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Characterization of the supply and value chains of Colombian cocoa

Rafael G. García-Cáceres [a], Alejandra Perdomo [b], Oscar Ortiz [c], Paulina Beltrán [d] & Karen López [e]

[a] *Escuela Colombiana de Ingeniería "Julio Garavito", Colombia, rafael.garcia@escuelaing.edu.co*
[b] *Department of Industrial Engineering, Pontificia Universidad Javeriana, Bogotá, Colombia perdomo-maria@javeriana.edu.co*
[c] *Industrial Engineering School, Universidad de Pamplona, Colombia,* oscarortiz@unipamplona.edu.co
[d] *Department of Industrial Engineering, Instituto Tecnológico de los Mochis, Sinaloa, Mexico*
[e] *Department of Industrial Engineering, Instituto Tecnológico de los Mochis, Sinaloa, Mexico*

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Abstract
This paper introduces the supply and value chains of the Colombian cocoa agribusiness. For such purpose, we have identified not only the agents, phases, stages and factors influencing the planting and harvesting of the product, but also the chocolate and confection production process, as well as the final consumption. Finally, the national production is described in the context provided by the international market.

Keywords: value chain, supply chain, cocoa agribusiness.

Caracterización de las cadenas de abastecimiento y valor del cacao en Colombia

Resumen
El presente artículo presenta la cadena de abastecimiento y de valor del sector agroindustrial cacaotero en Colombia. Para ello identifica los agentes, fases, eslabones y factores que influyen en la siembra y cosecha del grano, así como en el procesamiento del mismo hacia la producción de chocolates y confites, hasta llegar a las manos del consumidor final. Igualmente, se describe la producción nacional en el contexto del mercado mundial.

Palabras clave: cadena de valor, cadena de abastecimiento, agroindustria del cacao.

1. Introduction

As a basic contribution to the development of the cocoa sector, the current paper is aimed at characterizing the supply chain (SC) and value chain (VC) of this commodity. This type of characterization allows companies to identify the value added by a given unit or function, in order to satisfy customer needs. Framed in the search for competitiveness, value is the amount that the customer is willing to pay for a product or service supplied by a company. Based on previous developments of the concept [1], the definition of VC proposed in this work highlights the fact that SC dynamics integrates several companies, together with their activities and interrelations. The SC comprises all activities involved in the flow and transformation of goods, from raw materials to final consumers, including information flow [2, 3]. In this work, "Supply Chain Management is defined as the systematic, strategic and tactical coordination of traditional company interactive functions aimed at improving the individual performance of organizations within the chain as a whole" (ibid).

Colombia has been making sustained progress in agribusiness chains such as those of sugar and confections, coffee and instant products, milk and dairy products, meat and derivatives, oils and oleaginous materials, cereals, poultry and pig farming, among others; all of which has had a significant overall impact on exports.

Taken together, agriculture and agroforestry are ranked fifth in the Colombian economy, thus constituting one of its most important sectors, contributing 9% of the Gross Domestic Product (GDP), 21% of total exports in the sector, 19% of its employment at the national level and 66% in rural areas [4]. During the 2004 – 2009 period, this sector's GDP grew by 2.3% real annual average, reaching levels of 3.9% in 2006 and 2007. This favorable behavior is explained both by a rise in exports (from three to six thousand million US$ between 2004 and 2009) and an expansion of the internal

market [5]. In addition, the Cocoa Market Review 2012 foresees a 100,000 tonne deficit, the satisfaction of which constitutes a good business opportunity.

The importance of this supply chain in Colombia lies on its economic and social impact, since cocoa (Theobroma cacao L.) is grown by approximately 25,000 families, 90% of production being carried out by smallholders [4]. Yet, the export potential is just marginal, as far it is only accounted for by the few producers that are able to fulfill certification requirements such as those of Good Agricultural Practices (GAP) and Rainforest Alliance, among others. The 2012 - 2021 National Cocoa Plan [4] contemplates the modernization of 130 thousand hectares by a transition in which the old and less productive plants are substituted by the so called clones in order to guarantee the productivity of world quality cocoa. In general, the efforts of the farmers, the National Government and international agribusiness development entities have made cocoa a good alternative for illegal crop substitution.

Therefore, the current paper is structured as follows. First, a literature review is presented, followed by the identification of the agents and interactions involved in this chain and of the product flow and value adding processes at each step. Finally, upon discussing the data, we draw conclusions and highlight future challenges. The particular value of the current contribution lies on its contextualizing the gray literature on the topic, complemented by information obtained through interviews with different agents of the SC.

2. Background

A series of different standpoints, namely strategic [6] marketing [7], and supply chain management [8] have clearly recognized how the competitive development of organizations is strongly affected by the way they interact to exchange goods and services. In this sense, the supply chain structure has a two-fold effect, comprising both cost reduction [9, 10] and generation of added value [10].

The work of [11] focuses on the cost performance of the SC, taking into account final customer delivery times under a centralized administration and integrating the performance level of the SC into its quality management processes.

For its part, the contribution of [12] analyzes the modularization of the SC's processes, which allows increased flexibility. This is usually done when very similar products change their form after assembly, or when the chain incorporates outsourcing and postponement, which means that the products differentiate more and more as they approach the final consumer. This allows reducing uncertainty in the predictions about the operation of the chain, thus improving the overall performance of the company. These authors state that low input modularization levels are associated to vertically integrated supply chains; while the opposite case corresponds to SCs with elevated levels of decentralization through outsourcing. On the other hand, elevated output postponement indicates a make-to-order SC environment in which the products differentiate towards the last stages of the process; whereas low postponement levels identify a make-to-stock environment in which demand satisfaction is guaranteed through abundant inventories.

Table 1.
Summary of works dealing with Colombian agribusiness SCs

Reference	Methodology
[15]	Based on [16] and [17], agents, associated product flow and their interactions are defined.
[18]	Based on [19], this work characterizes relationships within the supply chain through its central logistic functions: Procurement – Production – Distribution, which are performed by its different actors.
[20], [21] and [22]	Based on methodology by [18], these works are featured by: 1. Identification of quantitative and qualitative variables affecting the SC. 2. Identification of decisions featuring SCs in general and specifically agribusiness SCs. 3. Description of the oil palm SC phases and of the cropping, harvest, transport, storage and stocking processes.
[23]	Methodology is based on defining SC phases according to the stages of the productive process, namely the primary, trading and industrial ones.
[24]	This method consists not only in identifying the network of socio-economic actors that interact to take cocoa intermediate industrial products to international markets, but also in determining the phases of this productive chain.

