERP) focused on planning and integration between databases and logistics components.
2004	The Logistics Management Council will change its name again to the Council of Supply Chain Management Professionals. The term "supply chain" emerged to refer to strategic issues while the term "logistics" began to refer to tactical and operational issues

Note: Authors, information taken from (Sindi & Roe, 2017)

Due to the highly competitive environment that organizations face, alternatives must be sought to meet the requirements of the market, to promote exchange relations in each link involved from production to marketing of products. In other words, you must know and understand what a supply chain is, the necessary resources in the indicated amount to achieve business objectives.

In this sense, the supply chain is defined as "The network of services, materials and information flows that links the processes of customer relations, order fulfillment and relations with suppliers of a company with the processes of its suppliers and customers" (Krawjesky et al., 2008, p. 372)

For their part, Manrique et al. (2019) specify that the supply chain is "the set of links that, in an interrelated way, execute various activities through which the necessary inputs, the product and the information flow until delivery to the final consumer" (p. 1138). An organization as a whole is influenced by the supply chain.

Also, Santander et al. (2014) mention that supply chains are conditioned by environmental factors (hiring, resource allocation, investment plans) of which, although control can be exercised, there are events that differ from what was initially planned, as well as factors such as natural events, country infrastructure or government policies over which it is not allowed to have control. Therefore, companies must create action plans to prevent damage to the supply chain.

Taking into account the above, the term resilient supply chains are indicated, which, after being affected by internal or external events of the system, are able to return to their original state or transition to a new desired state (Santander et al., 2014).

In general terms, the supply chain, from the point of view of the key links, consists of three phases: Procurement, which includes the collection points of raw materials; Production, raw materials are transformed into a finished good; Distribution, through which the finished product is transferred to places of commerce for storage and subsequent sale (Pires & Carretero, 2007).

2.2. Supply Chain Management (SCM)

The term supply chain management was used by Oliver & Webber (1982) to refer to a new marketing perspective that replaced the unsatisfactory methods of integrated marketing channel management. The primary objective of SCM was to maximise the level of profitability and competitiveness of the supply chain, including the final consumer, Lambert et al. (1998). In order to achieve a better result of the system as a whole, Cooper & Ellram (1993) specify SCM as the management and analysis of the entire network, from the supplier to the end user.

On the other hand, Vargas (2014) states that supply chain management involves "the transfer of knowledge, the promotion of innovation, the improvement of quality standards and the implementation of efficient communication

mechanisms throughout the chain" (p. 47).

The term SCM is broadly considered by Mentzer *et al.* (2001) and defines it as the systemic strategic coordination of traditional business functions and tactics across these business functions within a particular company, and across supply chain companies, for the purpose of improving the long-term performance of individual companies and the supply chain as a whole.

On the other hand, the supply chain is not only a chain, but rather consists of a network structure of companies that are centrally interrelated in the business process, from the procurement of raw materials to the end customer (Lambert & Cooper,

2000).

In addition, the complexity of the supply chain is determined, according to (Svensson, 2007), by "generic components (such as actors, activities, and resources) and generic interfaces (such as interaction, coordination, cooperation, and competition)" (p. 247). Interfaces and components together make up supply chain management.

It is important to mention that, in order to respond to changes in the environment, there are supply chain management models that allow some events to be foreseen. Some of the most influential models are described in Table 3.

Table 2: Supply Chain Management Models.

Author	Model	Description
(Fisher, 1997)	Fisher Supply Chain Model	It proposes a classification of the supply chain according to demand and supply. It divides the chain into "agile supply chain" for uncertain demand, "aligned supply chain" for predictable demand, and "efficient supply chain" for stable demand.
(Supply Chain Council., 2008)	Model of the Chain of SCOR Supply Chain Operations Reference)	SCOR is a framework developed by the Supply Chain Council that provides a set of processes, metrics, and best practices for managing and measuring supply chain performance. It helps standardize processes and terminology in supply chain management.
(Lee, 2004)	Model of the Chain of Triple A Supply	It focuses on three key areas: Agility, Adaptability, and Alignment. This approach seeks to improve the responsiveness of the supply chain to changing, market conditions and customer needs.
(Liker & Convis, 2012)	Lean Supply Chain Model	Based on the principles of Toyota's production system, this model focuses on eliminating waste at all stages of the supply chain to achieve greater efficiency and reduce costs
(Christopher, 1999)	Model of the Chain of Supply Responsive and Efficient	It proposes a matrix that classifies products according to their demand and the variability of demand. Then, it suggests specific supply chain strategies for responsive and efficient products
(Vachon & Klassen, 2008)	Model of the Chain of Dynamic Delivery	It focuses on the continuous adaptation of the supply chain to respond to changes in the environment. It highlights the importance of flexibility and collaboration in the supply chain.

Source: Author-based elaboration

2.3. SCOR Model

According to Arana-Solares *et al.* (2012), proper management in a supply chain is essential for companies to optimize their competitiveness, facilitating the efficiency of the use of resources and helping end users to achieve service objectives, improving relationships between supply chain participants and reducing inventory levels and delivery times.

Thus, in order to respond to changes in the environment, there are supply chain management models that allow some events to be foreseen, among these is the SCOR model.

The SCOR model is a framework developed by the Supply Chain Council that provides a set of processes, metrics, and best practices for managing and measuring supply chain performance. It helps standardize processes and terminology in supply

chain management (Supply Chain Council., 2008).

It is composed of indicators that seek to measure its behavior internally (costs and assets) and externally (reliability, response, and flexibility) in a general way, facilitating decision-making (Zuluaga-Mazo *et al.*, 2014).

