EVALUATION OF THE AGRIBUSINESS CHAIN OF PANELA PROCESS USING HIERARCHICAL ANALYSIS: CASE STUDY COLOMBIAN ANDEAN REGION

Gabriela Leguizamon [(a)], Nelson V Yepes Gonzalez [(b)], Maria V Cifuentes [(c)]

[(a)] Physical Engineer, Master in Industrial Engineering; professor of Industrial Engineering faculty of the Antonio Nariño University

[(b)] Industrial Engineer, Master in Design and Project Management, professor of Industrial Engineering faculty of the Antonio Nariño University

[(c)] Matematico, Magíster in Sciences-Mathematics, student of Industrial Engineering in Antonio Nariño University, professor in mathematics in the National University of Colombia

[(a)]gleguizamon@uan.edu.co, [(b)]neyepes@uan.edu.co, [(c)] macifuentes@uan.edu.co

ABSTRACT

The diferent sectors, which boost the developing of Colombian Economic, are searching to become competitive in globalized environment. The Panela sector is the second Colombian rural agro-industry, under Coffe Production, as well as a developing support for differents regions of the Country and its productive chain is characterized by its dynamism and by its various public and private actors. Achieving sector eficience and productivity involves to work with many variables and decision criteria that are submitted to uncertainly conditions. Analytic hierarchy process (AHP) is a technique for organizing and analyzing complex decisions, and it is used in order to figure out the main influential factors in competitiveness, which have to be in the focus of Panela agro-industry.

Keywords: Productive Chain, Panela (jaggery, gur), Analytic hierarchy process (AHP).

1. INTRODUCTION

Panela production is one of the most important farming activities for Colombian economy due to different reasons such as: its significative participation in Gross Domestic Product (GDP), which is 7,3% farming; another reasons are the big amount of land dedicated to cane cultivation (249.384 hectares), rural employment generation (about 25 million annual work part-time jobs and 120.000 permanent jobs – Osorio, 2004) and finally, because Panela production joins, approximately, 350.000 people that represents 12% of Colombian economically active rural population. To study factors getting involved in Panela agro-industry competitivity, is related to physical, economic and politic conditions, or even to production factors evolution (Zimmermann and Zeddies 2002).

There are three variables that guide analysis in competitive environment: in the first place, we have the normative environment of Panela sector, which allows to contrast among current applied politics with the purpose of encouraging Panela production; secondly, is organizational environment, whose function is to identify organization and integration mechanism in order to promove competitivity in the specific sector; and last but not least, the third variable is productive environment, which is crucial to determine economical and social relevance and competitivity level in the product production and marketing (Castellanos, et al 2010). The objective of this three-variable analysis is to provide elements that facilitate the study of the organizational and institutional environment where productive activities have place.

Eficience and productivity search in enterprises is promoting the implementation of supporting metodologies for decision making in industrial sectors and in Colombian regions, so that competitivity is boosted particularly, in scenarios with multiple variables or multiple selection criteria (Berumen and Llamazares 2007).

These precepts are the starting point of the studio, as well as identify the specific weight of each determinant sector factor; this situation implies the use of current methodologies to make decisions, such as multicriteria evaluation (MCE). This study has as objective to identify the primordial alternatives for enhancing sector competitivity through Analytic hierarchy process (AHP).

Analytic hierarchy process (AHP) is a multicriteria metodology for complex decisions making, and it was developed by Thomas L. Saaty (1977, 1980). AHP has been applied succesfully since its creation in many studies, as an useful and assistive instrument for strategic problem-solving. For instance:

1. In the evaluation of risk factors for farming (Toledo, Engler and Ahumada 2011).
2. In performance evaluation for archive management (Gomes 2012).
3. In increasing competitivity environments (Berumen 2007).
4. In the Delphi method used to measure projects complexity (Ludovic 2010).
5. In the management of intellectual capital assets, in particular, a TIC services industry aplication (Calabrese, Acosta and Menichini 2013).

6. In to determine intangible priority factors for technology transfer adoption (Lee, Kim, Min and Joo 2011)
7. In Corea competitivity as a developer of hydrogen-based energy technology (Seong, Yong Jand Jong 2007).
8. In the use of TRIZ and AHP to develop innovative design for automation of manufacture systems (Li 2009).
9. In multi-dimensional evaluation of oraganizational performance: integration of BSC and AHP (Veronese, Carneiro, Ferreira da Silva and Kimura 2012).

The AHP that is based on pairwise comparison, uses a hierarchical scale model for decision problem, which has a general objective, a group of alternatives and a group of useful criteria to link the identified alternatives with the goal (Vidal 2011).

For the developing of the current study, some referents were considered such as the prospective agenda of searching and technological development for productive Panela chain and its agro-industry in Colombia, the results of the annual panela poll 2012 (by Federación Nacional de Panaleros (Fedepanela)) and interviews with actors of the Chain: farming producers, processors and marketers. The studied population was one of the largest producers of Panela: Hoya del Río Suárez, a territory composed of 13 municipalities localized between Santander and Boyaca departments (Table 1).

Table 1: Hoya del Rio Suarez, Colombia –Incoder, 2012

Departamento	Municipio	Área (ha)	% Área
Boyaca	Chitaraque	14738	7,6
Boyaca	Moniquira	21075	10,9
Boyaca	San Jose de Pare	7348	3,8
Boyaca	Santana	6962	3,6
Boyaca	Togul	10807	5,6
Santander	Barbosa	4505	2,3
Santander	Chipata	9537	4,9
Santander	Guavata	7817	4,0
Santander	Guepsa	2769	1,4
Santander	Puente Nacional	25589	13,2
Santander	San Benito	5411	2,8
Santander	Suaita	27983	14,5
Santander	Velez	48655	25,2
Total general		193198	100,0

The profile physiographic of the Rural Development of Hoya del Rio Suaez consists of a structural denudative type Mountainous landscape, which covers a surface of 134 551 hectares, representing almost 70% of the area. The largest part of the lands of ADR, (82 404 hectares), corresponds to Class VI (they allow the development of certain annual crops under semi-intensive schemes) that are mainly concentrated in the municipalities of Moniquira, Santana, San José de Pare, Chitaraque and Toguí (Romero 2012). (Figure 1)

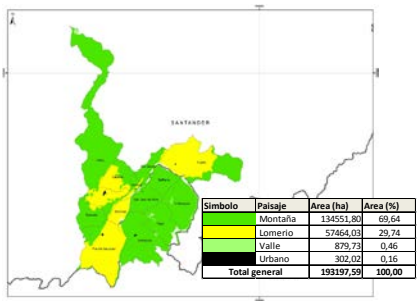


Figure 1. Physiography Hoya del Rio, Incoder 2012

In Hoya del Río Suárez, Bocadillo and Panela production represents the main economical activity in the región. That activity involves 13 municipalities that together make the sustainability font to many families for more than three generations. Currently, there are 128 Bocadillo Factories and more than 1276 sugar mills (for Panela production) that add value to the 14.000 Guayaba hectares and to the 46.000 Cane hectares, respectively (Gómez 2011) .

The AHP model processing for Panela productive chain, is made through hierarchical model structuring, which identifies the goal to accomplish, criteria, sub-criteria and alternatives; lately, it priorizes hierarchical process elements and makes the binary comparisons among the elements using weights assignment, in that way the AHP sets the ranking of alternatives according to the weights assigned. Finally, a summary of results is elaborated with a sensibility analysis to determine the inconsistency index of the established model. To develop the mentioned process, the used tool is Expert Choice 8.0 (EC), which is a program useful to eliminate conjectures in decisions making, is based on AHP as well as uses a hierarchy to organize thought and intuition in a logical way. This hierarchical approach allows that the user analyzes all options in order to get an effective decision-making. The EC program may compare tangible with the intangible factors, for instance, “Project costs” opposite to “Project viability”, besides tolerating uncertainty and allowing review so as to individuals and groups are able to address the problem with all their concerns (Expert Choice 1993).

The paper is organized following the next scheme: First section contains AHP model justification of applying it to Panela sector competitivity; the second one has the AHP model application since the conformation of hierarchical structure until sensibility analyisis and numeric results are discussed.

Finally, conclusions are submmitted and future research is considered.

2. JUSTIFICATION

With the opening of international markets, industry sectors and regions are required to be competitive and innovative. Competitiveness refers to enterprises capacity to compete and, base don its succes, to earn market share, to increse its benefits and to grow. (Berumen 2007). But such a competitiveness is not achieved without **economic sustainability** that refers to tha sector ability to generate income based on comparative and competitive advantages of products;

social sustainability, which refers to that income generated by Panela sector might be enough to guarantee an adecquate life style for producers; and finally, **environmental sustainability** means that agricultural activity should preserve environment (Leibovich 2009).

Using analysis hierarchical process (AHP) aims to help establish priorities for decision making. Besides, ranking strategic issues, assignating budgets for urgent situations, building farsightedness and managing complex projects are essential for Panela guild capabilities developing. The AHP allows to guide the key factors priorization of competitiveness, and in that way to accomplish economic, social and environmental sustainability.