Source: The authors

In turn, [13] take an Activity-Based-Cost (ABC) approach to Supply Chain Management (SCM), taking into consideration monetary expense and value appreciation on the part of the client, and proposing production volume improvements according to costs, by identifying value adding activities and eliminating those that reduce or do not add any value to the process. Featuring a cause-effect relation between costs and demand, this approach is based on identifying those processes that promote a better performance in the organization, thus allowing a complete control of production and manufacturing costs and of the company's general expenses.

In the study conducted by [14], time is considered to be a SC performance measure that allows the identification of those activities which do not generate any value within the chain, together with their associated costs, finally integrated into the total costs of the system. This facilitates identifying the relation between time and cost within SC processes, as well as the adequate combination of both parameters when it comes to decision-making.

As to SC characterization [15,18, 20–22] it has been mainly oriented to agribusiness, namely biodiesel, oil palm upstream and middlestream phases and, specifically regarding cocoa, the performance of its different SCs from 2003 to 2012 (Table 1). In addition, we researched general market aspects and the position of Colombia in the international context.

3. Methodology

Inspired by Stone [16,17], we followed the methodology detailed in [15-22, 18], which is apparently the only one developed so far to characterize SCs. It has been frequently used in agribusiness SCs such as those of coffee and oil palm, which facilitates future comparisons between Colombian agribusiness SCs. Hence, the method in question comprises the following steps: 0. Providing the local and global contexts of the studied SC. 1. Determining and describing its links and

stages. 2. Describing the value added by the chain's agents and links. 3. Describing performance specificities. 4. Diagnose and conclusion about the SC. This methodology does not include data collection specific procedures, which is understandable if we take into account that SC characterization requires both primary and secondary information that, in turn, demands a broad and diverse series of procedures. In the current work we maximized the information available in the literature, which we complemented with primary information obtained through 29 interviews with key actors of the SC, namely personnel from FEDECACAO, cocoa growers, and agents from the chocolate industry, among others. The interviewed organizations are detailed under "acknowledgments".

3.1. Global and national markets

The International Cocoa Organization presents statistical data on the major cocoa importing and exporting countries along a yearly production cycle which, in Colombia, goes from October 1st to September 30 [25]. Cocoa is mainly cultivated in Western Africa, Central America, South America and Asia. Colombia is the fourth Latin American producer after Brazil, Ecuador and the Dominican Republic, as it can be seen in the following Table 2.

Currently, Colombian cocoa plantations cover an area of 147,000 ha with a domestic production of 36,118.10 tonnes harvested from common, hybrid and cloned trees. As it can be observed in Table 3, the department of Santander accounts for half the national production (mainly through common germplasm), while the rest is broadly distributed over the country.

Table 2.
Cocoa world production.

Cocoa bean production by countries (2005/2010)							
		Thousands of tons					2005-2010 Average
No.		2005/06	2006/07	2007/08	2008/09	2009/10	
1	Ivory coast	1,407.8	1,229.3	1,382.4	1,223.2	1,190	1,286.54
2	Ghana	740.5	614.5	729	662.4	645	678.28
3	Nigeria	210	220	230	250	260	234
4	Other countries	297	302.6	351.3	384.6	374	341.9
Total Africa:		2,655.3	2,366.4	2,692.7	2,520.2	2,469	2,540.72
1	Brazil	161.6	126.2	170.5	157	150	153.06
2	Ecuador	117.5	123.5	27.5	130	140	107.7
3	Dominican Republic	45.9	42.2	45.3	55	55	48.68
4	Colombia	36.8	29.6	27.4	35.5	40.5	33.96
5	Other countries	99.4	101.1	94.5	105.4	104.8	101.04
Total America:		461.2	422.6	365.2	482.9	490.3	444.44
1	Indonesia	585	545	485	490	525	526
2	New Guinea	51.1	49.3	51.5	51	57	51.98
3	Other countries	58.1	56	54.3	48.5	47	52.78
Total Asia and Oceania:		694.2	650.3	590.8	589.5	629	630.76
WORLDWIDE TOTAL:		3,810.7	3,439.3	3,648.7	3,592.6	3,588	3,615.92

Source: International Cocoa Organization, 2012, [25]

Table 3.
Cocoa production zones

Cocoa production zones	National production (%)	Production (tons)
Santander	47.8	17,272.1
Norte de Santander	3.7	1,338.57
Antioquia	5.6	2,029.68
Nariño	5	1,795.38
Arauca	11	3,967.42
Huila	8.3	3,009.01
Caldas	1.3	491.37
Cundinamarca	1.5	550.73
Valle	1.3	451.78
Tolima	5.7	2,059.32
Meta	1. 9	676.36
Cesar	2.4	881.91
Risaralda	0.7	237.94
Others	3.8	1,356.53

Source: Federación Nacional de Cacaoteros. FEDECACAO, 2007, [26]

Cocoa production in Colombia is generally featured by several decade old, hybrid material plantations with low planting densities (600 to 700 trees per hectare) [27] and low technological levels, all of which considerably hampers productivity and competitiveness (Ministry of Agriculture and Rural Development - MADR, 2010).

CORPOICA, FEDECACAO and the MADR [28] conducted a zoning study on land suitability for cocoa cropping, which estimated that in Colombia there are 2 million ha very suitable for cocoa production (2003). Of this area, 662,669 ha have no restrictions (they do not require any soil adjustment for cultivation) and 1.3 million present moderate restrictions.

Table 4.
Cocoa clones recommended for the different Colombian agro-ecological zones

RECOMMENDED CLONES BY AGRO-ECOLOGICAL ZONES					
Nº	Clones	TRF	DIV	AZ	MS
1	THS-565	X	X	X	X
2	ICS-1	X	X	X	X
3	ICS-39		X	X	X
4	ICS-40			X	X
5	ICS-60	X	X	X	X
6	ICS-95	X	X	X	X
7	IMC-67	X	X	X	X
8	MON-1	X			
9	TSA-644		X	X	
10	EET-8				X
11	EET-96		X		
12	EET-400		X		
13	CCN-51	X	X	X	X
14	CAP-34				X
15	UF-613				X
16	FLE-3				X
17	SCC-61				X
18	FSA-11	X			
19	FSA-12	X			
20	FAR-5	X			
21	FTA-1	X			
22	FTA-2	X			

MS: Mountains of Santander, TRF: Tropical Rain Forest, DIV: Dry Interandean Valley, AZ: Andean Zone or Low marginal coffee zone: Great Caldas, Southwestern Antioquia and Northern Tolima.