It should be noted that this model allows the description of the business activities necessary to meet the needs of consumers and is organized around six main management processes (Figure 1): planning, supply, production, distribution, return and enablement.

Also, (White, 2021) states that there are three levels that are used to measure supply chain performance, which allow standardizing supply chain performance metrics so that companies can be evaluated against other companies, even if they operate differently, the three levels are presented in

Figure 2.

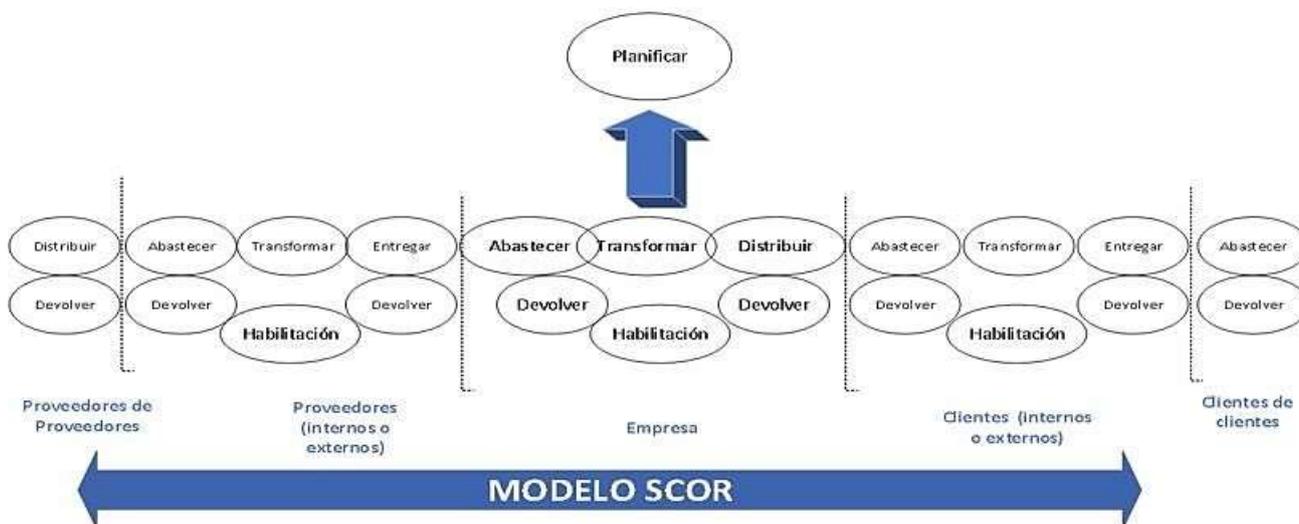


Figure 1: SCOR Model Structure. Original Language: Spanish. Source: Taken from (APICS, 2017)

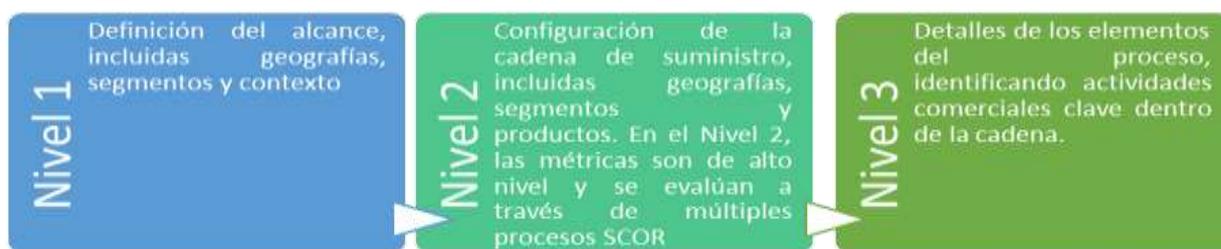


Figure 2: SCOR Model Levels. Original language: Spanish. Source: own elaboration information taken from (White, 2021)

2.4. Agricultural Supply Chain

Supply chain management in the agricultural sector is essential to ensure efficiency and quality in the production, distribution and sale of agricultural and livestock products. It is important to mention that the choice of the management model depends on numerous elements such as the nature of the products, market trends, the capabilities of the actors involved and geography. In addition, changing trends in the industry and technological advances can also play a role in choosing the right model.

There are also elements that are fundamental and that support the operation and movement of the chain (Error! The origin of the reference is not found.), the institutions of the supply chain direct the actions of the participants in the chain through regulations or laws that govern commercial practices, product quality and food safety; infrastructure includes telecommunications systems, logistics service providers, packaging and preservation technologies King & Venturini (2005)

In this context, the global agri-food supply chain includes a network of companies from primary

production to sales to end consumers. It is made up of primary producers, processors, distributors, traders and service providers. Each actor carries out certain activities of purchase, processing, and sale of products and/or services, adding value to the product until it reaches its destination (Gutiérrez & Infante, 2017).

2.5. Horticultural Producers

According to DANE (2015), an agricultural producer "is the natural or legal person who directs the Agricultural Production Unit and makes the main decisions on the cultivation of plants, animal husbandry, agricultural practices, the use of the means of production and the sale of agricultural products" (p. 3).

In this way, a horticultural producer is a person, organization or entity that is dedicated to the cultivation and production of vegetables, fruits and other horticultural crops. These crops can include vegetables, legumes, fruits, and ornamental plants. Horticultural producers work on land management, planting, plant care, harvesting, and in many cases,

marketing their produce.

