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Mathematical Modelling of Costs and Organizational Development of Cocoa Producers in the District of Guadual, Municipality of Rivera, Republic of Colombia

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Abstract: The domestic agenda for productivity and competitiveness of the Department of Huila includes definite commitment to productive agribusiness by aiming to boost the production and marketing of products as the cocoa. The lack of modernization of crops, the scarcity of work forces, low yields per hectare, market prices, technical absence of the state and the low associativity of the actors in the production chain in the district are problems detected in the studies by the National Technical Committee of the National Council of cocoa. Using MATLAB Software, the identification of the cost and demand functions of cocoa production in the Guadual District is performed. The Guadual District of the Municipality of Rivera is where the 27 cocoa producers immersed in this diagnostic live. In this part of the study, elements were analyzed that were associated with productivity and associativity as well as different social processes within the community. In the district the Guadual the production chain was characterized considering socioeconomic and educational aspects to the climatic and organizational culture to generate an efficient and effective model to increase productivity of the chain in the region. The proposed model is based on changing the behavior of the inhabitants of the village through ongoing training, motivation of individual interests and improvement of the conditions for cocoa producers.

Key words: Production process, cacao, organizational model, the Guadal District, production, community

INTRODUCTION

The economy of the department of Huila is mainly based on agriculture, livestock production and mining as well as oil exploitation, the hidrogenara and trade (Castellanos *et al*., 2011; Hector *et al*., 2005). In Rivera, it is based on two main pillars, agriculture and tourism (Anonymous, 2014a-c; Motamayor *et al*., 2008).

During the investigation of cocoa production in El Guadual, producers of cocoa farms were identified and the factors that in uence the current situation of the population, the reason for low production and own possibilities for improvement were established to describe the production and living conditions of the farmers (Anonymous, 2014a-c; Arpide, 2007).

Finally, a characterization of a development model organization for cocoa farmers in the district the Guadual was elaborated in order to improve the living conditions of cocoa and help increase productivity (Batista, 2009; Santos, 2010; Castellanos *et al*., 2014; Cordova-Avalos, 2014; Somarriba *et al*., 2014).

Literature review

Study area: For the state of the art we can be refer to the assessments by Maryluz Eslava Sanmiguel, Technical Secretary of the Cocoa Chain, made in its management report about Huila: “we provide a fine cocoa aroma where I state that the Committee of Cocoa Huila in 2011 developed the following activities (Fig. 1) structuring of the documentation of the cocoa chain in the department, update of the database of the actors, identification and dissemination of current regional supply and potential suppliers of plant material properties of cocoa certified by the ICA in the department, support of the process approval of two strategic alliances, use of media between actors of the chain, support for training programs and the

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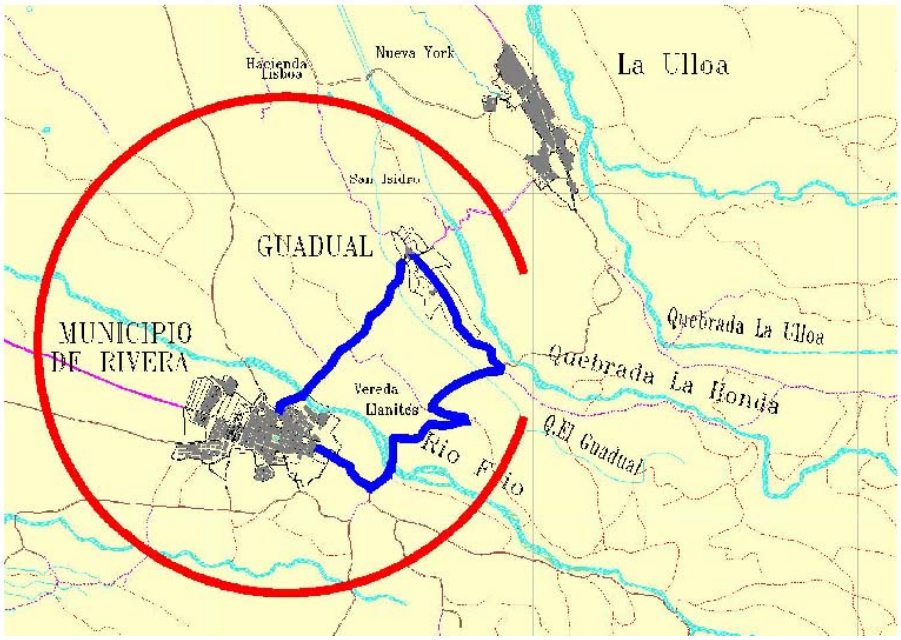

Fig. 1: Location district the Guadual, Republic of Colombia

formulation and implementation of research projects and promotion of cultural activities" (Castellanos *et al*., 2011, 2014).