Source: Pinzón-Useche & Rojas-Ardila, 2007, [29]

A recent study on the cocoa SC [23] reports that the Colombian production is completely absorbed by the national chocolate industry, which pays lower prices than international markets. Nevertheless, this industry has had to import part of their raw material because the national production has been decreasing lately, mainly because of a) low grain local price, which leads the farmers to quit plantation improvement processes and simply assume a harvesting attitude; and b) the growing attack of the crop by pests and diseases, in turn associated with poorly trained personnel in charge of technology transfer, finally resulting in the hindrance of necessary productive increases.

Productivity drop is expressed through lesser yields in areas where the crop has not been traditionally grown and through the aging of plantations in the most suitable areas, thus determining the need to import the product in order to supply local market requirements. This situation takes place in spite of the availability of adequate clones (Table 4), and probably due to lack of adequate promotion strategies.

3.2. Characterization of the Colombian cocoa supply chain

Cocoa beans are the major raw material for the confectionery, chocolate, cosmetic and pharmaceutical industries. The characterization of this SC goes from agricultural supply providers to final consumers [28].

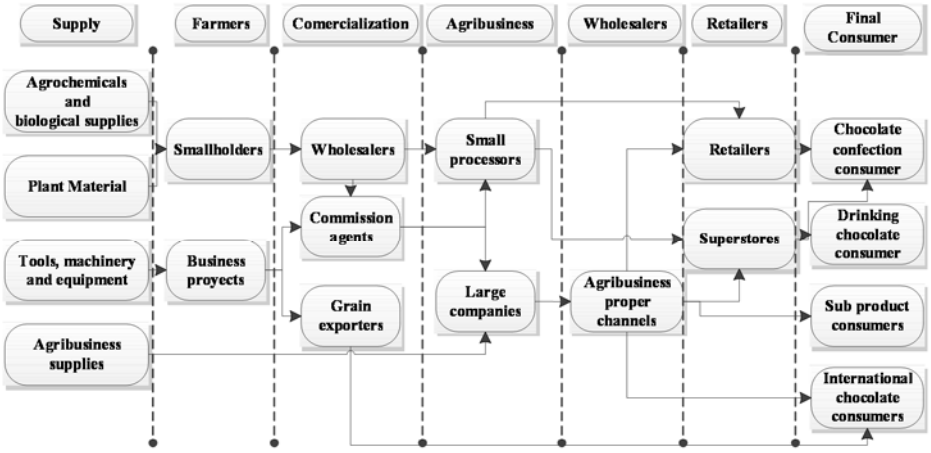

Figure 1. Characterization of the Colombian cocoa supply chain.
Source: Castellanos, et al, 2007, [28]

According to its industrial process, this SC is divided in three phases: Upstream, Middlestream and Downstream. Comprising plantation set up, maintenance and harvest, the Upstream phase groups all farmers, land owners and supply manufacturers. Middlestream consists in grain commercialization both at the national and international levels, from the moment it is bought by wholesalers to its selling to the factories. Finally, the Downstream phase covers the industrial processing of the beans to obtain liquors, pasta, cocoa butter, cocoa powder, and chocolates and confections containing chocolate, all of which is carried out by the cocoa processing and chocolate industries, as well as by those producing confections containing chocolate. Fig. 2 illustrates the cocoa SC from cropping to final consumption.

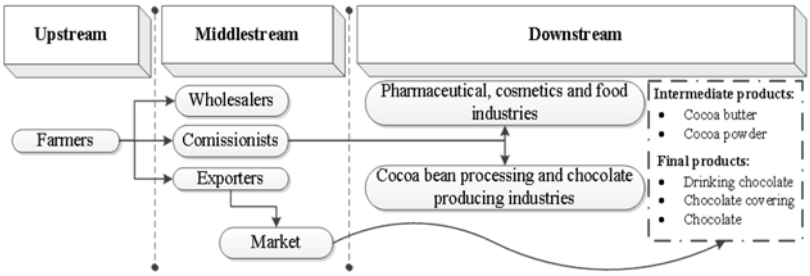

Figure 2. Links of the cocoa supply chain Source:
Source: Adapted from Espinal, et al, 2005, [23]

3.2.1. Upstream

After harvest, which is carried out with pruning scissors, the cocoa beans are extracted from the pod, which is commonly known as *mazorca* in Colombia. Next, the beans undergo a post-harvest process known as *beneficio*, after which they are ready to be commercialized for industrial transformation purposes that depend on market needs. The stages of the upstream phase are detailed in Table 5:

Table 5.
Upstream stages

STAGES	DESCRIPTION
Land selection:	Optimum crop growth soil conditions should be sought. A series of factors must be taken into consideration, namely climate (temperature should range between 22 and 30 °C; precipitation between 1,500 and 2,500 mm well distributed along the year so as to guarantee a minimum of 120 mm per month), altitude (up to 1,200 m. asl), and the following physical and chemical soil properties: deep loose conditions, good water drainage and retention, and adequate Potassium (K), Phosphorus (P), Nitrogen (N), Magnesium (Mg), Calcium (Ca), Sulphur (S), Zinc (Zn), Nickel (Ni), Cobalt (Co), Boron (Bo), Iron (Fe) and Molybdenum (Mo) levels[30].
Soil preparation:	This process starts by clearing up the plot from preexisting vegetation, which shall be replaced by the cocoa and accompanying shade trees. The residues of this vegetation should ideally be decomposed in situ, since they improve soil quality. Next, the cocoa plant sites (and then the shade tree ones) are preliminarily located by stabbing "witness" sticks in a triangular pattern to provide uniform spacing between trees. Usually planted first, the shade trees take approximately six months to grow, during which parallel nursery processes are conducted, namely cocoa seed sowing and plantlet protection against pests and diseases. Each seed is put into a plastic bag, planted at a three cm depth, and then covered with at least two cm of soil. Both the underneath and covering substrates must be watered and fertilized. There, the plantlets must remain under strict surveillance since the moment of seed sowing and until their transplant to the field [30]. While the shade trees are growing in the field, the holes for the cocoa plants must be dug (reaching dimensions of approximately 40 by 40 cm) [30] and amended with one pound of organic manure. The cocoa tree starts producing by the age of 24 months, during which the farmer obtains income from transitory crops such as cassava or plantain.
Weeding and pruning:	The rooted area around the growing cocoa trees has to be protected from weeds for a period of two years, after which the first pods are obtained. Both these and the shade trees must undergo formation pruning to prevent not only inadequate crown orientation or shaping, but also the covering of the crop by the shade trees, which results in delayed growth. Pruning must be done twice a year. The first one is the main pruning, while the second one is known as central pruning. Both processes start with the highest branches, which are followed by the lateral ones; then, this stages antecedes the culling of remnants.
Pest and disease control:	The most common insect plague is Monalonion dissimulatum, whose attack on the cocoa fruit is associated to excessive shading and is controlled manually or chemically. Witches' broom disease and frosty pod rot, caused by Moniliophthora perniciosa and Moniliophthora roreri, respectively, are the most common diseases attacking cocoa. For this reason, farmers ought to check the plantation and remove the damaged pods once a week. Twice a year, they clean the trees from the parts affected by the witches' broom disease. It is worth noting that these are lifelong controls.
Harvest:	The gathering process only takes into account ripe and healthy (i.e., disease free) fruits, which are identified through variety specific external color and appearance and must be cut from the tree with pruning scissors (never plucked down). The main flowering period takes place between June and July, while the second flowering, which is less abundant, corresponds to September and October. Fruit ripening takes from four to six months, depending on altitude and temperature. Hence, the first harvest takes place from October to November, while the second one comes between March and April. Fruit gathering can be done on a weekly basis, depending on available labor. As to disease control, a disinfectant is applied on the fruit pedicel after it has been cut. The harvesting tools are also disinfected when the process moves from one tree to another [30].
Pod opening:	The pods are initially separated in groups, leaving aside those that are not at the adequate ripening point, as well as the diseased ones, which are destroyed and buried in the field. The resulting fruit piles are placed in a plot in the field to render an easier splitting later on, which can be carried out manually or mechanically. The fruit shells are also piled up for them to undergo decomposition and turn into organic fertilizer, which is later applied to the plantation.
Shelling:	Once opened, the pods are scooped out in order to get the seeds and take them to the post-harvest process.

Source: The authors

Table 6 details the steps of the post-harvest process.

Table 6.
Post-harvest process steps

STAGES	DESCRIPTION
Fermentation:	This step confers the product its characteristic taste and aroma. The grains are stored in a ventilated place and covered with leaves for five days, which allows bacteria and yeasts to grow on the grain. When this process fails, ordinary cocoa is obtained. Well fermented cocoa is featured by a swollen, dark brown, easily breakable bean releasing a pleasant aroma and offering a bitter taste. During fermentation, the beans must be put in wooden boxes with lateral and bottom holes (at 10 to 15 centimeters above the ground) to allow the resulting liquids an easy drainage. These boxes should be kept in a sheltered and warm place protected from cold breeze. This warm, constant temperature is essential to guarantee a complete and uniform fermentation process [30].
Washing:	Although fermentation usually eliminates all fruit pulp, the beans must be washed to eliminate any possible remnant.
Drying:	During this step, the product loses any moisture excess. It can be carried out by exposing the beans to sunlight on structures such as drying greenhouses, "cocoa houses", or simply drying yards. Just as well, it can be done artificially in mechanical stoves or dryers which pass a warm air current through the cocoa mass.
Selection:	This process eliminates impurities such as soil particles and moldy or broken beans, among others. It can be done manually or by passing the grain through a series of sieves while blowing hot air to eliminate the residues.

Source: The authors

3.2.2. Middlestream

This phase includes the commercialization of the product from wholesalers to commission agents, who act as quality inspectors by checking the grain for its necessary aroma, color and moisture. The minimum trading cocoa qualifications have been established by Colombian Technical Norm 1252 (Norma Técnica Colombiana – NTC 1252).

Cocoa commercialization is carried out among associations of farmers, wholesalers, commission agents (who trade at the national level) and exporters. Exports depend on whether there is an internal market surplus and on attractive international prices. Seventy five percent of the national cocoa production goes to the cocoa processing and chocolate and confectionery industries; the remaining 25% is absorbed by small drinking chocolate manufacturers [31].

Wholesalers operate in local towns, where they have direct contact with farmers and frequently sell the product

they get to commission agents [23]. This product has low quality, since it is stored with other merchandise goods for prolonged periods. The price is fixed according to moisture and spoiled bean content. Wholesalers frequently omit applying NTC 1252 because the elevated national demand currently leads them to stock huge amounts of product at the expense of quality, thus paying the same for different product qualities. In face of this, many farmers dismiss complete fermentation in wooden boxes, instead resorting to grain fermentation in plastic fiber bags. The commercialization of this product, which is known as cacao en baba (pulpy cocoa), has a negative effect on grain quality.

Table 7.
Middlestream transformation stages.

Roasting	Threshing	Alkalinization	Grinding and pressing
The cocoa beans are roasted to enhance chocolate taste and aroma. During this process, cocoa loses moisture excess. It is worth noting that different bean types require specific time and temperature combinations.	This process, which is carried out by machines, removes the bean shell, leaving only the seeds.	It is intended to neutralize the acids that might be contained in the bean, in order to prevent any negative effect they may have on chocolate quality.	During this process, the beans are ground to obtain cocoa liquor, which is then pressed to separate cocoa butter from a solid mass known

Source: Prepared by the authors based on Proexport, 2012, [4].