One important advantage of the AHP use is its ease. It can work with processes uncer uncertainty and with subjective information, because the AHP gives priority to the criteria that are based on experience and on intuition in a logical way. Perhaps, the AHP most important advantage is in the developing of the hierarchy itself, which compels decider to considerate consciously and to justify criteria pertinancy (Nydick 1992). In conclussion, the AHP, by Thomas Saaty, is a powerful tool employed in decisión making when multiple purposes affects decision.

5. The AHP and ANP application

5.1. Hierarchical Structure

Method has four stages: a problema presentation, a criteria and alternatives evaluation through estimating the inconsistency index of the model, after an alternatives evaluation is done and lately, alternatives are hierarchized. Hierarchy is not only structurally efficient because it allows to represent a system, but also functionally, as soon as it is useful to control and transmit information via the System (Eraslan and Dağdeviren 2010).

Firstlty, it is identified the goal wanted by the decision making hierarchical model, “Prioritize the best decision alternatives for strengthening the competitiveness of Panela sector”.

Secondly, the decision criteria and subcriteria that will allow to get the competitiviness of Panela agro-industry chain are identified and by using GO-CART method (Hernandez 2006) it was allowed to plan the serarch of secondary external data from previous studies obtained by experts, public and prívate entities, studies such as: agro-industrial value chains (Bisang, Anlló, Campi and Albornoz 2009); research tendencies, technologic developing and marketing in Panela agribusiness (Castellanos, Torres and Flórez 2010); business clusters zoning and organization for Panela cane (Abaunza 2012); the microeconomics of competition of Cane cluster in Colombia (Dueñas, Morales, Nanning, Noriega and Ortiz 2007); the basis of the agreement of Panela agro-industry chain development (IICA 2001); Panela producer profitability affectation because of the implementation of environmental and health standards (Llano 2012); sugar cane competitiveness: a Kenana Sugar Company study, Sudan (Emam 2010); Becoming enterprise of Panela sector, as a developing of productivity and competitiveness factor (Perez 2011); agroindustrial Panela chain in Colombia: A global insight of its structure and dynamics 1991-2005 (Martinez 2005).

Undoubtedly, it is evident that many issues affect competitiveness, so it is necessary to consider a wide amount of variables and indicators. The Institute for Management Development - IMD uses about 331 criteria organized in four main classes: economic performance, governmental eficience, enterprises eficience and infraestructure (Lopez 2009). For our purposes, decisional analysis allows teh identification of six fundamental criteria: Economic, Productive, Logisctic, Environmental, Social and Marketing, where three actors are participacting: (I) Producers (Cane Farmers / wholesalers and retailers); (II) Processsors (Big, medium and small mills); (III) Marketers (Big, medium and small marketers). Their performances depend on each one interests.

The competitiviness subcriteria in economic, marketing, productive, logistical, environmental and social aspect, for each actor, are:

1. Producers subcriteria. In economic issue: Financing to develop agricultural activities, developing of technology transference to implement new productive processes in Panela Cane production, productive planification as an important element in Panela chain to avoid product oversupply. In productive issue: Enhancing skilled labor capacity to agricultural activities, decrease in harvesting costs and crop renovation. In Marketing: expansion of marketing channels and improving market prices. In Logistical issue: enhancing distribution channels and improving transport systems since cultivation as far as processing zone or mill. In environmental issue: hygienic and health conditions according to regulations and to a sustaintable, organic and not environmental-alterative agricultural developing. In social issue: developing of skilled labor, trade union and an effective fraudulent practices control (the dishonest use of sugar cane for Panela production, when Sugar price drops).
2. Processors Cane (Mills): In economic issue Financing to develop agricultural activities, developing of technology transference and productivity increase; In Marketing: Expansion in productos diversification, decrease in production costs and enhancement in marketing margins, diversification of productive activities; in producrive issue: Mills

modernization, productivity increase and regulation fulfillment; in Logistic issue: presentation of the product in units, packaging standardization and processes centralization; in Ambiental one: environmental regulation fulfillment and organic Panela production. In social one: to fulfill with the same requirements that producers.

3. Competitiviness subcriteria defined for marketers are: in Economic issue: Prices control and expansion of exportation offer; in Marketing one: Product Differentiation, packaging improvement, Offer and Marketing channels extension, Marketing Information Systems for Panela productive chain; in Productive issue: Offer growth, packaging improvement and marketing centralization; in Logistic issue: Logistic information systems improvement, product availability in individual units and distribuition centralized In. Environmental one: Regultion Fulfillment and environmentally sustainable products marketing.

Once we defined subcriteria, let's determinate strategic developing alternatives that have been made by competitiveness agenda and technologic development of the Chainy:

1. Development of clean technologies for susteinable and competitive sector growing (DCT)
2. Quality presentations and Panela uses improvement (QPP)..
3. Diversification alternatives developing to take advantage of Panela cane (DAD)
4. Logistical and comercial integration integration of Market (LCI)
5. Marketing Information systems development (MIS).

In that way, hierarchical net model is structured having in count interactions of those elements that affect Panela supply chain.

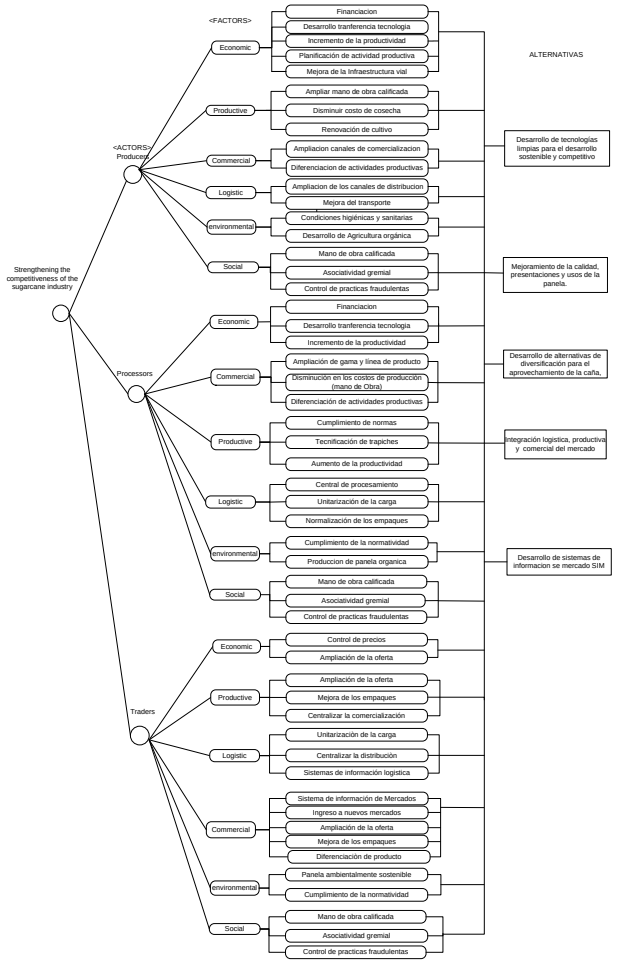


Figure 1: Red hierarchical process

In table 2, it is represneted decision subcriteria and its importance in productive chain structure:

Table 2. Subcriteria or essential factors and its importance.

Essential Factors	Relevance
Financial	Profitability and economic sustainability affectation of the chain, to log in credits with productive purposes. An efficient credit and to al lis primordial in sector competitiveness recuperation perspective.
Reduction in production costs	Inputs supply affects in production cost as well as in the need of promoving its appropiate and rational use , so that it is an important part of structural elements to arrange among Panela producers.
Product adulteration	Pressure by sugar melter people "Derretideros" over Panela supply in domestic market.
Productive activities differentiation	Diversification in product (panela) use, in another sectors such as cosmetics, enegy drinks, powdered panela or bioethanol.
Product Variability	Panela producers posibility of having another alternatives to process their cane.

Essential Factors	Relevance
Packaging improvement	To improve primary and secondary packaging systems in final product until it arrives to consumer.
Qualified labor	Shortage of skilled labor for harvesting and post-harvesting activities.
Marketing, transporting and distribution channels extension	Opening of marketing channels, logistical corridors and distribution systems that minimize product brokering.
Logistical integration	To integrate chain actors in market, production and logistics aspects.
Road infraestructure	Improving primary, secondary and terciary road fence for product transporting. Development of logidtical corridors.
Centralizing distribution	The development of comercialization and distribution centers with efficient transporting, storage and product-trazability operations systems.
Price control	Reference price definition and control based on econometric studies.
Organic Panela production	The development and promotion of organic powdered panela production to access international markets (Korea)
Crop renovation	The decision to renew crops requires important aspects that must be presented: 1. To Analyze crops age for strains renew if they are very old, because it causes crop production goes down in each new sowing. 2. To make the decision to renew crops taking into account the resistance of certain varieties in the country to diseases such as Coal, Ustilago scitaminea and Roya, Puccinia melanocephal.
Marketing Information Systems	Marketing Information systems that allow the Access to all the chain actors, like “a set, whose components are interrelated that meets (or obtain), process, store and distribute information to support decision making and organization control”.
Technological transference	To transfer knowledge and technologies for the entire production chain.
Regulations Fulfillment	Mills adequacy is important not only for improving quality and acceptance of the product, but also because the 779 resolution, which was published in 2006 by the Ministry of Social Protection, stablished technical regulations that health requirements. Aditionally, Panela Mills must be certified in Good Manufacturing Practices and they must be enrolled in INVIMA.
	Panela Mills are compeled to accomplish an adequate water, air and another renewable resources management according to 1594 of 1984, 1791 of 1996, 948 of 1995 decrees. To give continuity and forcefulness to polluting practices eradication, such as the use of wood, tires and chemicals that threaten human health.
Associativity	Producers are scattered in almost all Colombian Regions, they dont work together and they have mostly had unfavorable prices in comparison with production costs, which arise from inefficient production and marketing systems.