In the prospective agenda for research and technological development for the cocoa production chain in the Department of Huila, the Ministry of Agriculture has advanced investigative proposals in this regard (Hector *et al*., 2005). With their study in 2007, Castellanos *et al*. used a methodology including surveillance technology to analyze the scientific and technological information about on the production chain (Castellanos *et al*., 2011; Bussenius, 2008; Utomo *et al*., 2016).

The surveillance of the supply chain cocoa-chocolate focused on four aspects: the determination of global trends in cocoa research, identification of trends in technology development, identification of existing national capacities and analyses of the market dynamics of end products. The development of the Surveillance involved establishing an observation period of information which in the study corresponded to the years between 1990 and mid 2007. Additionally, the use of different types of information was needed which for the cocoa-chocolate chain included the analysis of information through scientific research papers published in international journals while the technological development in the chain is evaluated from patents filed worldwide (Castellanos *et al*., 2011, 2014; Onumah *et al*., 2013a, b; Friedman, 2014).

There is no specific studies on the organizational development of the productive chain of cocoa rural area of the Guadual in the municipality of Rivera in Huila or research related to the specific issue referenced earlier.

MATERIALS AND METHODS

Technical considerations: The cocoa cocoa is a tropical tree of the family to which also belong esterculiacias or other trees such as the bottle tree (*Brachychyton populneus*) or the tail tree (Cola nitida, Cola acuminata). Cocoa is scientifically known as *Theobroma Cacao*. This name comes from the Greek God Theosbroma "meaning" food. This name was coined by the botanist and Linnaeus in reference to the importance that this plant had to Native Americans (Anonymous, 2014a, b; Onumah *et al*., 2013a, b; Palacios and Porcell, 2012).

There are about 20 species of the genus. Nevertheless, the most important species is cocoa (*Theobroma cacao*) due to the commercial value of the products that can be obtained from the seeds like cocoa powder and cocoa butter which build the base for chocolate production.

The word cocoa can refer to three closely interrelated concepts: to begin with cacao can refer to the fruit and the seeds of the cocoa, similar to the palm tree, where the cob grows directly from the trunk. Cocoa is also the product resulting from the fermentation and drying of the seeds (or beans or maracas) of the fruit of the cocoa tree. Cocoa, thus, understood is the basic component of chocolate. Third, the dry cocoa powder is obtained by grinding the

beans, meanwhile the fat of the cocoa butter gets totally or partially removed. Traditionally there are three main varieties of cocoa: Criollo, Trinitario and Forastero (Anonymous, 2014a-c).

Most wanted cocoa types and countries that produce them: The ICCO (International Cocoa Organization) established a list of 17 countries producing fine and aromatic cocoas with 9 of them being in the stage of semi production. All major manufacturers of chocolate and homes of famous chocolate use the fine or aromatic cocoas of Criollo and Trinitario (National plus the Ecuador).These cocoas are distinguished by their individual avors: fruity, woody and oral and are also recognized for their color and their structural and agronomic characteristics.

World cocoa production; Growth trends: The Far East replaced Latin America in the third place in world cocoa production it occupied before 2007 because it presented an acceler-ated growth of 2.7% in Indonesia, who exceeded their expected yields at that time. According to the FAO, government policies in that country have driven the expansion of production areas to promote the use of hybrids in conventional plantations (the most profitable product in the last 20 years).

Growth projections in 2010 showed a growth of 2.5% for Latin America with Brazil leading the continent with a growth of 2.2%, although, its production did not reach the levels achieved in the past decade due to the considerable losses suffered in that time. Ecuador experienced a significant progress due to the discovery of a new strain of the disease resistant witches broom cacao.

Colombia has a decline of 3.2% while Africa suffers a decrease of 1% mainly due to the outbreak of diseases such as the edema virus, black rot of cocoa pods and plant bugs, increased competition in the global market and low export prices (Rohan, 1964; Alvarado *et al*., 2014). Ivory Coast, Ghana, Indonesia, Nigeria and Brazil are the main producers who sell their cocoa beans to Holland. The United States, Germany, Malaysia, France and Belgium (Onumah *et al*., 2013a, b; Friedman, 2014).