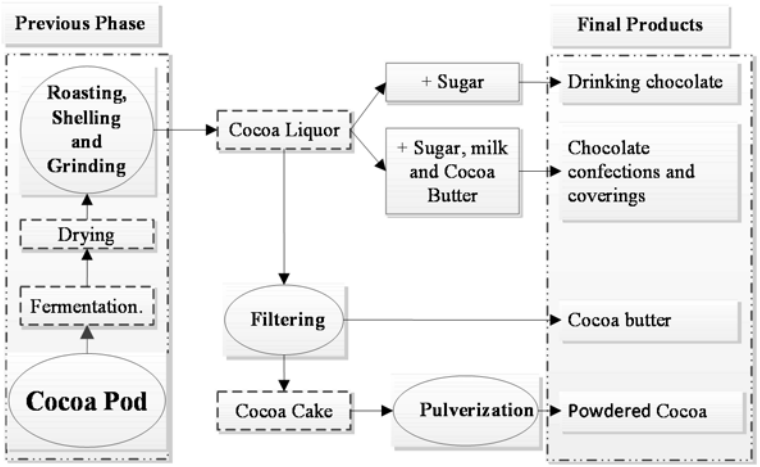

Figure 3: Manufacturing process of basic cocoa products
Source: The authors

Representing the cocoa processing companies, commission agents operate in small towns, where they purchase and stock huge amounts of beans. The price they pay depends on bean size, number of grains in 100 grams, fermentation degree, moisture, impurities, spoiled bean content and presence of plagues. They usually receive bonuses for their purchase work from the companies they represent. When the commission agent is too far from the factory, the beans are sold to wholesalers [23].

Both wholesalers and commission agents sell the purchased product to the processing industry. The national market is under the influence of two economic signals, namely importing and exporting bean prices [27].

Regulation: cocoa regulation is assumed by entities taking action in both internal and external markets. The objective pursued by these organisms is to promote product consumption and regulate its price, offer and demand.

Within the Middlestream phase, Table 7 presents the most value adding processes of the cocoa SC, namely the transformation ones, which are carried out by the trading and processing companies.

After these processes, the resulting products split the SC: cocoa butter goes to chocolate, ice-cream, cosmetic and pharmaceutical production; while cocoa cake is employed for powdered cocoa or drinking chocolate.

3.2.3. Downstream

This phase comprises the manufacturing and trading of the different final products obtained from the cocoa basic products resulting from the previous phase (Fig. 3).

In the International Standard Industrial Classification of all Economic Activities (ISIC), the two sub-sectors involved in this part of the SC are:

31191: manufacturing of chocolates and cocoa derivatives.

31192: manufacturing of chocolate confections.

The processing industry does the roasting, shelling and grinding of the grain [23]. An important portion of the resulting cocoa liquor goes to chocolate production. Drinking chocolate elaboration constitutes a lesser value adding process in which ground cocoa is mixed with sugar. For its part, the chocolate confectionery and covering industry mixes cocoa liquor with sugar, milk and cocoa butter. The cocoa liquor that is not employed in either of these processes is filtered to separate cocoa cake, which is solid, from cocoa butter, which is liquid. Cocoa cake is pulverized to obtain powdered cocoa, while cocoa butter is centrifuged, crystallized, molded and packed.

Table 8
Chocolate Types

Chocolate Types	Description
Black chocolate	Consists in cocoa cream with sugar, containing up to 70% cocoa
Milk chocolate	Corresponds to black chocolate mixed with condensed or powdered milk
White chocolate	A mix of milk, sugar and cocoa butter, owing its color to the lack of roasted cocoa grain
Liquid chocolate	In which cocoa butter has been replaced with vegetable oil to keep a liquid mix; it is usually employed for baking [32]. In the lines that follow, we will present a general perspective of the different stages of the chain.

Source: The authors

The great variety of existing chocolate products results from the various ingredients that are combined with four basic raw materials differentiated by their cocoa content (Table 8).

Both at the local and global levels, the stages of the cocoa SC differentiate through the activities, processes and market types they involve. At the national level, this chain comprises agricultural production, post-harvest processing, industrial transformation and end point commercialization of the manufactured goods. The agents of the VC are presented next.

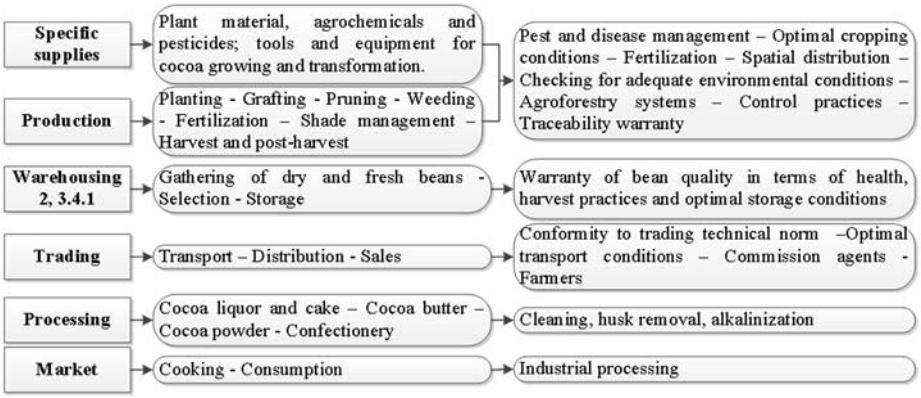

Figure 4. Characterization of the Colombian cocoa value chain.
Source: The authors

3.3. Description of the local supply chain

3.3.1. Non-regulatory entities

Table 9 shows the Non-regulatory entities of the local SC:

3.3.2. Regulatory and development entities

These are guild and government institutions intended to provide technical or financial support to cocoa growers in order to promote and regulate the issues related to this commodity. The Colombian organizations in this category are introduced in Table 10.

Table 9
Non-regulatory entities of the Colombian cocoa supply chain

Entities	Role
Suppliers:	They provide cocoa growers with agricultural supplies such as tools, fertilizers, financial, technological and transportation services, etc.
National growers:	Supplying the chain with the cocoa grain.
Warehouses:	Purchasing and stocking cocoa beans in order to sell them to the commission agents.
Commission agents:	Corresponding to cocoa grower cooperatives, guilds, and individual farmers, they are responsible for cocoa harvest purchase, distribution and selling.
National industry:	It responds for cocoa grain processing into several products like chocolate and cocoa powder and butter, among others.