One objection received in this regard is from Johnson (1979) who noted that if the hierarchy is incomplete, the weights can be distorted, therefore Epstein and King (1982) incorporated the possibility of structuring decision process through a hierarchy and the differences of information on each level of the hierarchy, should be represented by introducing distortions in the valuations of its elements. According to Saaty, the problem is the availability of information, not the method (Zahedi 1986).

.

5.3. Priority Establishment

The AHP methodology implies that decider has to indicate his preference or priority for each decision alternative. Given the information about the relative importance and preferences, it is used the mathematical process called synthesis for summarizing information and providing a priority hierarchy of alternatives according to a global preference that is built since weights and initial criteria given by decider. The AHP uses a scale of 1-9 to rate the relative preferences of both elements.

To fill the matrix, you must first understand the meaning of each value Saaty scale presented in Table 3:

Table 3. Saaty scale

Importance/ preference	Intensity	Meaning
1	**Equally Important** Equal of different to...	Comparing two elements, and there is no difference between them. The Decider doesn’t prefer any of them.
3	**Moderate Importance** Slightly more important or more prefered than...	Comparing two elements, first one is slightly more important or more prefered than the other.
5	**Strong Importance** More important or more prefered than...	Comparing two elements, first one is considered more important or more prefered thant the second one.

Importance/ preference	Intensity	Meaning
7	**Very Strong Importance** Much more important or much more prefered than...	Comparing two elements, first one is considered much more important or much more prefered that the second one.
9	**Extreme importance** of one element. Absolutely much more important or prefered than…	Comparing two elements, first one is absolutely much more important or prefered than the other.

The scale established by Mr. Thomas L. Saaty, was the development of studies based on experimental activities and it uses a scale with nine elements, in where different grades or levels are showed and which allow to discriminate ***relation intensity*** among the elements belonging to a set. In that way, comparisons and measurements are achieved, so technique is initially adjusted to the ***Homogenization Principle of Measure Theory***, particularly, when working variables or factors of great variability and diversity in the study that is being conducted.

In the first instance, it should be to accomplish an assessment of criteria importance in relation to their contribution to the achievement of the goal, then, for each criterion might determine what is the relative importance of the attributes that depend on it. The assessment process should continue with the appreciation of the importance of the alternatives respect to each of existing and valued attributes.

Frequent use of AHP-Expert Choice software allows hierarchical model estructuration, through the goal, criteria, subcriteria and decision alternatives introduction (Figure 2).

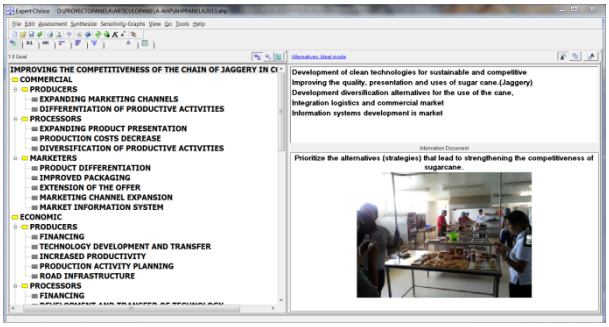


Figure 2.Hierarchical Model Introdution.Expert Choice Software.

Comparison matrix between criteria, uses Saaty scale base don parwise comparison. So it prioritizes criteria with respect to the goal.

Let Z be an matric n x n and Pij the element located in the position (ij) inside of Z, for i=1.2.3…n and j=1.2.3…..n, Z is a parwise comparison matrix of n alternatives.If Pij is the preference grade of alternative i against alterntaive j, when i=j, we will have Pij=1 due to the fact the alternative is compared against itself.

$$Z = \begin{bmatrix} 1 & P_{12} & \dots & P_{1n} \\ P_{21} & 1 & \dots & P_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ P_{n1} & P_{n2} & \dots & 1 \end{bmatrix} \quad (1)$$

In this case, in first level, comercial, economic, productiv, logistical, environmental and social criteria were compared parwise (Pij) and it resulted that all the criteria has the same relevance, except commercial and economic ones are a little more important over productive criterion, as well as environmental criterion has a greater weighting than logistical one.

Figure 3. First Level Criteria comparison

Comercial, economic and productive criteria are the most important issues inside the supply chain, having in account current competitiveness conditions. With prices and costs established for 2010 in regions and the required investment to implement health and environmental regulations, Panela production in sugar mills comes across as financially non-viable (Llano, Duarte and Moreno 2012), so environmental criteria weight will be less within the chain than the other ones.

Following with comparison matrix, another important property is that Pij.aij=1, that is to say:

$$Z = \begin{bmatrix} 1 & P_{12} & \dots & P_{1n} \\ 1/p_{12} & 1 & \dots & P_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/P_{1n} & 1/P_{2n} & \dots & 1 \end{bmatrix} \quad (2)$$

The last property is due to Reciproc judgments axiom: *If Z is a parwise comparison matrix, $P_{ij}=1/P_{ji.}$ Where compared elements of the same level and that have hierarchical dependence.*

Hierarchical second level consists of comparing chain actors (producers. processers and marketers) with respect to economic, commercial, productive, logistical, environmental and social criteria. The weight of each actor over criteria has been established asreciproc relation, so importance/preference has been estimated as (1), without preference for any actor. For the study, everyone will have equal hierarchical importance.

Figure 4.Parwise comparison between actors for factors

Third hierarchical level consists in comparing subfactors for each actor, with regard to criteria (commercial, economic, productive, logistical, environmental and social). As an example, it is the comparison and priorization of subfactors (product differentiation, packing improvement, product offer enhancement, marketing channels expansion and marketing formation systems implementation) for marketers in commercial competititveness structure.

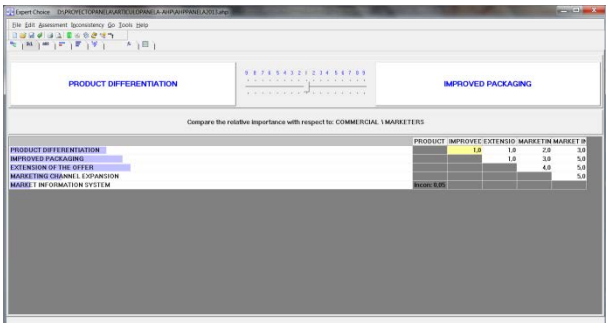


Figure 5.Parwise comparison between actors and subfactors, for each competitiveness factor.

5.4. Priorization of Factors

Once comparison matrix is already filled out, priorities might be calculated. Traditional AHP uses the eigen-valor method. Let´s considere a coherent matrix with the know priorities p_i. So that comparison between alternatives i and j is given through p_i / p_j, which multiplied for priority vector p, produces:

$$\begin{bmatrix} P_1/p_1 & P_1/p_2 & \dots & P/P_n \\ P_2/P_1 & P_2/P_2 & \dots & P_2/P_n \\ \dots & \dots & \dots & \dots\dots \\ P_n/P_1 & P_n/P_2 & \dots & P_n/P_n \end{bmatrix} = n \begin{bmatrix} P1 \\ P2 \\ \dots \\ Pn \end{bmatrix} \quad (3)$$

If matrix is enougly consistent, the transitivity rule (4) is satisfied for all the comparisons Pij

$$Pij = Pik.Pkj \quad (4)$$

Where P identifies priorities vector; in corresponds to matrix Z dimensión.

Then in (3) it is an eigenvector problem. Priorities calculation is exact for a consistent matrix (5).

$$Zp = np \quad (5)$$

The aggregation of the results of pairwise comparison to make the prioritization of the factors. are defined in Table 4. by reference to the structure Zangeneh study results (2009). It was determined that the most important criterion for experts (0.206), is commercial one. This fact is reflected in the present time of agribusiness, where producer, processer and marketer concern is focused on product position in the Market. As a strategy it is presented the integration of Panela cooperatives or associations that can compete with new Panela producers (Delgado 2009). Another justification that provides a higher score to commercial criteria, it´s presented with the need to streng then sector sustainability from a suitable commercial management, which looks for solving two problems: the domestic price of food decrease and the diminution of domestic consumption (Rios 2013).

In the second comparison level, the earmaked weight for each actor (productors, processors and marketers) is the same (0.333): Producers could not have a greater preponderance than neither processers nor marketers. Currently, the strategy has to be a kind of “wins-wins” for every actors involved in the chain.