Thus, in the words of (Rozano et al., 2005) "vegetables are a set of plants generally grown in orchards or irrigated areas, which are consumed as food, either raw or cooked. The term vegetable includes vegetables and green legumes" (p. 3). In the case of vegetables in Colombia, the Agri-food Chain is made up of representatives of primary producers, wholesale marketers, chain stores and department stores, processing industries, seed producers and importers, planters, suppliers of export inputs, representatives of academia and research centers (Minagricultura, 2016). Where the characteristic of primary producers is that 75% of the farms are of a size of less than 3.0 hectares. and 40% less than 1.0 ha. Being a peasant economy that satisfies the domestic market and the limited generation of value through transformation processes restricts the supply to the commercialization of fresh produce (Minagricultura, 2020).

3. METHODOLOGY

To carry out this process, the Participatory Rural Innovation Model (IRP) was implemented, which is defined by (Gutiérrez, 2010,) as "The IRP method consists of a sequence of steps to carry out a social intervention based on participation and sustainability" (p. 526), this methodology is important since it involves small producers, distributors and other actors in the supply chain according to the SCOR model (Gutiérrez, 2010, p.527).

3.1. Research Focus

For the development of the research, a mixed approach was implemented, defined as a "set of systematic, empirical and critical research processes and involve the collection and analysis of quantitative and qualitative data, as well as their integration and joint discussion", to make inferences from all the information collected and achieve a greater understanding of the phenomenon under study" (Valverde, 2002), the mixed research approach offers the opportunity to integrate different perspectives and methodological approaches to obtain a more complete and in-depth understanding of a phenomenon, which makes it relevant for the optimization of the horticultural production supply chain by allowing to address both quantitative and qualitative aspects in an integrated manner.

3.2. Methodology-Participants

The object of study is the SCOR model of supply chain and its analysis as a social phenomenon that

generates changes in the practices of horticultural producers in the development of daily processes. An intentional sampling will be used to obtain more relevant data for the research, likewise for (Bonilla-Castro & Sehk, 2005) the researcher "configures an initial sample with participants who have information and experience of the topic to be investigated" as well as taking voluntary participants which, according to (Sandelowski, 2000) "allows researchers to explore the unique common manifestations of the phenomenon under study" (p.338), To carry out this sample, the following inclusion criteria will be taken: horticultural producers, which are distributed in 5 villages in the municipalities of Duitama for a total of twenty (15) farms, who voluntarily agree to participate in the research, the call will be made including all producers who meet the inclusion criteria, the objectives of the research will be commented, it will be indicated that it is an academic exercise in which they may or may not participate according to their interests, then an agreement will be made with those interested in the research on the day, time and place of the focus group. Once the group of participants has been formed, a socioeconomic record will be applied. Large horticultural producing companies and producers who are not interested in taking part in the research will not be taken into account as exclusion criteria for the research

3.2. Methodology-Instruments, Materials and/or Equipment

Conduct surveys and interviews with growers, processors, distributors, marketers and other key players in the horticultural supply chain in Duitama, to obtain qualitative information and insights on the supply chain Likert survey to identify consumption patterns and consumer preferences and market needs, additional. Design of inventory and records file with the purpose of identifying the stages of the supply chain, including the production, processing, distribution and marketing A focus group which is defined as "a conversation, carefully planned, designed to obtain information from a defined area of interest, in a permissive and non-directive environment" (García C & Rodríguez, 2000, p. 82)

3.3. Analysis of Information

The data will be collected, coded and with them an Excel database will be formed.

- For the analysis of the distribution and normalization of the data, the statistical system R will be used.
- For non-parametric data, the SPSS statistical

system will be used.

- For qualitative data, the atlas Ti5 software and the Nvivo software will be used.

4. RESULTS

For the development of the research, it is

proposed through the following phases

1. Identification of supply chain processes, from production to marketing to determine critical points and opportunities for improvement, which is developed through the following flowchart

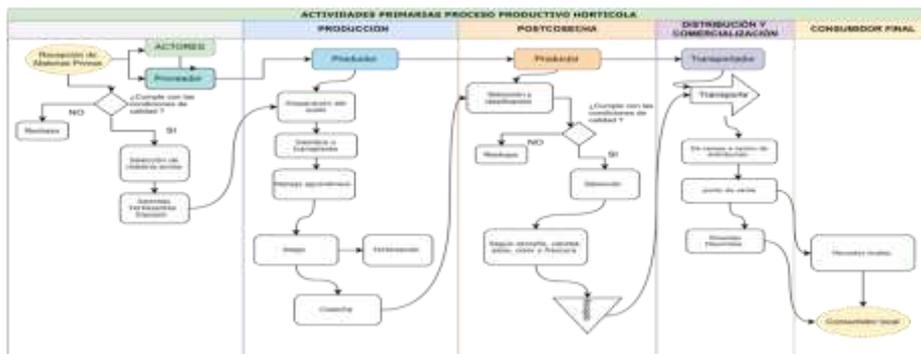


Figure 3: Map of Activities of the Horticultural Production Process. Original Language: Spanish.

The previous figure identifies the processes from the acquisition of raw materials with suppliers

4.1. Raw Material Reception

Stakeholder involved: Supplier

Activities: Reception of raw material: The producer receives the necessary inputs for planting and production (seeds, fertilizers, equipment), then a selection of raw material is made: Here the quality of the raw materials is reviewed if they do not meet the required standards, they are rejected if they meet the standards they are selected to advance in the process.

Production

Actor involved: Producer

Activities:

Soil preparation: The land is conditioned for cultivation.

Sowing or transplanting: Depending on the type of vegetable, seeds are sown or seedlings are transplanted.

Agronomic management: Includes all the necessary practices to ensure the good development of the crop (pest control, crop nutrition, etc.).

Watering: Provide the necessary water for the plant to develop properly.

Fertilization: Application of nutrients to optimize growth.

Harvest: Harvesting of vegetables once they reach their point of ripeness.