Colombian internal market of cocoa: The Colombian sector of cocoa and preparations imported about 68.1 million FOB dollars in 2010 which is an increase of 79% over the previous year. This behavior remained constant in 2011. In August 2011 50.9 million FOB dollars were imported, 17% more than in the same period last year. The growth represents a business opportunity for producers in this sector.

Regarding the imports of the Colombian sector, the main line consists of chocolate and other food preparations containing cocoa with 38.8% of imports (FOB value $26, 435, 840.05 for 2010), followed by cocoa beans with 31.9%. Cocoa powder and cocoa paste represent 18.7 and 10.4%, respectively.

The main competitor is Ecuador with 40.9% of imports, followed by Peru and China with 11.6% and 10.2%. It is important to note that of all imports from Ecuador, about 50% belong to the chapter of chocolate and other coca related food preparations; the remaining part is beans.

Regarding the fate of Colombian imports, the department's with the highest international production demand and most cocoa preparations are Antioquia with a share of 55.1% of the national total, followed by the capital of the Republic with 24.2%, the department Valle with 7.7%, Cundinamarca with 3.6%, Atlantico with 3%, Narino with 2.6%, Norte de Santander with 1.8% and Caldas, Bolivar and Sucre with 1% each.

The main national companies that import products and its preparations in the cocoa sector are, first, the National Chocolate Company with 47.5% of total imports ($ 32,390,683.09 FOB value for 2010) followed by Nestle Colombia with 11.8%. Also industries like Ferrero SA and Almacenes Exito are in the top ranks (Castellanos *et al*., 2011, 2014; Palacios and Porcell, 2012; Isaac, 2012; Rohan, 1964; Alvarado *et al*., 2014).

The National Chocolate Company and Casa Luker are major buyers of the current production in the region. Compared to the average price of imports in the sector, a highly volatile behavior is observed, especially, during the months of May and July as it occurred in 2016.

For 2016 an increasing import was observed, reaching a peak in June where an average price of imports and cocoa preparations of $7.3 was recorded.

Colombian Foreign cocoa market: The Colombian cocoa sector exported in 2010 about 73.9 million FOB dollars, thus, registering an increase of 11.5% over the previous year. Exports until August 2011 amounted to 53.2 million FOB dollars, representing an increase of 10.5% over the same period the year before.

From the Colombian exports sector, the most important item is the chocolate sector including other food preparations containing cocoa, with 56.1% of total exports (FOB value $41, 410, 312.78 for 2015). Within this product line such as cocoa powder are added sugar and chocolate in blocks and bars. The second in line is comprised of raw or roasted cocoa beans with a share of 22%, followed by butter, fat and cocoa oil with 13.8% of the export sector. Both preparations, cocoa and cocoa beans, recorded an increase in the volume of exports in 2010, from 39.1 million in 2009 to 41.4 million FOB dollars in 2015 for the case of chocolate and cocoa preparations

and 6,0400000016200000 FOB dollars for cocoa beans (Castellanos *et al*., 2011, 2014; Bussenius, 2008; Utomo *et al*., 2016; Onumah *et al*., 2013a, b; Isaac, 2012).

Organizational climate in Colombia: Will Werhane, Global Director of the Division of Organizational Climate Management Hay Group, one of the most knowledgeable people on organizational climate in the country was giving a lecture on the subject, to help organizations improve performance through engagement, retention of employees and organizational change management and let them know the latest trends in the management of organizational climate (Anonymous, 2014a, b; Onumah *et al*., 2013a, b; Isaac, 2012; Alvarado *et al*., 2014).

The true concept of commitment by Hay Group, defines participation as employees who are proud and want to stay in the organization. In addition, employees are willing to contribute discretionary effort on behalf of the organization. Although, the results may be different for the change between different organization types, there are four main areas that Hay Group determined, that potentially can increase participation levels among employees.

Leaders must provide a clear and convincing way, along with organizational priorities, to ensure that employees focus on higher value tasks. The organization must also provide clear growth and development opportunities for employees which include all new and challenging work as part of the formal process. Ensure that employees at all levels have the tools, resources, structures and work processes they need to do their jobs well. And once employees are in place, organizations should take a step back and provide space for them to get on with their work in a way they know it's best (Anonymous, 2014a-c; Moriarty, 2012; Fuller *et al*., 2014).