In the third hierarchical level, subcriteria weights are compared with regard to the actors. We could say that **productive activities differentiation** (0.833) for producers (0.333) will be more significative in **commercial issue** (0.206) in order to develop and deepen research to get new applications for the use of sugarcane different to Panela production. As an example, it is the study on the alternative use of molasses sugar cane waste to synthesize rigid polyurethane foam (ERP) for industry (Vega, Delgado, Sibaja and Alvarado 2007), or production of feed for animal breeding or dairy production agribusiness diversification into industry sucrochemistry seems to be a very interesting option to face oil depletion (Viniegra 2007). In the current conditions, production costs decrease for processors (0.674) would have greater importance in commercial aspect (0.206) in order to expand the marketing marginsof the product. The average cost of producing a kilo of panela, in the 26 departments and 350 municipalities producers. including the social and placed in the hold of the mill is $ 2200 Kilo (Colombian Pounds - COP). Someplacessold it at below cost, e.g. in Cundinamarca. Nariño and Cauca, today the price is about $ 1400 a kilo (COP) (Ramirez 2013). On the other hand, **supply expansion** (0.304) will be more important for **marketers**, for being able to enter new international market niches, preferably, with special emphasis on sugarcane products that have global merchandise: companies involved in Marketing, presentations and driven prices, imports and exports. guidance on trends, new products made from the juice sugarcane as well as Panela, characterization and potential markets for the principal panela products nationally and internationally (Castellanos, Torres and Flórez 2010).

In the second hierarchical level, economic criterion has the secod place (0.184), where producers and processers

prioritize financing schemes (0.473 y 0.528). One option for applying suitably health and enironmental regulations in Panela infrastructure could be a subsidized credit, as a special line of ICR (*Incentivo de capitalización rural* – Rural capitalization incentive), however the amount of resources to guarantee a complete re-adequacy is at least $0.6 billions (COP), assuming an incentive of 40% (Llano, Duarte and Moreno 2012). For marketers in the economic issue, it is principal Price control to avoid its destabilization with in productive chain generated by the product oversupply and fraudulent practices. First of all, Panela and sugar are competitive or substitutable goods in both production and consumption, beacuse they come from the same plant species (cane) and being both daily sweeteners.At the second level of hierarchy is environmental criteria (0.184), where producers gives equal importance for **maintaining a hygienic and basic sanitation system in crops** (0.500) and for **developing an organic agriculture** (0500). for the processor sub-criterion of highest priority is compliance with environmental regulations (0.857) and the commercializador. the sale of sustainable organic panela with the environment (0.875); for processers, the most important subcriterion is the **fulfillment of the environmental regulations** (0.857) as far as for marketers it is the **environmentally Sustainable sale of organic Panela** (0.875). Adopting good practice is the operative baseline of the different mills, in as much as: it involves the application of many different processes in order to avoid consumer health risks, it reduces costs generated by a poor quality caused by mishandling, and finally, good practice increase customer satisfaction that results in increased sales (Guerrero and Luengas 2011).The environmental Panela guide becomes a reference tool and basic orientation that contains the methodological and general procedures panelera development activity,under a integrated environmental management approach (Fonseca 2002). The third level of hierarchy is occupied by social criteria (0.163) where sub-factors such as the development of skilled labor for the entire chain, the union associativity and the control of fraudulent practices have all the same weight (0.333).To develop skilled Manpower, the sugar cane sector board that is located in Villeta – Cundinamarca, has contributed to the development of occupational competency standards and qualifications.

Productive criterion is the fourth within the hierarchy (0.131), where for producers is fundamental the renewal of crops (0.577), for processors is to increase productivity (0.731) and for marketers, to centralize Marketing (0.758). The national government is promoting the initiative to develop a central of cane juices for the Hoya del Rio Suarez where should be concentrated all the cane production from the region and in that way to eliminate intermediation. On this same level, it is thelogistical criteria (0.131) where for producers the most importance focuses on expanding Commercialization channels (0.833), while for processors will be to centralize the process (0.726) and for marketers, to have a market information system, which were safe, available and reliable (0.709).

Table 4. Weights for criteria and subfactors or specific criteria for each actor

Criterion	Weight	Actors	Weight	Specific criteria for each actor	weight	Overall = (1) x (2) x (3)
Level (1)		**Level (2)**		**Level (3)**		
1. Commercial	0.206	1.1.Producers	0.333	1.1.1. Marketing channels expansion	0.167	0.011
				1.1.2. Productive activities differentiation	0.833	0.057
		1.2. Processors	0.333	1.2.1. Expantion in the product presentation	0.226	0.016
				1.2.2. Production cost´s decrease	0.674	0.046
				1.2.3. Productive activities diversification	0.101	0.007
		1.3.Marketers	0.333	1.3.1.Product Differentiation	0.235	0.016
				1.3.2.Improved packaging	0.280	0.019
				1.3.3.Offert´s extent	0.304	0.021
				1.3.4. Marketing channels expansion	0.129	0.009
				1.3.5. Market information system	0.052	0.004
2. Económic	0.184	2.1.Producers	0.333	2.1.1.Financing	0.473	0.029
				2.1.2.Development and Technology´s transfer	0.124	0.008
				2.1.3.Productivity increase	0.267	0.016
				2.1.4.Production planning	0.041	0.003
				2.1.5.Infrastructure line	0.095	0.006
		2.2.Processsors	0.333	2.2.1.Financing	0.528	0.032
				2.2.2. Development and Technology´s transfer	0.333	0.020

				2.2.3.Productivity increase	0.140	0.003
		2.3.Marketers	0.333	2.3.1.Price control	0.857	0.053
				2.3.2.Offert´s extent	0.143	0.009
3. Productive	0.131	3.1.Producers	0.333	3.1.1.Increase labor quality	0.081	0.0S04
				3.1.2.Reductionharvestingcosts	0.342	0.015
				3.1.3.Renewal of crops	0.577	0.025
		3.2.Processors	0.333	3.2.1.Factory´s upgrade	0.188	0.008
				3.2.2.Regulatory compliance	0.081	0.004
				3.2.3.Productivity increase	0.731	0.032
		3.3.Marketers	0.333	3.3.1.Offert´s extent	0.091	0.004
				3.3.2. Improved packaging	0.151	0.007
				3.3.3.Centralizing marketing	0.758	0.033
4.Logistic	0.131	4.1.Producers	0.333	4.1.1.Distribution channels expansion	0.833	0.036
				4.1.2.Improving transportation systems	0.167	0.007
		4.2.Processors	0.333	4.2.1.Centralize processing	0.726	0.032
				4.2.2.Burden unitization	0.102	0.004
				4.2.3.Packing standardization	0.172	0.008
		4.3.Marketers	0.333	4.3.1. Market information system	0.709	0.031
				4.3.2. Burden unitization	0.179	0.008
				4.3.3.Centralize distribution	0.113	0.005
5.Ambiental	0.184	5.1.Producers	0.333	5.1.1.Basic hygiene and sanitation	0.500	0.031
				5.1.2.Organic agriculture	0.500	0.031
		5.2.Processors	0.333	5.2.1.Regulatory Compliance	0.857	0.053
				5.2.2. Production and export of organic panela	0.143	0.053
		5.3.Marketers	0.333	5.3.1. Sustainable organic panela	0.875	0.054
				5.3.2. Regulatory Compliance	0.125	0.008
6. Social	0.163			6.1. labor quality	0.333	0.054
				6.2. Associativity trade-union	0.333	0.054
				6.3. Control fraudulent practices	0.333	0.054

5.5.Synthesis

The last step is to synthesize the local priority of each criterion for determining the global priority. The historical approach AHP (called late distributive) adopts an additive aggregation (6) through a weighted sum of the priorities (Table 5), let's see the formulation:

$$Pi = \sum_{j=1}^{m} Wj \,.\, Lij \quad ; 1 \leq i \leq n \qquad (6)$$

Where n is the amount of alternatives, m is the amount of criteria, Pi is the global priority of alternative i, Lij is the local priority of alternative i with regard to criterian j and Wj is the j-criterion weight.

Table 5. Summary of results

Pi Level	Criteria and Sub-Criteria	*Alternatives Lij*					*Pi*
		DCT	QPP	DAD	LCI	MIS	
2	**1. Commercial**	0.194	0.175	0.207	0.364	0.060	0.206
3	1.1.Producers	0.154	0.124	0.346	0.332	0.044	0.069
4	1.1.1. Marketing channels expansion	0.300	0.111	0.293	0.221	0.076	0.011
4	1.1.2. Productive activities differentiation	0.125	0.127	0.356	0.354	0.038	0.057