Source: The authors

Table 10
Regulatory and development entities of the Colombian cocoa supply chain

Entities	Role
Fedecacao:	A national private law, non-profit guild association grouping those cocoa growers operating in the country who have manifested their intention to be part of it.
Ecocacao (cooperative association):	A non-profit business associative organization made up of farmer families and people related to this SC at different phases. Its main objective is the economic progress of its associates, for which purpose it delivers
Aprocasur:	Non-profit agricultural organization opened to all cocoa growers without any racial, religious or political
Local and regional associations:	These are regional not-for-profit private agricultural companies associated to the two first links of the chain. For example, Asocati, located the municipality of Tibú, Norte de Santander, gathers cocoa bean producers and traders.
Finagro:	The Fund for the Financial Support of the Agricultural Sector (Fondo para el Financiamiento del sector Agropecuario) was created through Law 1 of 1990 to respond to the call for an Agricultural Credit National System. It is an autonomous specialized institution in charge of managing credit resources which are scattered in several entities. Finagro is a complementary variant of the macro-economic policy of the Board of Directors of the Bank of the Republic (Banco de la República).
Corpoica:	A public, non-centralized entity with a private law regime. It is in charge of generating scientific knowledge and technological solutions not only through research, innovation and technology transfer, but also through researcher training activities benefiting the Colombian agricultural sector.

Source: The authors

3.4. Considerations about information and material flow

Regarding the flow of materials, Colombian logistics is considered to be one of the most important limitations for SC competitiveness due to its considerable dependence on road transportation, the latter being particularly sensitive to climate change which, in turn, produces a stronger impact in tropical countries. In addition, the Colombian public servants in charge of transport infrastructure and maintenance are constantly criticized.

The Colombian cocoa SC is oriented to the local market. In this respect, during upstream and middlestream, materials are transported along a variety of roads that go from the farms themselves through country paths to tertiary and secondary roads, most of which are unsurfaced, thus bringing about costly technical difficulties that affect both farmers and traders. During downstream, transport is done along primary roads, where productivity is significantly improved, although it is far from the standards of the competing countries in the region.

For its part, information flow might constitute a larger difficulty because lack of communication and redundant flows take a considerable tall on upstream (and especially downstream) product quality and profitability as a consequence of middlestream expansion, which is basically devoted to transport and has created an unnecessary commercial link with speculative hues. Upstream and downstream are the most value-adding stages within the chain. Yet, a more thorough communication between them is necessary to guarantee profit quality and equality, which are considerably precarious for the upstream stage, thus urgently calling for price improvement.

4. Analysis of results

In the lines that follow we synthesize the fieldwork employed to confirm information and identify the sector's problems. This activity was carried out in plantations of the departments of Santander and Norte de Santander, where we researched cocoa cropping and commercial details; and in FEDECACAO (Bogota), where we conducted meetings with guild leaders about specific features and competitiveness of this SC.

Cocoa cultivation in Colombia has comparative advantages arising from favorable natural conditions for production determined by climate, humidity and environmental conservation due to agroforestry. Development agencies of the cocoa sector can take advantage of these conditions to develop strategies for future grain exports. However, most lands are located on sloppy areas that prevent mechanized work and make cultivation excessively labor demanding, thus raising logistic costs and hindering productivity and profitability.

An important part of cocoa production is classified as fine flavor cocoa, which is mainly used for the production of high-quality chocolates. But unlike the commercial policy of other countries such as Ecuador, there has been no proper promotion of the brand "Colombia" in terms of developing a quality culture among cocoa farmers. Sustainability strategies are required to achieve this goal.

Cocoa growing in Colombia is featured by abandonment and recovery of the plantation by the farmer. The reason for this are prolonged periods of unfavorable prices resulting in no income for the farmer, who finds it difficult to invest in crop maintenance. As a result, plantations receive only minimum or simply no attention. This leads to cycles of low national production and, consequently, to the importation of this commodity by the processing industry.

The presence of wholesalers in towns and country settlements comes to be a Colombian specific feature, inasmuch as they operate as credit agents for the farmers, who finally pay their debts with coming production. Government strategies intended for value adding, in situ processing of the grain (i.e., local agribusiness activity) should be implemented and evaluated. Such a strategy would not only strengthen cooperation and association among cocoa growers in the municipalities that concentrate production, but also improve, by adding value, the quality of life of the farmers and their families, who, after all, constitute the main agents of the cocoa-chocolate chain in Colombia.

From an economic standpoint, upstream is the most vulnerable phase, but also the one that produces the strongest social impact. The government should ideally develop downstream strategies, labor unions and business initiatives, which would position the brand "Colombia" as an icon of quality culture and first-rate production. For such purpose, it is important to implement in situ transformation processes and local performance controls and evaluations so as to strengthen cooperation and partnership between farmers in cocoa producing municipalities. This is likely to bring about a series of advantages: a) balanced production across regions at the national level, thus opening the possibility of a common front negotiation before the chocolate industry; b) value added increase throughout the chain, thus enhancing the quality of raw materials and final products and optimizing final prices; c) improved life quality of the cocoa growing families, thus advancing this activity as an effective alternative against the proliferation of illegal crops; and d) product and process innovation, which confers international prestige to the middlestream and downstream phases.

According to the latest Cocoa World Conference [33], greater cooperation is necessary among all actors in the chain in order to foster sustainability. Those efforts that help growers perceive more benefits from the wealth generated by the chain are likely to improve their quality of life, especially when children are involved. As well, it is important to move towards a more innovative, qualified, clean and environmentally friendly chain also taking food security, biodiversity and conservation of existing ecosystems into account. In this sense, Nutresa, a food industry trust operating in the department of Antioquia and its surroundings, has been conducting an important effort through which they supply cocoa growers with cropping resources from a specific fund for such purpose, without claiming any property on the farmers' lands. This is not only a more egalitarian way of sharing risks and benefits with all chain links, but also a value adding strategy for stakeholders.

From the current results it can be said that both the state and the sector should: a) conduct further analyses to determine how much land should be dedicated to this crop, looking forward to reducing subsidies to a minimum; b) ensure training that generates a quality culture as supported by Good Agricultural Practices; and c) facilitate soft credit and affordable extension services, which become more important in face of the risk associated to this activity, especially under the adverse effects of climate change. In turn, the cocoa guild ought to implement not only an observatory of best practices in all phases of this supply chain in order to ensure the quality of the brand "Colombia", but also a series of policies promoting the consumption of cocoa in Colombia, the penetration of emerging markets and the consolidation of those already in operation.

5. Conclusions and research perspectives

The current study presents a clear perspective of the logistical processes involved in the cocoa SC and VC. It summarizes key local and global aspects of this chain, looking forward both to supporting future studies and aiding in the establishment of policies, strategies, tactics and operational possibilities for its different stages and processes. The methodology applied to characterize the chain provides an organized and detailed description of the stages through which cocoa and its derivatives are processed, thus identifying value added at each step.