Postcosecha

Actor involved: Producer

Activities:

Selection and classification: The harvested vegetables are reviewed and separated according to

their quality, size, color, weight, and freshness.

Reject: Products that do not meet the established standards are discarded at this stage.

Collection: The selected vegetables are grouped for subsequent distribution.

Distribution and Marketing

Actor involved: Transporter

Activities:

Transportation: The vegetables are moved from the field to a distribution center or point of sale.

From field to distribution center: Products are taken to centers where they are distributed.

Point of sale: Retailers and wholesalers purchase the products.

End Consumer

Actor involved: Local consumer

Activities:

Buying at local markets: Consumers buy vegetables at local markets or points of sale

2. Define the performance indicators for each of the processes of the supply chain, in order to measure and monitor the performance of the chain.

Efficiency is critical to reducing costs and ensuring timely availability of fresh produce. Medina (2009) emphasizes the importance of logistics indicators in the distribution of fruits and vegetables, especially metrics related to storage, packaging, packaging, transportation, and distribution. Cabrera Méndez (2019) highlights that logistics indicators help to improve competitiveness and customer satisfaction.

For Gutiérrez & Romero (2020), performance indicators are tools that allow you to measure the

performance of the supply chain in terms of efficiency, effectiveness, and effectiveness. Efficiency refers to the use of resources to achieve a goal. Effectiveness refers to the achievement of a goal. Effectiveness refers to the impact that an action has on a goal

Likewise, to measure the efficiency of the vegetable supply chain, it is necessary to define key performance indicators (KPIs) for this case it was taken into account: cost, time, losses and product quality, as shown in the following figure:

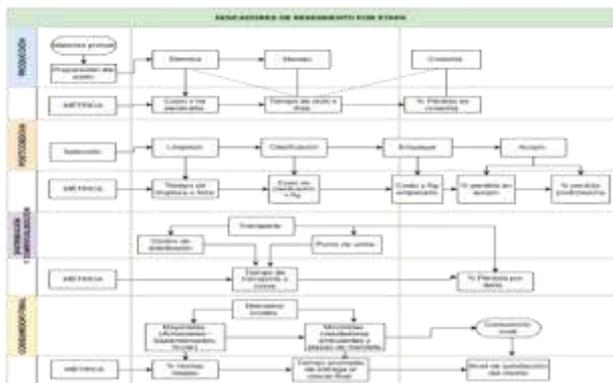


Figure 4: Performance Indicator Maps. Source: Authors (2024). Original language: Spanish.

Production Stage Cost x has been planted: in this case, an estimated breakdown of production costs is made

Land Adaptation, Agricultural Inputs: (seeds, fertilizers, pesticides), irrigation, labor, planting, handling and weeding, harvesting, packaging cost and transportation cost.

Cycle time x days: days from sowing to germination, vegetative growth, ripening and harvesting

% Crop Loss: Mechanical Damage, Late Harvest, Weather Conditions, Quality Selection

Post Harvest Stage (Cleaning, classification,

packaging and collection)

(Cleaning, sorting, packing and stockpiling)

Cleaning time: X hours time a worker can clean x kg x hour.

Sorting cost x Kg: Depending on salary and kg x hour

Cost x Kg Packed: This indicator evaluates the cost of packing each kilogram of product, based on the labor and material costs involved in the packaging process.

% loss in stockpiling, % post-harvest loss: harvesting, sorting and cleaning and transport and storage

Distribution and Marketing Transportation to the distribution center or Transportation to the point of sale, Transportation time: X hours, Transportation cost per km, Loss due to damage in transportation: X%

Final Consumer Local markets

Supply Chain Process Bottlenecks and Inefficiencies According to (Campos, 2023) One of the most important challenges faced by SMEs is logistics, they have difficulties in guaranteeing the quality and freshness of their products during transport and distribution. These challenges can hinder your ability to optimally meet the demand for fresh produce. Challenges can include inefficiencies in transportation processes, storage and distribution issues, lack of timely information, and ineffective management of logistics indicators. These issues, if not addressed properly, can lead to economic losses, food waste, and even more critically, threaten the food security of the population

In the vegetable supply chain in Boyacá, a small producer faces several bottlenecks and inefficiencies that affect both his productivity and the quality of his product. These issues range from production to marketing.

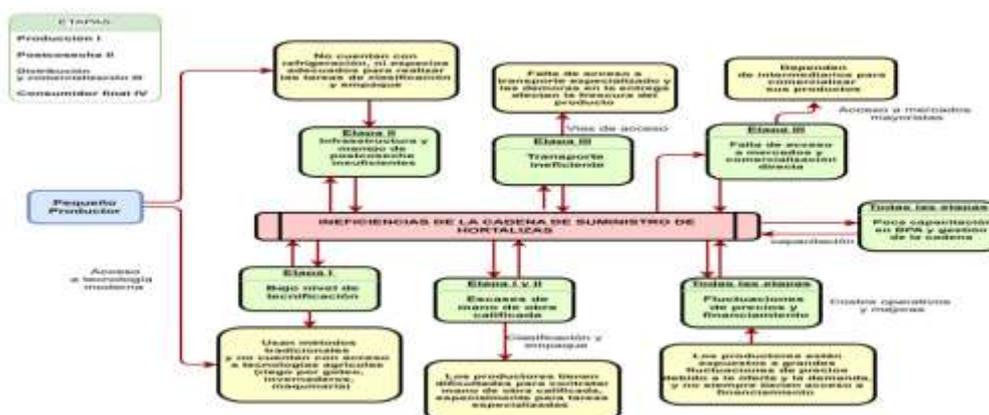


Figure 5: Inefficiencies of the Vegetable Supply Chain. Source: Authors (2024). Original Language: Spanish.