3	1.2.Processors	0.261	0.195	0.101	0.392	0.052	0.069
4	1.2.1.Expansion in the product presentation	0.135	0.427	0.069	0.314	0.054	0.015
4	1.2.2. Production cost´s decrease	0.307	0.115	0.115	0.413	0.050	0.046
4	1.2.3.Productive activities diversification	0.233	0.207	0.079	0.426	0.055	0.007
3	1.3.Marketers	0.059	0.334	0.042	0.387	0.178	0.069
4	1.3.1.Product Differentiation	0.050	0.189	0.056	0.531	0.174	0.016
4	1.3.2.Improved packaging	0.042	0.591	0.042	0.183	0.142	0.019
4	1.3.3.Offert´s extent	0.074	0.268	0.034	0.451	0.174	0.021
4	1.3.4. Marketing channels expansion	0.070	0.276	0.038	0.474	0.142	0.009
4	1.3.5. Market information system	0.077	0.145	0.034	0.244	0.500	0.004
2	**2. Economics**	0.203	0.193	0.285	0.202	0.117	0.184
3	2.1.Producers	0.207	0.111	0.453	0.180	0.049	0.109
4	2.1.1.Financing	0.198	0.108	0.451	0.180	0.063	0.052
4	2.1.2.Development and Technology´s transfer	0.429	0.250	0.154	0.130	0.036	0.014
4	2.1.3.Productivity increase	0.132	0.075	0.561	0.192	0.040	0.029
4	2.1.4.Production planning	0.268	0.087	0.570	0.050	0.026	0.004
4	2.1.5.Infrastructure line	0.144	0.060	0.498	0.265	0.033	0.010
3	2.2.Processors	0.233	0.454	0.040	0.210	0.064	0.046
4	2.2.1.Financing	0.234	0.505	0.042	0.158	0.060	0.024
4	2.2.2. Development and Technology´s transfer	0.139	0.505	0.035	0.254	0.067	0.015
4	2.2.3.Productivity increase	0.449	0.139	0.039	0.303	0.071	0.006
3	2.3.Marketers	0.142	0.087	0.038	0.274	0.460	0.029
4	2.3.1.Price control	0.145	0.056	0.038	0.233	0.528	0.025
4	2.3.2.Offert´s extent	0.124	0.271	0.037	0.517	0.051	0.004
2	**3. Productive**	0.172	0.247	0.190	0.280	0.111	0.131
3	3.1.Producers	0.278	0.139	0.485	0.058	0.040	0.044
4	3.1.1.Increase labor quality	0.248	0.133	0.517	0.067	0.035	0.004
4	3.1.2.Reductionharvestingcosts	0.320	0.125	0.445	0.068	0.042	0.015
4	3.1.3.Renewal of crops	0.258	0.148	0.504	0.051	0.039	0.025
3	3.2.Processors	0.148	0.386	0.048	0.348	0.071	0.044
4	3.2.1.Factory´s upgrade	0.131	0.272	0.051	0.522	0.024	0.008
4	3.2.2.Regulatory compliance	0.481	0.300	0.066	0.096	0.057	0.004
4	3.2.3.Productivity increase	0.115	0.425	0.045	0.331	0.084	0.032
3	3.3.Marketers	0.091	0.216	0.037	0.434	0.222	0.044
4	3.3.1.Offert´s extent	0.152	0.495	0.043	0.235	0.075	0.004
4	3.3.2. Improved packaging	0.049	0.506	0.047	0.262	0.136	0.007
4	3.3.3.Centralizing marketing	0.092	0.125	0.034	0.492	0.257	0.033
2	**4.Logistic**	0.113	0.246	0.066	0.361	0.214	0.131
3	4.1.Producers	0.152	0.221	0.087	0.495	0.045	0.044
4	4.1.1.Distribution channels expansion	0.155	0.224	0.079	0.499	0.043	0.036
4	4.1.2.Improving transportation systems	0.138	0.206	0.127	0.471	0.057	0.007
3	4.2.Processors	0.101	0.343	0.047	0.388	0.122	0.044

4	4.2.1.Centralize processing	0.107	0.371	0.045	0.342	0.135	0.032
4	4.2.2.Burden unitization	0.111	0.278	0.042	0.529	0.040	0.004
4	4.2.3.Packing standardization	0.070	0.259	0.057	0.497	0.116	0.008
3	4.3.Marketers	0.085	0.175	0.066	0.200	0.474	0.044
4	4.3.1. Market information system	0.085	0.175	0.066	0.200	0.474	0.031
4	4.3.2. Burden unitization	0.094	0.338	0.076	0.320	0.171	0.008
4	4.3.3.Centralize distribution	0.079	0.094	0.094	0.612	0.120	0.005
2	**5. Environmental**	0.405	0.286	0.171	0.080	0.055	0.184
3	5.1.Producers	0.383	0.123	0.397	0.049	0.047	0.061
4	5.1.1.Basic hygiene and sanitation	0.359	0.072	0.464	0.057	0.047	0.031
4	5.1.2.Organic agriculture	0.407	0.174	0.330	0.042	0.047	0.031
3	5.2.Processors	0.511	0.264	0.049	0.122	0.054	0.061
4	5.2.1.Regulatory Compliance	0.520	0.254	0.045	0.130	0.051	0.053
4	5.2.2.Production and export of organic panela	0.462	0.323	0.068	0.072	0.075	0.009
3	5.3.Marketers	0.320	0.469	0.078	0.068	0.065	0.061
4	5.3.1.Sustainable organic panela	0.330	0.462	0.070	0.071	0.068	0.054
4	5.3.2. Regulatory Compliance	0.251	0.524	0.135	0.047	0.043	0.008
2	**6. Social**	0.289	0.209	0.093	0.308	0.101	0.163
3	6.1. labor quality	0.261	0.189	0.171	0.189	0.189	0.054
3	6.2.Associativity trade-union	0.067	0.226	0.069	0.566	0.073	0.054
3	6.3.Control fraudulent practices	0.540	0.211	0.039	0.169	0.041	0.054
Overall priority of each alternative Pi		***0.229***	***0.232***	***0.167***	***0.262***	***0.110***	***1***

Global prioritization of results gives as the first alternative for decider, to choose Logistical and Commercial Integration Strategy (LCI) (0.262), followed by the alternative of quality, presentations and Panela uses improvement panela (QPP) (0.232); in third place, we have the development of clean technologies for sustainable and competitive sector growing (DCT) (0.229): in fourth place, it is the developing of diversification alternatives to take advantage of sugar cane (DAD) (0.167) and finally it is the Marketing Information systems development (MIS) (0.110).

5.6.Consistency

The third step will be to check the trial´s consistency.If R was a matrix completely consistent, then the λ_{max} will be equal to n.However, the decider will have some inconsistencies in his trials and is a great idea take an measure of the inconsistency´s degree of the trial made by the decider, because if you have not been careful with the ratings, the vector of priorities or weights obtained may be unrepresentative.

The consistency may be measured by the consistency index (IC), that has the following expression.

$$IC = \frac{\lambda_{max} - n}{n-1} \qquad (7)$$

This measure can be used toimprove the consistency of trials when compared with the appropriate number in the table No 3, that have the random consistency index (IA):

Tabla No.3.Random consistency index (IA) in fuction on the dimension of the matrix (n)

n	1	2	3	4	5	6	7	8
RI	0	0	0.525	0.882	1.115	1.252	1.341	1.401
n	9	10	11	12	13	14	15	16
RI	1.452	1.484	1.513	1.535	1.555	1.570	1.583	1.595

The Random consistency index (IA) is defined as the average random consistency index obteined by simulating 100,000 reciprocal matrices generated randomly using the scale of Saaty (1/9.1/8.....1..... 8. 9).

If we calculate the ratio of the consistency index (IC) and the random consistency index (IA), we can be calculated the consistency ratio (RC).

$$RC = \frac{IC}{IA} \qquad (9)$$

Now, if RC = 0, the matrix is consistent, but if RC ≤ 0.10the matrix R has an inconsistency admisible, which means that it is considered consistent and the weight vector obtained is accepted as valid. But if RC > 0.10, the inconsistency is unacceptable and is necessary to recheck the trials.

For our case, the inconsistency ratio is 0.0216 as show in the figure 5, this indicates that the consistency obtained is acceptable, because RC ≤ 0.10

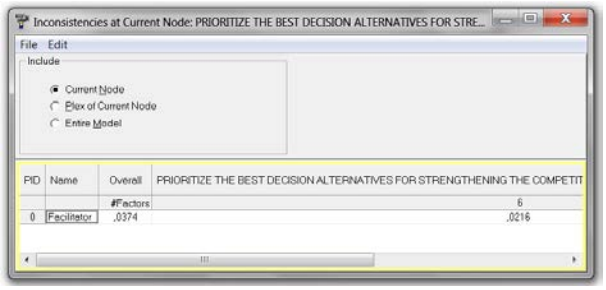


Figure No.6. Inconsistency Index

5.7. Sensitivity analysis

A last step in AHP development, is to accomplish a sensibility analysis, a procedure that confirms results sturdiness and reducing random risk. Analysis consists in varying weight values and observating numerically and graphically how these changes affect the other weights and alternatives prioritization.

Analyzing sensibility, priorities can be changed in order to observe how alternatives prioritization would change. Expert Choice software presents five possibilities to do sensibility analysis. In figure 7, there is one of the methods use for changing dynamically objectives or criteria priorities, to establish how these changes impacts the prioritization of alternatives.

By increasing the economic criterion on a scale of 9 (Extremely important), it can be seen how the strategic decision alternatives vary, in this case becomes more vital to promote the development strategy of clean technologies for sustainable and competitive development of the productive chain.

By increasing the economic criterion on a scale of 9 (Extremely important).We can see how the strategies of alternatives decision vary (Figure 7), in this case becomes more vital to promote the development strategy of clean technologies for sustainable and competitive development of the productive chain.

