CHAPTER 5

BIOFUEL VALUE CHAINS
AND
CONTRACTUAL RELATIONSHIPS

The following section will present a complete description of how value chains work within the biofuel industry and how legal and informal arrangements are establish to ease these chains' functioning. This description is particularly useful to understand how benefits and responsibilities are distributed from a socioeconomic perspective.

The concept of a chain makes reference to a holistic vision of a productive process, which allows proper observation of different links, thus it is possible to see the representation of new forms of new scenarios and bonds which are developed in an economic system, that imply the coexistence of a set of parties and activities that are inextricably interconnected to obtain a product in a given space (Kaplinsky & Morris, 2001). This concept and analytical approach is a fine tool to explain the economic reality of a particular industry. In Colombia the "Chain Approach" has been adopted as a tool to design and implement public policies for the agricultural and agribusiness sectors (Gilbert, 2008).

Agribusiness biofuel chains, which have their final link in energy provision in the form of a liquid carrier, are highly privileged because of the interactions that they represent. On the one hand, they utilize feedstock and primary crude materials from the agricultural sector, but they also offer and demand products, services, and money flow up and downstream. Government, as a dynamic agent, must intervene in sundry aspects along the chains, with the purpose of regulating, stimulating, monitoring and controlling some of these parties and their corresponding actions.

5.1 FEEDSTOCK PRODUCTION AND COMMERCIALIZATION

5.1.1 Land Use in Colombia and its relationship with bioenergy

The unit of agricultural studies of the DNP (Departamento Nacional de Planeación – National planning department) has made projections on the utilized land area for agriculture and livestock farming for 2010 to 2019, including in these projections the latest progresses in efficiency in both fields. The table below is a more complete version than the one presented in Chapter 3 shows these results, contrasted with some internal data provided by FEDEPALMA, and with forecasted results on sugarcane crop performance. It also uses some information from the Ministry of Agriculture on the plantations for commercial forestry purposes, forestry for preservation, and some data on jungles and natural reserves. Finally, the Instituto Geográfico Agustin Codazzi —IGAC— (Agustin Codazzi Geographic Institute) specified some indiscriminate data on rivers, mountains and cities from the survey that took place in 2004.

Table 5.1. Current and forecasted land use in Colombia (Million ha)

Concept	2007	2010*	2019*	2019 * (including biofuels)
Agricultural land without energy feedstocks	4.58	4.58	4.54	4.54
Palm oil for biodiesel	0.00	0.16	0.80	2.12
Sugarcane for ethanol	0.04	0.08	0.15	1.00
Agricultural land (subtotal)	**4.62**	**4.82**	**5.49**	**7.66**
Livestock and fallow land	38.87	33.90	27.50	24.65
Agricultural land (Total including livestock)	**43.49**	**38.71**	**33.00**	**32.32**
Commercial forestry	0.26	0.35	1.36	1.36
Protected forestry land	7.21	7.21	7.21	7.21
Forest	38.90	38.90	40.60	40.60
National parks and reserves	9.00	9.00	9.00	9.00
Forest and reserves (total)	**55.38**	**55.47**	**58.17**	**58.17**
Cities, rivers and mountains	15.31	19.99	23.00	23.68
Total	**114.17**	**114.17**	**114.17**	**114.17**

*** These calculations are based on the projections of the PNBs**

Source: (Infante & Tobón, 2010; Fernández Acosta, 2009 #499)

Evolution of the agricultural sector is shown in the previous table. In particular, it can be seen that the last 2 columns represent future scenarios. In the very last columns it is shown an aggressive plan put forward by the Ministry of Agriculture, where by in 2020 the land for ethanol production will increase by up to 1 million hectares and the area destined for biodiesel feedstock crops will reach 2 million hectares. That will be noted as scenario 1. The other projections (plain 2019) correspond to a scenario where it is assumed to follow the ongoing production trend. That will be noted as scenario 2.

Following the initial scenario, i.e. under an active biofuels production scenario it is thought that the destined territory for biofuel plantations would grow from 0.24 hectares to 3.12 in a time span of 9 years. Such a projection would imply agricultural arrays 13 times bigger than present, to cope with biofuels demand, in less than a decade. In other words, this change would require an annual growth rate of approximately 33.25%. In the second scenario the growth of this area is more discrete, starting at 0.24 hectares in 2010 and ending up with 0.95, which corresponds to slightly less than 4 times the production of the beginning of the decade. That is an average annual growth rate of 16.51%.

In the 2 scenarios the projections are more favorable to biodiesel production rather than ethanol production. In the first situation, by 2019, the planned area destined for palm plantation is 13.25 times the one presented in 2010. This can be seen as an annual growth of nearly 33%. In the case of ethanol production, the plantations destined for sugarcane need to develop at a similar pace (only slightly less). In the second scenario this dissimilarity is more obvious: while palm area develops a speed of 19.58% per annum, sugarcane would require a growth rate of 7.23%.