- The design of the SCOR model for the vegetable supply chain in the Cundiboyacense highlands, establishing the processes, sub-processes, activities and tasks necessary to optimize the chain.

5. SCOR R (SUPPLY CHAIN OPERATIONS REFERENCE MODEL) MODEL IN THE VEGETABLE SUPPLY CHAIN IN THE PROVINCE OF TUNDAMA

As mentioned above, the SCOR Model is a tool that allows identifying opportunities for improvement through the best practices established in industries in the same sector. For the development of the project, this model was applied in order to determine the disconnections that occur throughout the vegetable supply chain in Boyacá, specifically in the municipality of Duitama. The SCOR model is composed of three stages based on its structure: definition of the scope and techniques of the supply chain; definition of process categories; and decomposition of it.

For the development of this section, the methodological proposal for the application of the Supply Chain Operations Reference model defined by Salazar & López (2012), which is composed of 4 stages based on the levels of the SCOR model structure:

- Higher level: Types of processes.
- Configuration level: Process categories.
- Process Element Level: Process Decomposition.
- Level of implementation. Description of process activities

The stages of the methodology must be executed sequentially, but the scope depends on the administrative maturity and logistical processes of

the organization, that is, it can be applied partially or totally according to the characteristics and state of the company's processes

5.1. Stage 1. Definition and Evaluation of the Scope and Basic Processes of the Vegetable Supply Chain

For this stage, the main actors in the supply chain (suppliers, producers, marketers and customers) are identified. Similarly, this chapter presents the key performance indicators (KPIs) based on the SCOR (Supply Chain Operations Reference Model), with the aim of aligning the operations of an agri-food chain of leafy vegetables, specifically lettuce, with the local market. This is achieved through coordination and collaboration between the different links involved in the procurement, production, delivery and returns of the product. Based on the literature analysis on the SCOR model and the diagnosis made in the previous chapter, the indicators for the management of the vegetable supply chain in the department of Boyacá are proposed

For the horticultural supply chain, the table of attributes prepared by Santana & Granillo (2012) and the attributes exposed by Tapia (2016) will be used as a reference. In this way, in addition to the five traditional attributes established by the SCOR model (reliability, flexibility, responsiveness, cost and assets), the authors add the attribute of quality, which encompasses both product and process quality. Also, instead of referring only to costs, they introduce the attribute of efficiency, which includes the measurement of costs, profits and inventory management. The following table details the definition, calculation formula, units and frequency of measurement of each KPI per SCOR attribute.



Figure 6: Performance Attributes and Metrics for Supply Chains. Source: Santana & Granillo (2012). Original Language: Spanish.

Table 3: SCOR Indicators and Attributes.

Source: Taken from (Tapia, 2017)

	INDICATOR	DEFINITION	CALCULATION	UNIT	MEASUREMENT FREQUENCY
EFFICIENCY	INVENTORY COST	Measures costs related to storing and maintaining inventory during the crop cycle	Average Inventory Value by Crop Cycle*25%	\$	Crop cycle
	PERCENTAGE OF TOTAL PRODUCT COST	It measures the % of the cost of production or cost of sale of the product per kg with respect to the average price per crop cycle	[Raw material and input costs + direct manufacturing costs (land preparation, planting, fertilization, weed control, pest and disease control, and harvesting) + indirect manufacturing costs] / [Quantity produced per crop cycle* Average selling price]	%	Crop cycle
	PROFIT MARGIN	Measure the percentage of profit for each monetary unit of sales you generate	[Average sales price in the crop cycle*Quantity produced - Total costs] / Sales generated by crop cycle	%	Crop cycle
FLEXIBILITY	CUSTOMER SATISFACTION	Measure the % of customers who rate "satisfied" by having the perfect order	N° customers rated "satisfied" by having the perfect order *100/ Total customers served	%	Crop cycle
	VOLUME FLEXIBILITY	Measure the number of days to achieve a 20% increase in production, sustainable	Days from the accepted order of the additional 20% to the preparation for dispatch	Days	Crop cycle
	SHIPPING FLEXIBILITY	Measure the number of days to achieve a 20% increase in order delivery, sustainable	Days from the accepted order of the additional 20% to delivery to the customer	Days	Crop cycle
	BACKORDER QUANTITY	Measures the level of backlogs due to insufficient inventory	No. of orders not fulfilled on time due to lack of inventory	Units	Each time it occurs and its consolidation is compared by crop cycle
RESPONSIVENESS	COMPLIANCE RATE	Measure delivery performance	Number of Orders Delivered*100/Number of Orders Received	%	Monthly, but consolidating by crop cycle
	LATE PRODUCTS	Measures the level of backlogs due to insufficient distribution and transportation	Number of orders not fulfilled on time due to insufficient distribution and transport	Units	Monthly, but consolidating by crop cycle
	LEAD TIME DE LA ORDEN (Order Lead Time)	Measure the customer's order cycle	Number of days elapsed from the time the customer's order is accepted until the delivery of the order	Days	Monthly, but consolidating by crop cycle
	LEAD TIME DE LA PRODUCCIÓN (Manufacturing Lead Time)	Measure the production time of a ton of lettuce	Number of days elapsed from the time the 1 Tn production order is generated until it is packed at the production sites	Days	Monthly, but consolidating by crop cycle
	BOARDING ERRORS	Measures product dispatch and transportation performance	No. of orders that were fulfilled on time and did not meet customer requirements attributable to distribution and transportation	Units	Each time it occurs and its consolidation is compared by crop cycle
QUALITY	PRODUCT QUALITY	Measures compliance with agri-food health and quality standards attributable to product and customer requirements	% of compliant product	%	Crop cycle
	PROCESS QUALITY	Measures compliance with agri-food health and quality standards applicable to vegetables	% Compliance with NTC 5400, BPM and Global Gap requirements (if the product is export)	%	Crop cycle
	REDUCTION OF THE PROCESS	Measures the level of unsold finished product to reach shelf life	Expired Product Quantity*100/Product Quantity	%	Crop cycle