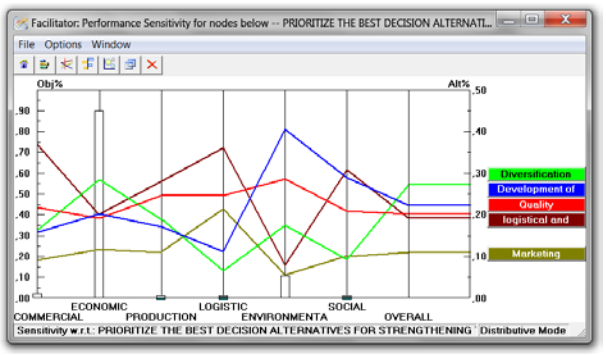


Figura 7 Sensitivity analysis when the objective economic is the most important

If we choose to give greater priority to environmental objective (Figure 8), the best alternative is the development of clean technologies and as a second alternative will be the improve the quality, the use and the presentation of the product.

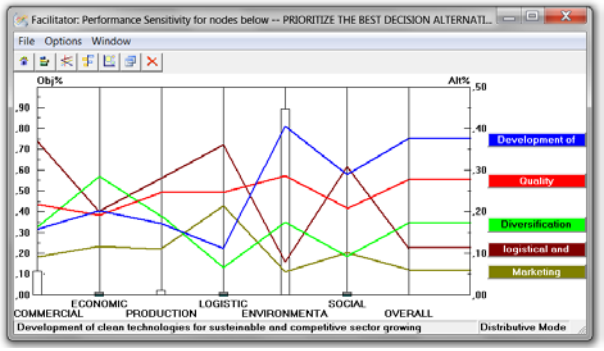


Figure 8 Sensitivity analysis when the environmental objective is the most important

When commercial purpose predominates (Figure 9) and this takes a higher value on the scale (9), the decision strategy that prioritizes is logistics and commercial integration, followed by improving the quality, presentation and usage of the product.

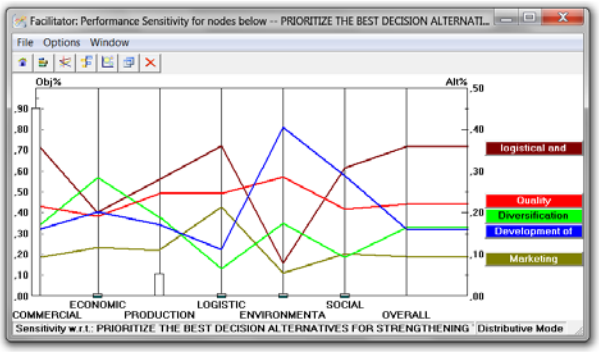


Figure 9 Sensitivity analysis when the commercial purpose predominates

Similarly, if the priority is focused on the product, the priority strategy will be the logistical and commercial integration (Figure 10).

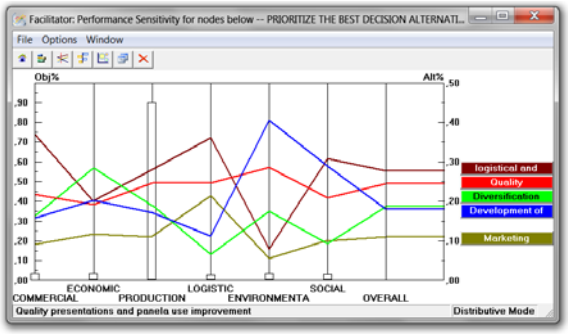


Figura 10. Sensitivity analysis when thepriority is focused on the product

If we prioritize the social objective (Figure 11), the highest alternative decision will be the strategy of commercial and logistical integration and secondly the development of clean technologies.

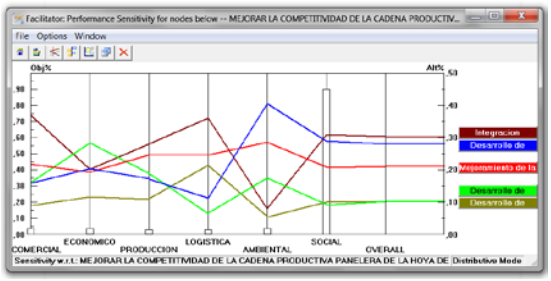


Figure 11 Sensitivity analysis when the social objective is the most important

The integration of regional logistics information resources is the most effective breakthrough for the integration of regional resources, but most of the information platforms that have established are respective and incompatible between the enterprises, so that every one is an "Information Island", which is not conducive to information sharing across enterprises throughout the regions. The integration of regional logistics information resources can make information flow smoothly across regional enterprises, so that logistics information become one of bridges among regional enterprises and provide effective services for regional enterprises (Wu and Shangguann 2012).

Authors like Gimenez and Ventura (2003) have competitive advantages derived from the integration in the supply chain, namely, the relationship between external integration and results in terms of cost of service, cost of transport, cost of ordering process , breaks in inventory and provisioning time (Marques, Molina and Vallet 2009).

The studies of Stank, Keller & Daugherty (2001) and Gimenez & Ventura (2003 and 2003b) share a common aim: to analyse the impact of internal and external integrationon performance. The integration-performance models of these authors included also a relationship between the levels of internal and external integration. All of them found that these levels of integration are positively correlated. This suggests that they positively influence each other (Gimenez 2004).

It is increasingly difficult for rural areas to meet the challenges of globalization only through vertical linkages. Beyond the need to overcome the disadvantages of demographic deficit, the size and the number of rural enterprises. etc., the presence of rural territories on the global stage, including politics, requires skills of dialogue, exchange and transfers to other territories (Farrell 2001).

6. CONCLUSIONS

In multi-criteria decision analysis there are really positive aspects. Some of the factors that favor its use is, for instance, that the AHP is a technique that offers an axiomatic theory. The participation of the actors involved in Panela production chain was of vital importance, however, it must be remembered that not only actors appreciation is important, but also experts opinion must be taken into account, not only to determine a priori actors needs, but also to display the best scenario projection.

Technological transformations and new consumer requirements have modified demand patterns towards a greater diversification facilitating new processes and products appearance, such as competition among agribusiness enterprises has based not solely on price, coming to the fore competitive factors as quality, design and product differentiation (Lopez Macias, 2007 and Boucher) .

AHP is an useful tool in multi-criteria decision making, where many actors involved. This can be very used by Panela associations and by the State in projects priorization, which are favorable for the sector.

The relevance of Commercial and Logistical integration strategy is based on that the scenarios, where union consolidation structures occurs, generate better results for the competitive structure of the chain, in this aspect can be cited as an example the agroindustry Doña Panela Ltda, which has successfully integrated all production factors and to have a place within national and international market with variety of products (Cadena 2004).

In areas where agendas converge, transport and trade facilitation measures need to be deepened to allow for further coordination and gains from cooperation. Continued emphasis on key processes regarding the development and harmonization of border crossings and the regulation of diverse transport modalities is of particular importance. Furthermore, the agenda for the expansion of productive integration and intra-regional logistics services must support both national and subnational organizations in order to fully achieve the economies of agglomeration necessary to reap the most benefits from these costly reforms (Guerrero, Lucenty and Galarza 2010).

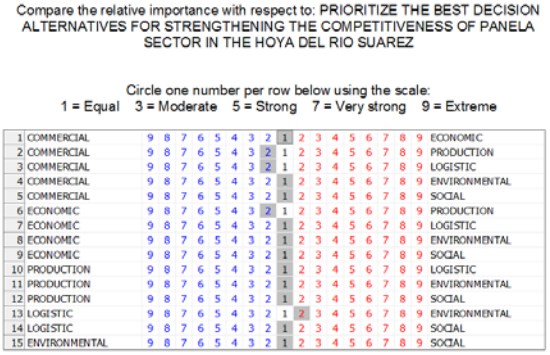
Future research should seek to identify models of logistical and commercial integration that contribute to supply chain strengthening, and using logistical simulation models to determine the best logistical and commercial integration model for the supply chain.

APPENDIX

Appendix A. Instrument for the analysis

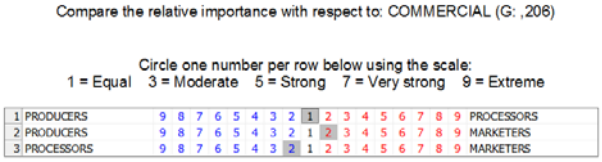
Evaluation of the categories of objectives keeping in mind the overall shery management goal to sustain viable sheries in the long run. The tables are read horizontally where each row is a single comparison for you to evaluate. The value of one means that both criteria are equivalent, while selecting a value along the scale means that a particular criteria is more important than the other. Higher numbers correspond with increasing importance, i.e.

3.moderately important, 6.strongly important, 9.extremely more important



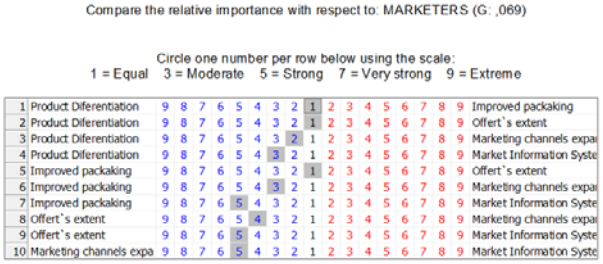
Appendix B

Example of comparision between the actors of the production chain



Appendix C

Example of the comparision between the subfactors and factors in the chain



ACKNOWLEDGMENTS

The researchers are grateful to experts, producers, traders and processors of Hoya del Rio Suarez, for his cooperation in the investigation, The National Federation of Panela makers (FEDEPANELA) for the information provided and the Science, Technology and Innovation Vice – Rector (VCTI) of the Antonio Nariño University, for funding the research project. The views expressed are those of the authors.