Research shows that only commitment is not sufficient to guarantee the performance of the organization, employees must also be able to convert their participation in performance. If they are not promoted, employees will be frustrated. Organizations must ensure that people are depending on using their skills and abilities and to remove the obstacles placed in their way of doing their job well.

Giving priority to the training of employees, reviewing routine tasks to determine how to improve them, providing employees with the specific freedom to take action and recall performance management is something that happens every day not just once a year (Anonymous, 2014a-c; Fuller *et al*., 2014). The two most important factors that lead to trust among employees and a manager is open and honest communication, so, the manager must support its words with actions. Therefore, an administrator can address the lack of confidence to transparency in communicating and implementing monitoring communications with the action.

The Hay Group does not measure this is important but the concept of engagement where employees expressed their pride in the organization and its intention to remain there. The commitment re ects the highest values of all the variables. While the study of the institutional climate is not a tool designed to measure leadership, it sheds important data on the perception of employees about the style of leadership of the organization and the results themselves show a similar trend to the overall results of the climate which are, above average (Anonymous, 2014).

The diffierence between climate and organizational culture lies in the methodological and epistemological diffierences the discussion is not so much about what but how to study.

Climate: The climate researchers, based on questionnaires, tried to characterize specific organizational situations with respect to dimensions and universal principles. Most were Sico Metristas who felt that progress was incremental within the context of this basic approach.

Culture: Researchers of with copious field notes, tried to understand the values and fundamental assumptions that individual members of organizations were adding to the social system of which they took part and how important the meaning or purpose was for the organizational performance.

Organizational climate: refers to a common understanding or a common reaction of individuals to a situation. So, there may be a climate of satisfaction, strength and participation.

Organizational culture: Organizational culture, organizational environment or atmosphere is a set of assumptions, beliefs, values or norms, shared by its members which also creates the human environment in which employees perform their work. Thus, a culture can exist in an entire room or refer to a division, subsidiary, plant or department organization (Bussenius, 2008; Martin and Frost, 2011; Hartnell *et al*., 2011).

RESULTS AND DISCUSSION

Organizational Development model of cocoa, the parcel: la Guadua, Colombia: Based on the article published by Gabriel Garcia (2003), professor at the Faculty of Economics at the University New Granada, Bogota and international references as: Deborah Rupp, Ramsey Awad,

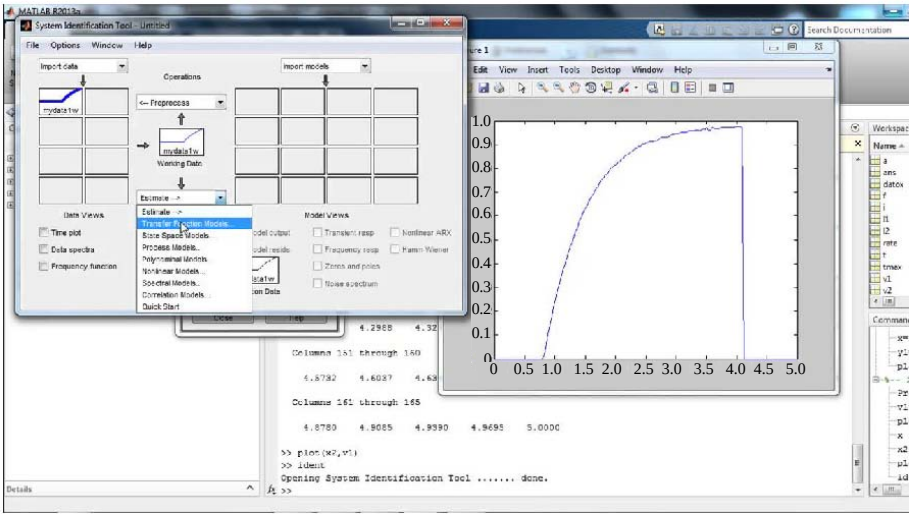

Fig. 2: MATLAB identification toolbox used to process information

Sue Sherratt and Marcus Jefferies; the foundations of a model of organizational development for the community of the district of cocoa "The Guadal" in Rivera in the municipality of Huila result (Nino *et al*., 2009; Rupp, 2011).

Work organizational psychology applies psychological principles in the labor field; its purpose is "to increase the dignity and performance of humans as well as the organizations for which they work to advance the science and knowledge of human behavior (Aamodt, 2015; Tannenbaum, 2015)".