RELIABILITY	PERFECT ORDER FULFILLMENT	Measures the % of perfect orders (delivered in compliance with quality, quantity, place, time, correct documentation and price agreed with the customer)	Quantity of Perfect Orders*100/ Number of Customer Orders Fulfilled	%	Monthly, but consolidating by crop cycle
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Subsequently, in the following figure, we can find four strategic objectives set by (Rodríguez, 2008)

which are adaptable to the vegetable supply chain in the department of Boyacá.

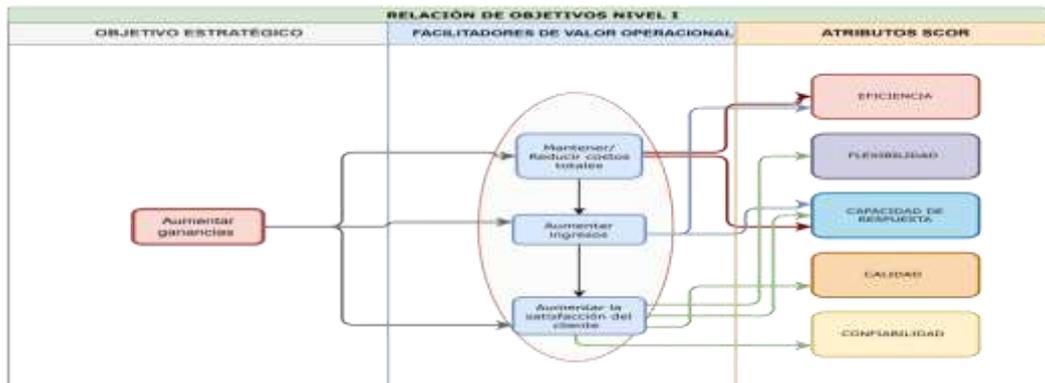


Figure 7: Relationship of Objectives. Original Language: Spanish. Source: Adapted from Rodríguez (2008)

5.2. Stage 2. Defining and Evaluating Process Categories

Once the performance specifications have been identified through objectives, goals and indicators, the connections or disconnections of fresh product flow in the vegetable chain are analyzed, in order to eliminate flows and facilities that do not generate value for producers and propose those that do.

In this sense, a geographical map is developed, which describes the existing process by identifying sources, manufacturing sites and distribution centers, using the process categories. The geographical map allows you to analyze and rethink the scope of the supply chain

The production system of the leafy vegetable production chain in Boyacá is made up of small producers who allocate 0.5 to 1 ha for cultivation. 52% of non-associated farmers sell vegetables on their farms and secondly in market places (42%). Only 3% sell it in the cities of Paipa, Sogamoso and Tunja in a smaller proportion. A similar behavior is presented by the associates, who sell 44% on their premises and 18% in the market places. When they sell on their farm, the transport is assumed by the intermediary or marketer and when they take it to the market, the transport is assumed by them. 43% of marketers consider that the production of leafy vegetables in Boyacá is sufficient in terms of quantity and quality.



Figure 8: Geographical Map of the Vegetable Supply Chain. Original Language: Spanish.

Figure 8 presents the geographical map of the current flow of fresh produce in the vegetable supply chain, the different links that participate from the supplier to the retail marketer are observed, the arrows represent the delivery routes of the product frequently, these nearby destinations are Duitama, Paipa, Sogamoso and Tunja in a smaller proportion, there is no return of the product, as well as the suppliers are agrochemical warehouses located mainly in Duitama.

Once the geographical map has been made, the

thread diagram is built, which, according to the model, graphically represents the current distribution of the main activities present in the supply chain and their relationship with the other links, to facilitate the realization of a new proposal on the configuration of the chain by observing these interactions.

Each link in the chain presents a specific way of categorizing its processes to achieve supply, production and distribution, as presented in the following diagram

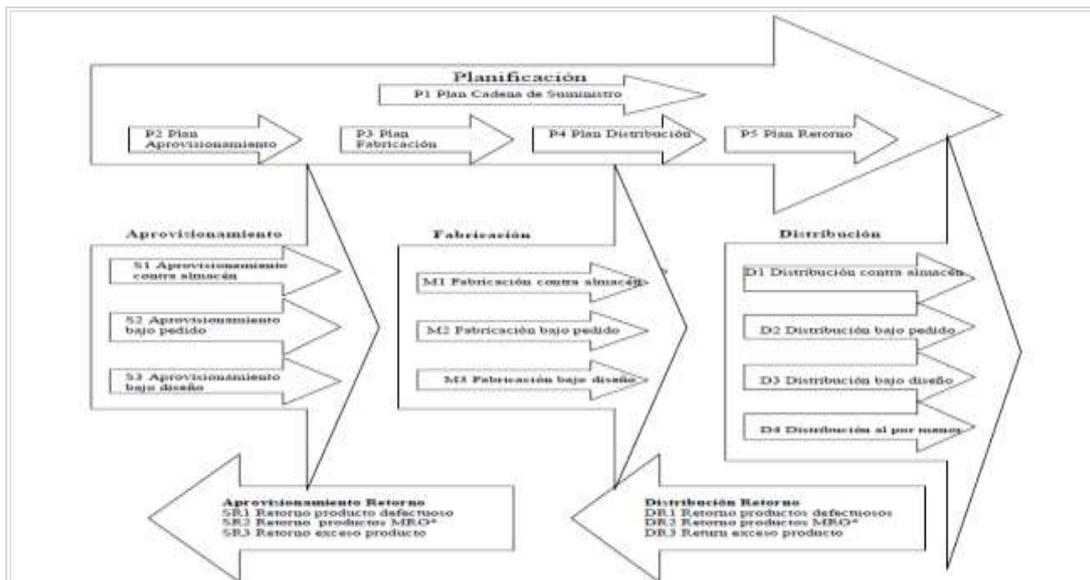


Figure 9: Process Categorization Diagram. Source: Adapted from SCC (2007) and Rodríguez (2008). Original Language: Spanish.