Efforts should be made to render the chain as short as possible, in order to improve coordination, efficiency and flow traceability. Moreover, the current global cocoa agenda should be followed. In this respect, Colombia did not participate in the World Cocoa Conference in 2012, which followed the International Cocoa Agreement 2010.

The case of the cocoa growers of the department of Santander constitutes a reference standard in the sense that they are associated, which allows solving two important upstream aspects, namely quality assurance and price management. Unfortunately, this case seems to be an exception, since cocoa growers in the rest of the country certainly face a survival economy.

In summary, crop quality and crop productivity are the key aspects to generate the welfare of the chain, especially in the upstream phase. This involves investing in research for the development of new species and the renewal of crops.

Research perspectives relate to government and sector gray literature making use of the results of this work in search of policies and actions aimed at improving the chain. From the scientific point of view, it would be desirable to characterize other important agribusiness chains such as that of floriculture.

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- Los Samanes farm, locality of San Nicolás Bajo, municipality of Lebrija, Santander.
- Lomalinda farm, locality of Honduras Bajo, municipality of Rionegro, Santander.
- Santa Inés farm, locality of El Quinal Alto, municipality of El Carmen, Santander.
- Parcela 4 farm, locality of Manzanares, municipality of El Tarra, Norte de Santander.
- Sabanalarga farm, locality of La Perla, municipality of Tibú, Norte de Santander.
- El Porvenir farm, locality of La Miel, municipality of Sardinata, Norte de Santander.
- La Siberia farm, Locality of Nueva Frontera, municipality of Cúcuta, Norte de Sder.
- La Fortuna farm, locality of Caño Victoria, municipality of Tibú, Norte de Santander.
- Parcela 2 farm "Luz de la Verdad", locality of Caño Victoria, municipality of Tibú, Norte de Santander.
- Parcela 7 farm, locality of Venecia, municipality of Tibú, Norte de Santander.
- San Antonio farm, locality of La Fortuna, municipality of Sardinata, Norte de Santander.
- El Diamante farm, locality of Bellavista, municipality of Sardinata, Norte de Santander.
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- Las Marías farm, locality of Vijagual, municipality of Teorama, Norte de Santander.
- La Trinidad farm, locality of Nueva Victoria, municipality of Cúcuta, Norte de Sder.
- Sincelejo farm, locality of Venecia Guamalito, municipality of Tibú, Norte de Santander.
- Villahermosa farm, locality of Campoeyuca, municipality of Tibú, Norte de Santander.
- La Arenosa farm, locality of El Llano, municipality of El Tarra, Norte de Santander.
- El Limoncito farm, locality of Los Curos, municipality of Sardinata, Norte de Santander.

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- El Horizonte farm, locality of Bracitos, municipality of El Tarra, Norte de Santander.
- El Diviso farm, locality of Caño Victoria Norte, municipality of Tibú, Norte de Santander.

References

[1] Porter, M.E., Managing Value: From competitive advantage to corporate strategy. Harvard Business Review, 65 (3), pp. 43-60. 1987.

[2] Handfield, R.B and Nichols Jr., E.L., Introduction to supply chain management. Upper Saddle River, NJ: Prentice-Hall, 1999.

[3] Ballou, R.H., Logística Administración de la Cadena de Suministro (Vol. 5ta Edición), México, 2004.

[4] Proexport, Cacao Colombiano fino y de aroma, [Online], 2012, [date of reference August of 2012], Available at: http://www.inviertaencolombia.com.co/images/Perfil%20Cacao%202012.pdf

[5] Departamento Administrativo Nacional de Estadística (DANE), Resultados generales Base 2005., 2011.

[6] Williamson, O.E., Comparative economic organization: The analysis of discrete structural alternatives. Administrative Science Quarterly, 36 (2), pp. 269-296. 1991.

[7] Dwyer, F.R., Schurr, P. and Oh, S., Developing buyer-seller relationships, Journal of Marketing, 51 (2), pp. 11-27.1987.

[8] Grover, V. and Malhotra, M.K., Transaction cost framework in operations and supply Chain management research – Theory and measurement, Journal of Operations Management, 21 (4), pp. 457-473. 2003.

[9] Brennan, C.D., Integrating the healthcare supply chain, Healthcare Financial Management, 52 (1), pp. 31-34. 1998.

[10] McKone-Sweet, K., Hamilton, P. and Willis, S., The ailing healthcare supply Chain: A prescription for change, Journal of Supply Chain Management, 40 (1), pp. 4-17. 2005.

[11] Guiffrida, A. and Nagi, R., Cost characterizations of supply chain delivery performance, International Journal of Production Economics, 102, pp. 22-36. 2006.

[12] Ernst, R. and Kamrad, B., Evaluation of supply chain structures through modularization and postponement. European Journal of Operational Research, 124, pp. 495-510. 2000.

[13] Askarany, D., Yazdifar, H. and Askary, S., Supply chain management, activity-based costing and organizational factors, International Journal of Production Economics, 127, pp. 238-248. 2010.

[14] Whicker, L., Bernon, M., Templar, S. and Mena, C., Understanding the relationships between time and cost to improve supply chain performance, International Journal of Production Economics, 121, pp 641-650. 2009.

[15] García-Cáceres, R.G. and Olaya, E.S., Caracterización de las cadenas de valor y abastecimiento del sector Agroindustrial del Café, Cuadernos de Administración, 19 (31), pp. 197-217. 2007.

[16] Stone, R.B. and Wood, K.L., Development of a functional basis for design, Journal of Mechanical Design, 122 (1), pp. 61-69. 2000.

[17] Stone, R.B., Kurfman, M.A., Rajan, J.R. and Wood K.L., Functional modelling experimental studies, Design Engineering Technical Conferences, Pittsburgh (USA), 2001.

[18] García-Cáceres, R.G., Olaya, E.S., Torres, S., Díaz, H.B. and Castro, H.F., Creación de valor en la cadena de abastecimiento del sector salud en Colombia, Cuadernos de Administración, 22 (39), pp. 235-256. 2009.