REFERENCES

Abaunza, C.A., Forero, C.A., Garcia, G.O., Carvajal G. H., 2012. *Zonificación y organización de clúster empresariales para las cadenas de caña panelera.frutales y papa criolla en Cundinamarca*. Colombia. Corpoica. xx p. ISBN: 978-958-740 Available from: http://www.corpoica.org.co/sitioweb/Archivos/Publicaciones/Cluster_para_evaluacion_de_tierras.pdf [accessed 15 July 2013]

Berumen, S.A. & Llamazares, R.F., 2007. *La utilidad de los métodos de decisión multicriterio (como el AHP) en un entorno de competitividad creciente*. Cuadernos de Administración. 20 (34). 65-87. Available from: http://www.redalyc.org/articulo.oa?id=20503404 [accessed 4 June 2013]

Bisang, R., Anlló, G., Campi, M., Albornoz, I., 2009. *Cadenas de valor en la agroindustria*. Cepal. Cap IV.p 219-272. Available from: www.eclac.org/publicaciones/xml/7/38557/CapituloIV.pdf [accessed 16 July 2013]

Cadena, D., Acuña, J., 2004.*"La agroindustria de la panela en la región de la Hoya del Rio Suarez, Bajo el enfoque de desarrollo regional y competitividad"* Universidad Industrial de Santander (UIS), Available from: http://repositorio.uis.edu.co/jspui/bitstream/123456789/8377/2/112751.pdf [accessed 18 July 2013]

Calabrese, A., Costa, R., Menichini T., 2013.*Using Fuzzy AHP to manage Intellectual Capital assets: An application to the ICT service industry* .Original Research Article. Expert Systems with Applications. Volume 40. Issue 9. July 2013. Pages 3747-3755. Available from: http://www.sciencedirect.com/science/article/pii/S095741741201322X [accessed 10 June 2013]

Castellanos, D.O., Torres, P.L., Flórez M.D., 2010. *Agenda prospectiva de investigación y desarrollo tecnológico para la cadena productiva de la panela y su agroindustria en Colombia*. Available from: http://www.minagricultura.gov.co/archivos/cadena_productiva_panela.pdf [accessed 15 June 2013]

Delgado, L.A., 2009. *"Propuesta para el redireccionamiento administrativo de la microempresa familiar panelera "caña gecha" en el municipio de la peña (cundinamarca)"*. Universidad de la Salle. Available from: http://repository.lasalle.edu.co/bitstream/10185/3194/1/T11.08%20D378pr.pdf [accessed 25 June 2013]

Dueñas, R., Morales, A., Nanning, C., Noriega, S., Ortriz J P., 2007. *Microeconomics of competitiveness of the sugar cane cluster in Colombia*.Harvard Business School. Boston. Massachusetts Available from: http://www.isc.hbs.edu/pdf/Student_Projects/Colombia_SugarCaneCluster_2007.pdf [accessed 05 June 2013]

Emam, A.A., 2010. *The Competitiveness of Sugar Cane Production: A Study of Kenana Sugar Company. Sudan*. Sudan University of Science and Technology.Faculty of Agricultural Studies Department of Agricultural Economics.Journal of Agricultural Science.Vol. 3.No. 3. ISSN 1916-9752. Available from: http://www.ccsenet.org/journal/index.php/jas/article/view/8361 [accessed 19 June 2013]

Eraslan, E., Dağdeviren M., 2010. *A Cognitive Approach for Performance Measurement in Flexible Manufacturing Systems using Cognitive Maps*.Cognitive Maps. Karl Perusich (Ed.). ISBN:

978-953-307-044-5.InTech. Available from: http://www.intechopen.com/books/cognitive-maps/a-cognitive-approach-forperformance-measurement-in-flexible-manufacturing-systems-using-cognitive-m [accessed 14 June 2013]

Expert choice version 8.0. Computers & Mathematics with Applications. Volume 25. Issue 8. April 1993. Page 117. Copyright © 2013 Elsevier Ltd. Available from: http://ac.els-cdn.com/089812219390179Y/1-s2.0-089812219390179Y-main.pdf?_tid=397e7e3e-ee68-11e2-b730-00000aab0f26&acdnat=1374014398_be2f5eca4f7109b4f711fc9123879077 [accessed 10 Juny 2013]

Farrel, G., 2001. *La competitividad de los territorios rurales a escala global.*"*innovación en el medio rural"*.cuaderno de la innovación nº 6 – fascículo 5 observatorio europeo leader. Febrero 2001. Available from: http://ec.europa.eu/agriculture/rur/leader2/rural-es/biblio/local-global/comlocalglobal.pdf [accessed 10 July 2013]

Fonseca, S.E., 2002. *Guia ambiental para el subsector panelero*. Ministerio del Medio Ambiente. Sociedad Colombiana de agricultores de Colombia (SAC).Federacion nacional de Paneleros (Fedepanela). Available from: http://www.panelamonitor.org/media/docrepo/document/files/guia-ambiental-para-el-subsector-panelero.pdf [accessed 10 July 2013]

Gimenez, C., 2004. *Logistics integration processes in the food industry*.Research Group in Business Logistics.Institutd`estudis territorials, UniversitatPompeuFabra. Available from: http://nir.upf.edu/joomla/images/pdf/publicacions/workingpapers/IET%20working%20paper%20014.pdf [accessed 25 July 2013]

Gomes, L.F., Autran, M., Andrade, R.M., 2012. *Performance evaluation in assets management with the AHP*. Pesqui.Oper.[online]..vol.32. n.1. pp. 31-54. Epub Mar 08. 2012. ISSN 0101-7438. Available from: http://dx.doi.org/10.1590/S0101 [accessed 10 June 2013]

Gomez, P.E., Silva, F.A., 2011. *Proyecto "Diseño y Desarrollo de un Plan de Marketing Territorial como estrategia de fortalecimiento del Desarrollo Local en 3 regiones de Colombia (Complejo Cenagoso de la Zapatosa. Hoya del Rio Suarez. Zona Norte del Valle del Cauca)"*.Available from: http://www.adel.org.co/archivos/LBL2HRS.pdf [accessed 10 June 2013]

Guerrero, P.K., Lucenti, Galarza, S., 2010. *Trade Logistics and Regional Integration in Latin America and the Caribbean.* ADBI Working Paper 233. Tokyo: Asian Development Bank Institute. Available from: http://www.adbi.org/files/2010.08.02.wp233.trade.logistics.latin.america.caribbean.pdf [accessed 02 July 2013]

Guerrero, C., Luengas, E., 2011. P*lan de manejo ambiental para el sector panelero en la Vereda Melgas.municipio de Chaguaní. Cundinamarca*. Universidad Militar Nueva Granada. Available from: http://www.umng.edu.co/documents/10162/745281/V3N2_4.pdf. [accessed 13 July 2013]

Hernandez, R., Fernandez C., Baptista P., 2006. *La información secundaria.* Metodologia de la Investigación. Mc. Graw Hill. ISBN: 9789701057537 Available from: http://www.mcgraw-hill.es/bcv/guide/capitulo/8448199251.pdf. [accessed 13 July 2013]

IICA 2001.*Bases para un acuerdo de desarrollo de la cadena agroindustrial de la panela.* Colección de documentos IICA. Serie Competitividad.Secretaría Técnica. Fedepanela.Available from: http://repiica.iica.int/docs/B0126E/B0126E.PDF [accessed 18 June 2013]

Lee, S., Kimb, W., Min, K.Y., Joo, O.K., 2012. *Using AHP to determine intangible priority factors for technology transfer adoption.* Available from: http://ac.els-cdn.com/S0957417411017015/1-s2.0-S0957417411017015-main.pdf?_tid=ba314f7e-e031-11e2-b903-0000aab0f6c&acdnat=1372451675_c1152276aad48844b7c2749698e86b6e [accessed 15 June 2013]

Leibovich, J., Laura, E., 2009. *Competitividad del sector agropecuario colombiano.*Availablefrom: http://www.compite.com.co/site/wp-content/uploads/informes/2008-2009/Agropecuario-(agricultura).pdf [accessed 10 June 2013]

Li, T., 2010. *Applying TRIZ and AHP to develop innovative design for automated assembly systems.* The International Journal of Advanced Manufacturing Technology,January 2010, Volume 46, Issue 1-4, pp 301-313 Available from: http://link.springer.com/article/10.1007%2Fs00170-009-2061-4#page-1.[accessed 10 June 2013]

Llano, M., Duarte, S.H., Moreno C.A., 2012. *Afectación de la rentabilidad al productor panelero por la implementación de la normatividad sanitaria y ambiental.* Contraloria General de la Republica Available from: http://186.116.129.19/c/document_library/get_file?folderId=75297808&name=DLFE-46852.pdf [accessed 18 June 2013]

Lopez, A. M., Méndez, J.J., Dones M., 2009. *Factores clave de la Competitividad regional*: *Innovación e intangibles.* Available from: http://www.n-economia.com/presentaciones/pdf/amlopez_jjmendez_mdones_jun09.pdf .[accessed 19 June 2013]