The following figure presents the activities currently carried out by each of the agents involved

in the process of the vegetable supply chain

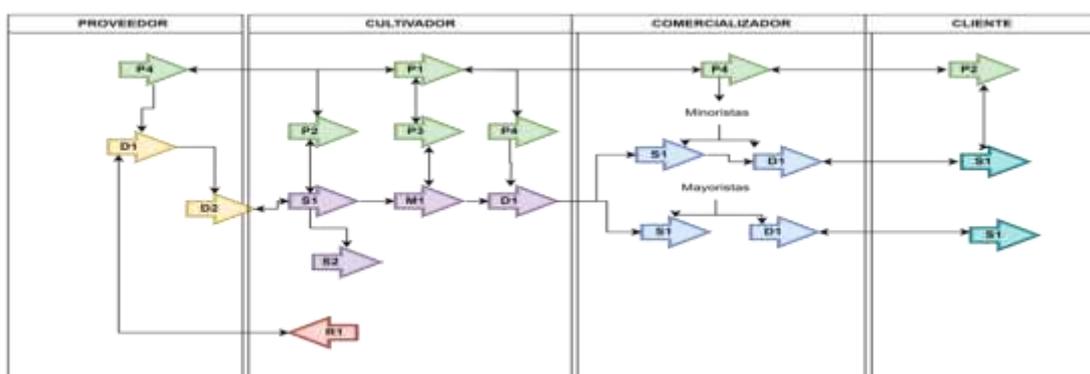


Figure 10: Horticultural Supply Chain Thread Diagram. Source: Authors Based on SCOR Model. Original Language: Spanish.

The SCOR Model has three categories under which the supply chain is deployed according to the production system it presents: Make-to-Stock, Make-to-order and Engineer-to-order

From the collection of information carried out, it is determined that the supply chain of leafy vegetables presents a production system based on the Make-to-stock policy (Manufacture against

warehouse) due to the fact that its customers do not emit

purchase orders, and it is the growers who specify the characteristics of the product to be produced and shipped following the parameters to ensure delivery and achieve the satisfaction of the customer's needs.

The P1 process is led by small and medium-sized independent producers, The Strategic Plan will be the central axis of the actions of the vegetable supply chain and will govern the P2, P3 and P4 plans that define the supply, production and delivery of fresh produce to customers.

The P2, P3 and P4 plans derive from the P1 process. Of course, P2 will be executed by the suppliers of seed, inputs and other specialized services in order to ensure supply to the production systems (crops). P3 will be materialized by producers. In the same way that P4 is carried out by the parties involved who perform delivery functions. Once the planning process is established, the elements of the supply, production, delivery and

returns processes must be integrated into each value stage of the chain.

After designing the flow of materials and information through the process categories, the next step is to describe the process elements. According to the SCOR model, processes are made up of enabling elements (process elements) that prepare, maintain, and manage information or relationships on which planning and execution are based. Defining process elements means describing in detail the activities that make up processes, inputs, and outputs.

5.3. Step 3. Defining Process Elements or Process Decomposition

In the third level, the different processes of the SC are represented in a more detailed way by breaking down the Categories into Process Elements. These are presented in a logical sequence (with rectangles and arrows) with inputs and outputs of information and materials.

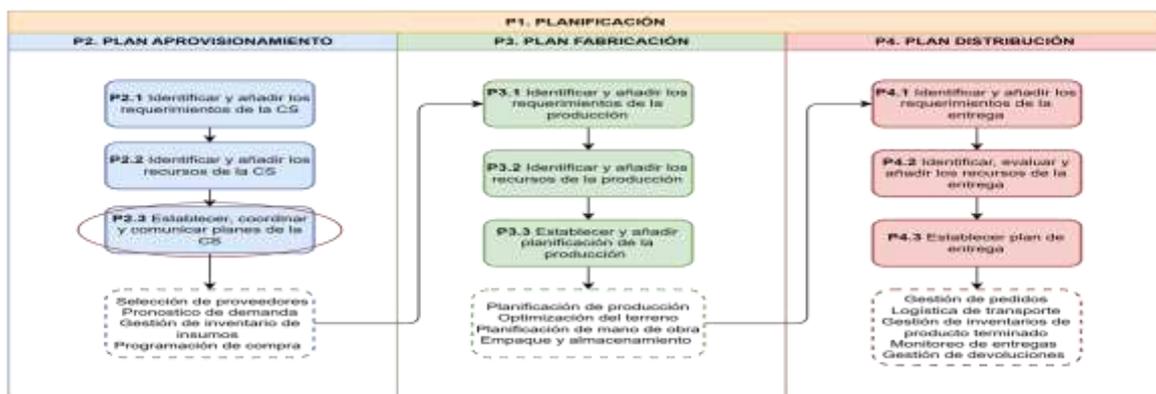


Figure 11: Identification of Planning Processes. Source: Authors (2024). Original Language: Spanish.