[19] Carrillo, J., Gantiva, J.C., Nieto, E and Yáñez, E., Implementación de buenas prácticas operativas. Lecture presented at IX Reunión Técnica de Palma de Aceite. Colombia [Online], 2010. [date of reference June of 2012]. Avalilable at: http://www.cenipalma.org/sites/default/files/Implementaci%C3%B3n%20beunas%20pr%C3%A1cticas%20operativas%20Frupalma.pdf.

[20] García-Cáceres, R.G., Núñez, A.L., Ramírez, T.A. and Jaimes, S.A., Caracterización de la etapa Upstream de las cadenas de valor y de abastecimiento de palma de aceite en Colombia, DYNA, 80 (179), pp. 79-89. 2013.

[21] García-Cáceres, R.G., Núñez, A.L., Ramírez, T.A. and Ortiz, O.O., Caracterización de la etapa Middlestream de las cadenas de valor y de abastecimiento de palma de aceite en Colombia, Reporte de investigación 02. Centro de investigaciones en Manufactura y Servicios CIMSER, 2012.

[22] García-Cáceres, R.G. and Jaimes, S.A., Caracterización de las cadenas de valor y de abastecimiento del biodiesel en Colombia. Reporte de investigación 03, Centro de investigaciones en Manufactura y Servicios CIMSER 2012.

[23] Espinal, C., Martínez, H. and Ortiz, L., La cadena de cacao en Colombia: Una mirada global de su estructura y dinámica 1991-2005. Documento de trabajo No.92. Ministerio de Agricultura y Desarrollo Rural. Observatorio de Agrocadenas Colombia, [Online] 2005. [date of reference August of 2012]. Available at: http://www.agronet.gov.co/www/docs_agronet/2005112145659_caracterizacion_cacao.pdf

[24] Alvarado, E., Línea base para la Caracterización de la cadena productiva de cacao y diagnóstico de la cooperación entre actores. Informe de consultoría para Aprocacaho-Catie. Project Cacao Centroamérica. Cortes, Honduras. [Online] 2006. [date of reference March 25th of 2012]. Available at: http://www.catie.ac.cr/BancoMedios/Documentos%20PDF/informe%20final%20cadena%20productiva%20honduras.pdf

[25] International Cocoa Organization (ICCO), Growing Cocoa - Origins of Cocoa and its spread around the world. [Online] 2012. [date of reference July of 2012]. Available at: http://www.icco.org/about-cocoa/growing-cocoa.html

[26] Federación Nacional de Cacaoteros. FEDECACAO, Producción Nacional de cacao en grano por municipio 2008-2009. [Online] 2007. [date of reference July of 2012]. Available at: http://www.fedecacao.com.co/cw/index.php?secinfo=15

[27] Ministry of Agriculture and Rural Development. Fondo de estabilización de precios del cacao. Federación Nacional de Cacaoteros (FEDECACAO). [Online] 2010. [date of reference September of 2012] Available at: http://es.scribd.com/doc/210143086/Fedecacao-2007-Guia-tecnica-para-el-cultivo-del-cacao-2%C2%AA-ed

[28] Castellanos, O.F., Torres, L.M, Fonseca, S.L., Montañez, V.M. and Sánchez, A. Agenda Prospectiva de investigación y desarrollo tecnológico para la cadena productiva de cacao-chocolate en Colombia In: Ministerio de Agricultura y Desarrollo Rural. Universidad Nacional de Colombia. Grupo de investigación y desarrollo en gestión, productividad y competitividad BioGestión. [Online] 2007. [date of reference July of 2012]. Available at: http://www.corpoica.org.co/SitioWeb/Archivos/Publicaciones/PublicableFinalCacao.pdf

[29] Pinzón-Useche, J.M. and Rojas-Ardila, J., Guía técnica para el cultivo del cacao. 2nd edition, FEDECACAO, 2007.

[30] Ministerio de Agricultura y Federación Nacional de Cacaoteros (Fondo Nacional del Cacao - FEDECACAO), Guía Ambiental para el cultivo del cacao. [Online] 2013. [date of reference June of 2013]. Available at: http://www.fedecacao.com.co/site/images/recourses/pub_doctecnicos/fedecacao-pub-doc_05B.pdf

[31] Gil-Vallejo, L.F., Guía de campo para la identificación y manejo de enfermedades y plagas en el cultivo de mango. Corporación Colombiana de Investigación agropecuaria. CORPOICA. [Online]

2013. [date of reference July of 2012]. Available at: http://www.corpoica.org.co/SitioWeb/Corpoica/Corpoica.asp
[32] Olvieras. J.M., La elaboración del chocolate, una técnica dulce y ecológica, Technical Industrial [Online] 268, March-April, 2007. [date of reference October of 2012]. Available at: http://www.tecnicaindustrial.es/tiadmin/numeros/28/37/a37.pdf
[33] Cocoa World Conference, Organized by the International Cocoa Organization, Abidjan, Republic of Ivory Coast, 2012.

R.G. García-Cáceres, received the Bs Eng. Industrial Engineering in 1998 from the Universidad Pedagógica y Tecnológica de Colombia (UPTC), Colombia; MSc. in Industrial Eng. in 1999 from the Universidad de los Andes, Colombia; PhD. in 2007 from the Universidad de los Andes, Colombia. Since 2010 is Associate Professor at Escuela Colombiana de Ingeniería "Julio Garavito", Colombia; director of the Centre for Research on Optimization and Logistics (CIOL) and the Research Center on Manufacture & Services (CIMSER). Main research interests correspond to operations research, decision making support systems and logistics.

A. Perdomo, received the Bs Eng. Industrial Engineering in 2013, from the Pontificia Universidad Javeriana, Colombia.

O. Ortiz, received the Bs Eng. Industrial Engineering, from the Universidad Libre de Colombia, Cucuta campus, Colombia; the MSc of Engineering Management in 2002 from the Queensland University of Technology, Australia; the MSc in Environmental Engineering in 2007, from the Universidad Rovira i Virgili, Spain; the PhD in Chemical Environmental and Process Engineering in 2009 from the Universidad Rovira i Virgili, Spain. Is Associate Professor at Universidad de Pamplona, Colombia. Main research interests associated to Life cycle analysis and sustainability.

P. Beltrán, received the Bs Eng. Industrial Engineering in 2013, from the Instituto Tecnológico de los Mochism México.

K. López. received the Bs Eng. Industrial Engineering in 2013, from the Instituto Tecnológico de los Mochism México.