Ludovic, A.V., Marle F, Bocquet J.C., 2010. *Measuring project complexity using the Analytic Hierarchy Process.* Original Research Article International Journal of Project Management. Volume 29.Issue 6. August 2011. Pages 718-727

Available from: http://www.sciencedirect.com/science/article/pii/S0263786310001092 [accessed 07 June 2013]

Marques , A., Molina, X., Vallet, T., 2009. *Influencia de la integración logística en los resultados logísticos de las organizaciones,* Cuadernos de Estudios Empresariales vol. 19, 175-20, ISSN: 1131-6985 Available from: http://dialnet.unirioja.es/servlet/articulo?codigo=3283731 [accessed 15 July 2013]

Martinez, H.J., Ortiz, L., Acevedo X., 2005. *La cadena agroindustrial de la panela en colombia una mirada global de su estructura y dinamica 1991-2005*. Ministerio de Agricultura y Desarrollo Rural. Observatorio Agrocadenas Colombia. Documento de Trabajo No. 57. Available from: http://201.234.78.28:8080/jspui/bitstream/123456789/436/1/2005112163343_caracterizacion_panela.pdf [accessed 19 June 2013]

Nydick, R.L., Hill R.P., 1992. *Using the analytic Hierarchy Process to structure the supplier selection procedure.* International Journal of Purchasing and Materials Management; Spring 1992; 28. 2; ABI/INFORM Global. pg. 31. Available from: http://www77.homepage.villanova.edu/robert.nydick/documents/Vendor%20Selection.pdf.[accessed 19 June 2013]

Osorio C.G., 2007. *Manual Técnico: Buenas Prácticas Agrícolas -BPA- y Buenas Prácticas de Manufactura -BPM-en la Producción de Caña y Panela*.Available from: http://www.fao.org.co/manualpanela.pdf.[accessed 12 July 2013]

Perez, M.T., 2011. *La empresarización del sector panelero.factor de desarrollo de la productividad y competitividad.* Programa de Productividad y Competitividad Agropecuaria del Huila. Available from:http://huila.gov.co/documentos/agricultura/CADENAS%20PRODUCTIVAS/INFORME%20DE%20GESTION%20CA%C3%91A-PANELA%202011.pdf [accessed 19 June 2013]

Ramirez, X., 2013. *La Industria panelera pide al Gobierno precio de sustentación de $2.200 por kilo. Diario la Republica.* Available from: Http://www.larepublica.co/economia/industria-panelera-pide-al-gobierno-precio-de-sustentaci%c3%b3n-de-2200-por-kilo_38969 **[**accessed 5 july 2013**]**

Rios, J.A., 2013. *Falta de tecnificación pone en aprietos a los paneleros*. Available from: http://www.laopinion.com.co/demo/index.php?option=com_content&task=view&id=424804&Itemid=32 [accessed 18 July 2013]

Romero, C.M., 2012. *Area de desarrollo rural de la hoya del rio Suarez.componente físico biotico.* Incoder 2012. Available from: http://www.fao.org.co/manualpanela.pdf. [accessed 14 June 2013]

Rudas, G., Forero, J., 1995. A*groindustria panelera en Colombia» Pequeña producción y relaciones interempresariales.* Cuadernos de Desarrollo Rural N" 35. Santafé de Bogotá. 1995 páginas: 7-17. Availablefrom: https://www.google.com.co/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&ved=0CCoQFjAA&url=http%3A%2F%2Frevistas.javeriana.edu.co%2Findex.php%2FdesarrolloRural%2Farticle%2Fdownload%2F3303%2F2508&ei=WRLzUej8K4jY8gTRv4GoDA&usg=AFQjCNGAqR4rPmO8wpXMJ0iM2C_3JolNTw&sig2=hk_eq6q6Q_V87of7_1Ul6Q

Saaty, T.L., 1990. *How to make a decision: The analytic hierarchy process Original Research Article* *European Journal of Operational Research*. Volume 48.Issue 1. 5 September 1990. Pages 9-26

Seong, k.L., Yong J.Y., Jong W.K., 2007. *A study on making a long-term improvement in the national energy efficiency and GHG control plans by the AHP approach*. Original Research Article Energy Policy. Volume 35.Issue 5. May 2007. Pages 2862-2868. Available from: http://www.sciencedirect.com/science/article/pii/S030142150600365X [accessed 10 June 2013]

Toledo, R., Engler, A., Ahumada, V., 2011. *Evaluation of Risk Factors in Agriculture: An Application of the Analytical Hierarchical Process (AHP)* Methodology. Chilean J. Agric. Res. [online]. 2011. vol.71. n.1 [citado 2013-07-15]. pp. 114-121. Available from: <http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-58392011000100014&lng=es&nrm=iso>. ISSN 0718-5839. http://dx.doi.org/10.4067/S0718-58392011000100014 [accessed 6 June 2013]

Vega, B.J., Delgado M.K., Sibaja B.M., Alvarado A.P., 2007. *Uso alternativo de la melaza de la caña de azúcar residual para la síntesis de espuma rígidas de poliuretano (ERP) de uso industrial. Tecnología. Ciencia. Educación.* julio-diciembre. 101-107. Available from: http://www.redalyc.org/articulo.oa?id=48222207 [accessed 5 July 2013]

Veronese, B.A., Carneiro, J., Ferreira da Silva J., Kimura H., 2012. *Multidimensional assessment of organizational performance: Integrating BSC and AHP Original.* Research Article. Journal of Business Research. Volume 65.Issue 12. December 2012. Pages 1790-1799. Available from: http://ideas.repec.org/a/eee/jbrese/v65y2012i12p1790-1799.html [accessed 12 June 2013]

Vidal, L.A., Marle, F., Bocquet, J.C., 2011. *Using a Delphi process and the Analytic Hierarchy Process (AHP) to evaluate the complexity of projects Original Research Article*. Expert Systems with Applications. Volume 38.Issue

5. May 2011. Pages 5388-5405. Available from: http://ac.els-cdn.com/S0957417410011607/1-s2.0-S0957417410011607-main.pdf?_tid=a53b26e0-e035-11e2-ba4d-00000aacb360&acdnat=1372453362_67d4234a4afc6339733e5297ba1c723c [accessed 15 June 2013]

Viniegra G., 2007.*Alternativas para el uso de la caña de azúcar.*Universidad Autónoma Metropolitana.. Iztapalapa. Aviablefrom: www.foroconsultivo.org.mx/eventos_realizados/.../dr_viniegra.pdf

Winston, W.L., 1991.*Toma de decisiones con objetivos multiples. Investigación de operaciones.aplicaciones y algoritmos.*In: PWS-kentPublising Company.Grupo Editorial Iberoamerica. S.A de C.V..eds. Investigacion de operacione.Aplicaciones y algoritmos. Mexico.Pag 792

Wu, H, Shangguann, X., 2012. *Regional Logistics Information Resources Integration Patterns and Countermeasures Original* Research Article Physics Procedia, Volume 25, Pages 1610-1615. Available from: http://www.sciencedirect.com/science/article/pii/S1875389212006992 [accessed 15 June 2013]

Zahedi, F., 1986. ***The Analytic Hierarchy Process: A Survey of the Method and Its Applications*** Interfaces. Vol. 16, No. 4 (Jul. - Aug., 1986), pp. 96-108

Zangeneh, A., Jadid, S., Rahimi-Kian, A., 2009. *A hierarchical decision making model for the prioritization of distributed generation technologies: A case study for Iran.* Original Research Article. Energy Policy, Volume 37, Issue 12, December 2009, Pages 5752-5763. Available from: http://www.sciencedirect.com/science/article/pii/S0301421509006296 [accessed 20 June 2013]

Zimmermann, B., Zeddies, J., 2002. *International competitiveness of sugar production*. 13th International Farm Management Congress. Wageningen. The Netherlands. July 7-12.2002 Department of Farm Management, University of Hohenheim, Stuttgart, Germany.D-70593 Stuttgart. Aviable from: http://www.ifmaonline.org/pdf/congress/Zimmermann_2.pdf. [accessed 15 Juny 2013]

AUTHORS BIOGRAPHY

Gabriela Leguizamon. completed her M.Sc. in Indistrial Engineering, at Los Andes University (Colombia), She received his degrees in Physics Engineer, at National University in 2007. She has been a university professor for the University Antonio Nariño and Open and Distance National University in Colombia and Research Professor of the organizations Management Group.

Nelson V Yepes.completed his M.A.Sc. in Design, Mangament Project at the University International Iberoamerican, Unini (Puerto Rico). He received his degrees in Industrial Engennering in Colombia in 1995. He has worked as an industrial engineer for logistics companies, has been a business consultant and university professor for the University Antonio Nariño in Colombia, is a professor of masters in projects for Fundaciòn Universitaria Iberoamericana (FUNIBER) and Research Professor of the organizations Management Group .

Maria Victoria Cifuentes. completed her M.Sc. in Mathematics, at National University (Colombia), She received his degrees in Mathematics, in the same university in 2009. She has worked as assistant teacher for National University and as an economic evaluator for VQ IngenieraLtda. in a special contract to Ecopetrol S.A.Currently, she is a ninth-semester student of industrial engineering of Antonio NariñoUniversity in Colombia, and a PhD student in Science – Mathematics of National University.