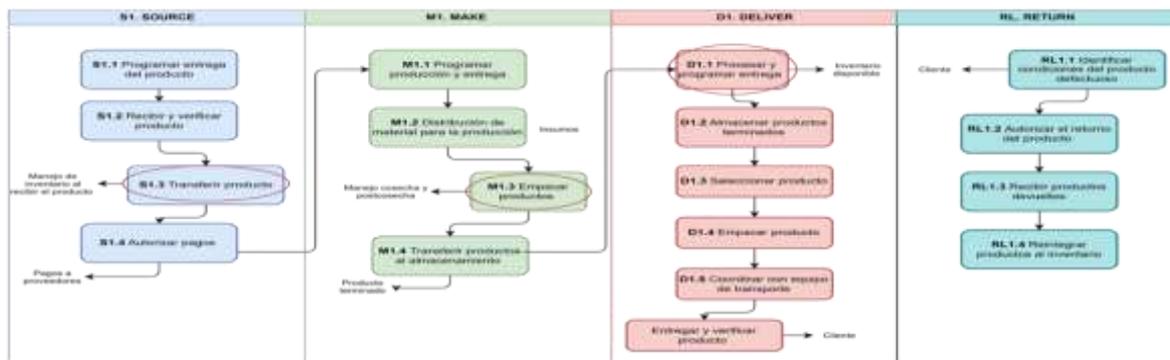


Figure 12: Level 3 Process Identification. Source: Authors (2024). Original Language: Spanish.

Based on the development of the above diagrams, the disconnections that are generated between agents and that affect the different processes of the chain are established. These critical variables are formed from

the information acquired in the sector and the current situation of the vegetable supply chain in the department of Boyacá.

Table 4: Disconnections in the CS of Vegetables in Duitama-Boyacá.

Source: Authors (2024)

DISCONNECTIONS	DEFINITION	CURRENT SITUATION	RECOMMENDATION
P2.3 Establish, coordinate and communicate CS plans	It refers to the lack of alignment, coordination, or flow of information between the different actors and stages within the supply chain. This disconnect can lead to communication problems, inconsistencies in planning, and a lack of visibility into shared goals and objectives.	Different actors (producers, suppliers, distributors) do not share information in real time, which leads to problems in the synchronization of activities such as planting, harvesting, and distribution.	Establish clear and effective communication channels between all actors in the supply chain. Ensure that all actors involved are aware of their roles within the planning and coordination process. Have a clear organizational chart and establish specific responsibilities for each task
S1.3 Transfer Product	It refers to the operational problems that arise during the receipt and handling of inputs or raw materials, such as incorrect inventories, poor product handling, lack of adequate tools to record transfers, and errors in documentation. This leads to delays, product damage, and lower supply chain efficiency.	The main activities in Boyacá include the inefficient management of inventories when receiving products, the lack of adequate tools to correctly record transfers. In addition, physical mishandling of the product, such as improper handling of inputs or improper storage, leads to damage to products that can affect their quality and availability for production.	Implement inventory management systems that automate the registration of products at the time of receipt, Train personnel in the proper handling of products to avoid physical damage during the unloading, storage or handling of inputs, especially those sensitive such as fertilizers or pesticides, Digitize documentation and use scanning systems or barcodes to reduce errors in data transfer and improve product tracking.
M1.3 Packing Products	It refers to problems that arise when handling freshly harvested vegetables and during their preparation for transport, such as damage to produce due to inefficient handling, and lack of adequate infrastructure for storage and preservation. This affects the quality of the product and its shelf life in the market.	Failures in harvest and post-harvest management are frequent due to a lack of adequate training in the delicate handling of vegetables during harvesting and packaging. This can cause physical damage, such as bruising or crushing, which reduces the quality and appearance of the product, causing shrinkage and economic losses	Train staff in proper harvesting and handling techniques, Implement appropriate technology and tools, Optimize times between harvest and storage, ensuring vegetables are handled quickly to reduce exposure time to non-ideal conditions
D1.1 Process and schedule delivery	refers to errors and deficiencies that occur when organizing product processing and planning delivery, such as inefficient scheduling, failures in coordination with carriers or customers, and problems in handling or packaging that affect the quality of the product during transport	inadequate planning that does not consider the perishable nature of the product. Often, the lack of coordination between the different actors in the chain, such as producers and distributors, generates delays in deliveries or accumulation of products in warehouses without optimal conditions	Proactively coordinate with customers and carriers, Monitor the handling and packaging process with trained personnel and quality control systems, Use track and trace technology such as barcode labels to track the status of products from processing to final delivery, improving chain visibility and allowing problems to be identified before they affect product quality in the market.

From the application of the SCOR model, it is possible to identify indicators and disconnections of the performance of the potato supply chain in the department of Cundinamarca. In the same way, it allows diagnosing the operation in terms of logistical aspects and describing the opportunities for improvement applicable to the system.

6. CONCLUSION

The application of the SCOR model in the vegetable supply chain in Duitama makes it possible to clearly identify the disconnections that affect the efficiency of the system, such as inefficient inventory

management, lack of adequate infrastructure, failures in the coordination of product delivery, and deficiencies in handling during harvest and post-harvest. By implementing solutions based on the best practices of the SCOR model, such as improving planning, integrating inventory and transportation management systems, and training personnel in proper handling, coordination and visibility throughout the chain are optimized. Benefits include increased operational efficiency, reduced losses from product damage or spoilage, increased customer satisfaction, and improved market competitiveness. The SCOR model provides a structured framework

for improving the performance and quality of the vegetable supply chain in the region.

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