In the present study, the researchers applied a structured survey instrument to characterize the cocoa producers according to different variables: demographic, education, property conditions, access to sanitation, cocoaproduction, inputs, finance, marketing, incentives and assistance from specialized government agencies.

With the information gathered from various sources and using software such as MATLAB and ANOVA, the cost functions, consumer surplus functions were identified and a block diagram of the organizational model was performed (Fig. 2). Afterwards, we plot these results to observe their behaviour and perform the points of discussion.

The proposed model: Organizational development attempts in organizations are sufficient spaces to make the best decisions based on the requirements of the organization to survive in satisfactory conditions, to meet the demands of the environment of the organization (adequacy of laws and regulations, develops opinion public, etc.) and to fulfill individual and social requirements that allow the development of the organization (Fig. 3). For organizational development to

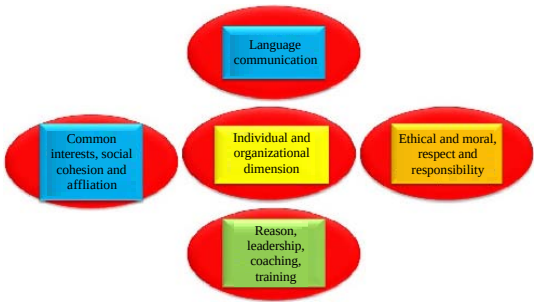

Fig. 3: Model of organizational development of the riverfront of the cocoa district in the municipality of Guadal, Colombia

be effective, organizational change must be generated within the organization. This is not achieved by only changing the culture of its members and of the organization, therefore, it is essential in order to improve the living quality of the producers of El Guadual, to increase productivity in developing economic activities. Thus, there would be an impact on the family, local and regional economy, the grouping of the settlers of the area and improving interpersonal and group relations that allow their permanence in time.

To generate these changes it is necessary to have an external agent tobetter influence the authority of the group, pointing out goals as improving interpersonal skills, understanding among members of the working group, improved methods of conflict resolution management of power within the organization, establishing more human and democratic values and what is most important, to integrate the interests of individuals within the organizational goals.

It is also essential to promote opportunities for the development of the capacity of self-analysis and combat of internal conflicts and suspicions that occur between smallholders, disarming the groups and seeking a compromise with the objectives of the organization.

It seems, through motivational speaking trainings, etc. as they are going to achieve a cohesive group to form a legal organization that lasts over time; gradually increasing the level of trust and support among members of the organization and confrontation of business problems within groups and between groups. Meanwhile, the problems should not be swept under the carpet. It should be created an environment in which the authority in charge is equipped with knowledge-based social skills and authority, increasing the opening of the vertical, lateral and diagonal communications, improving the level of excitement and personal satisfaction in the organization and incrementing individual responsibility and group responsibility in planning and implementation.

The organizational development model proposed is related to change the behaviour using training in order to encourage greater participation and communication in the organization. The method or model most usedin training is role playing. It is necessary to instil the group change for positive results and encourage fellowship and identification of persons in authority. Improve listening skills is a key feature of the model.

Analysing the information obtained during the advance investigation we obtain that the demand function p(x) is the unit price that the cocoa companies have to charge to sell x units of the product. Normally, selling larger quantities requires lowering prices, so that, the demand function is decreasing. From the above, we calculate the demand for the product in dollars is $p = 1600-0.3x-0.003x^2$ (Fig. 4). From this equation we can determine the consumer's surplus when the sales level is 450 as follows: Since, the number of tons of product sold is x = 450, the corresponding price is:

$$P = 1600-(0.3)(450)-(0.003)(450)^2 = 857.5$$

Therefore, from the definition of the sum of Riemann or the consumer surplus we have:

$$\int_0^{450} \langle p(x)-P \rangle dx = \int_0^{450} (1600-0.3x-0.003x^2-875.5)\, dx$$

$$\int_0^{450} (742.5-0.3x-0.003x^2)dx = 742.5x-0.15x^2-0.001x^3\Big|_0^{450}$$

$$(742.5)(450)-(0.15)(450)^2-(0.001)(450)^3 = 238443.75$$

Also, it has been estimated that the production costs of x tons of cocoa is $C(x) = 3600+12x+0:002x^2$ (Fig. 5), the average cost function can be obtained as:

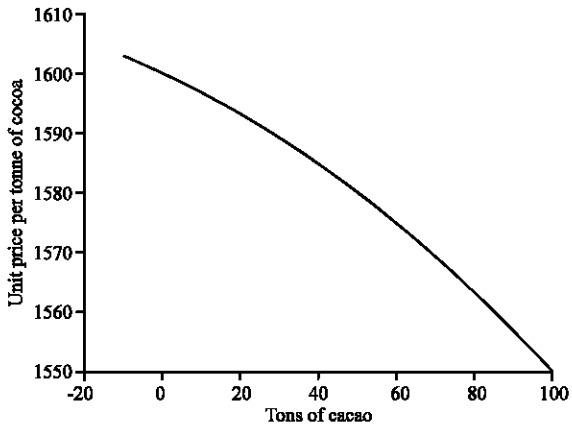

Fig. 4: Demand curve

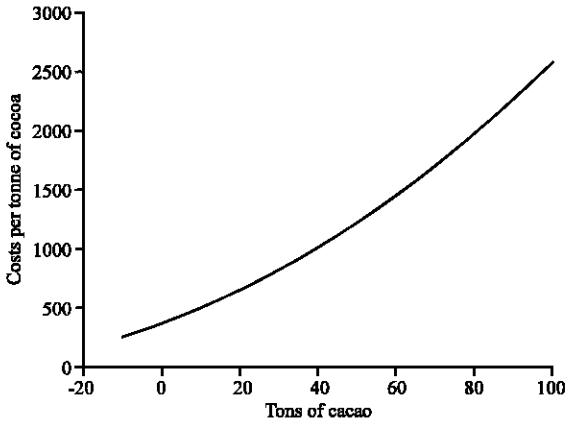

Fig. 5: Cost function

$$C(x) = \frac{C(x)}{x} = \frac{3600}{x}+12+0.002x$$

From the above equation, we obtain the marginal cost equation as:

$$C'(x) = 12+0.004x$$

Expressions are used to fill the following table which provides the projection of cost, average cost and marginal cost (in units per million tons of cocoa, rounding to the nearest hundredth) (Table 1). To minimize the average cost of cocoa production can be obtained as follows:

$$\text{Marginal cost} = \text{Average cost}$$

$$C'(x) = c(x)$$

$$12+0.004x = \frac{3600}{x}+12+0.002x$$

This equation reduces to:

Table 1: Cost table

x	C(x)	C(x)	C'(x)
1000	17600	17.60	16
2000	35600	17.80	20
3000	57600	19.20	24
4000	83600	20.90	28
5000	113600	22.72	32

$$0.002x = \frac{3600}{x}$$

So that:

$$x^2 = \frac{3600}{0.002} = 1{,}800.000$$

And:

$$x = \sqrt{1.800.000} = 1.341{,}64$$

We can observe that this level of production provides a minimum that will allow us to deduce the minimum cost, we observe that, so that, c is concave upwards in the whole domain. The minimum average cost is:

$$c\,(1.341,\,64) = \frac{3600}{1.341{,}64} + 12 + 0.002\,(1.341,\,64) = \$17.36/\mu m$$

These values approximate the values that can be observed in companies like Barry Callebaut Group and Blommer Chocolate Co. (Blommer, 2011).

The survey to characterize the Guadual district characterizes the family type as an adult population of more than 66 year, catholic, composed of a strong family, most have two to three children and have received theoretical training practice about cocoa production, most of them from the national Federation of cocoa (workshop type). The social layer of the districts show the following distribution: High zone is strata one, the middle zone is strata two while the lower one is stratum three. The population of the district has a Guadual income between one and two times the minimum wage and the level of primary education is mostly public.

The extensions of cocoa fields are mostly 2 ha and a gathering at the site is carried out every 21 days. Monthly, <100 k/ha are harvestet and the owners claim that the price of cocoa is very low and does not give stability for high production. The original habitants of the village contemplate an improvement of the production chain with technical assistance, agricultural inputs, training, handling of crops, identifying an increase in productivity and obtaining a high quality cocoa at reasonable prices which will be reflected in the quality of life of cocoa farmers and strengthen their organizational development.

The measuring instrument (Survey-56 Questions) allowed to gather information to propose a model of organizational development, applicable to other villages in the Department of Huila.

CONCLUSION

The model of organizational development for the Cocoa village is one where the Guadual facilitates agreements and balances the individual and organizational dimensions. Furthermore, it supports deep respect (ethical and moral), a structured language, a common interest and the use of common sense.

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