There is no substantial negative effect on the agricultural frontier in terms of direct food and feed provision in either scenario. Despite this great progress for biofuel feedstock plantation areas, the subtotal agricultural area does not seem seriously affected. The agricultural land destined for other purposes different to bioenergy crops will decrease 0.04 million hectares in 9 years, under either situation. However, the agricultural land destined for bioenergy and agricultural crops together will grow at an average pace of 5.28% in the pressure scenario, whereas just at 1.45% in the "no-rush" plan.

Of course land destined for bioenergy projects must be taken at the expense of other alternatives. According to these forecasts, the burden of cost will be on the fallow and livestock farming land, which falls by 6.4 million hectares between 2010 and 2019 in the less active scenario, and 9.25 in the other one. It is important to highlight that these reductions are not that significant if it is assumed that it was caused entirely by biofuels production. Based on those numbers presented on the table, only 11.09% and 31.13% of such reductions could be explained by bioenergy projects implementation, for the non-active and active scenario correspondingly. It is important to note that as in most cases, projections of expansion can be overestimated, as was illustrated with the American, Peruvian, and European cases in chapter 2.

Despite the allegedly minor effect of these lands conversion, it must be taken into account that cattle displacement could be costly financially and environmentally. The other option is using fallow land, which also has some implications. If those lands are deteriorated marginal lands, then bioenergy projects could be a very attractive choice in terms of profit, in the sense that they could invigorate depressed rural areas. If other feedstock varieties are contemplated (even those such as Jatropha) and the implementation needed to create the new agricultural array involves land clearance, particularly using burning methods, it could result in appalling consequences, by releasing all the carbon embedded underground and new carbon by the combustion effect (Achten et al., 2007; Romijn, 2011).

Additionally, it must be advised that bioenergy crops should be added to food crops, instead of substituting them, given that so far the feedstock used to produce biomass-based energy do not clash with food provision, but it is taken from that destined for export. Under any circumstance it is extremely important to keep monitoring land use, because the best agricultural lands should not be used for harvesting palm or sugar, for energy purposes.

There are some constrains in term of land quality in Colombia. Despite the recognition that there is enough land available for bioenergy projects, some areas are barely usable within government projections. For instance, in the eastern region of Colombia, there is a zone called the "wavy reef" in Orinoquia, a Colombian department, which has an land area greater than 6.4 million hectares that is hardly productive whether in agricultural projects or in cattle farming initiatives (Sánchez & Cochrane, 1985).

So, a real barrier to be tackled by Colombian bioenergy initiatives, under the Plan Nacional para el desarrollo sostenible de los biocombustibles —PNBs— (National plan for sustainable Biofuels Development) is to obtain enough land to cope with the ambitious demand. There are lands available in the eastern region (with some limitations as referred previously) and others in the Caribbean zone with good prospects to plant palm in particular. However, it is unwise to forecast large agricultural arrays, because:

- current land owners are hesitant to participate in biofuels initiatives,
- diversity in soil qualities,
- varieties of climates and heterogeneity in quality.

Despite these possible setbacks, there are documented successful experiences within these areas with biodiesel based enterprises. There are some cases where natural conditions do not permit to classify the used lands as suitable for cropping either. The experience with the sugarcane programs, leaving out those implemented in the Cauca Valley region, is quite limited in terms of documentation.

5.1.2 Production of palm oil

In Colombia the production of palm oil is relatively new. The first attempts to introduce palm oil took place during the early 1930's, but the plant was used for decorative purposes. It was not until 1945 when commercial plantations were setup in Buenaventura (on the Pacific coast) and Aracataca, close to the Caribbean coast. Central government asked the Cotton Promotion Fund to encourage these palm arrays for economic purposes, in the first half the century, and since then palm crops have grown significantly.

Given that palm trees were well suited to Colombian climate conditions; their expansion has been rapid and wide throughout national territory, with a presence in at least 11 out of 32 departments (geographically equivalent to states in other countries). About 34% of the planted area is located in the eastern region of Colombia (Casanare, Cundinamarca, Meta and Caqueta), 31% is within the Northern region on the Atlantic coast (Atlantico, Magdalena, North Cesar), 24% in the central region (Santander, North Santander and South Cesar) and the remaining fraction in the south western region (Nariño) (Infante & Tobón, 2010).

The palm industry has brought noticeable economic and social impact within the mentioned regions, and it has been one of the most dynamic agricultural sectors since the 1980's. Nowadays, it creates more than 16 thousand direct jobs and over 32 thousand indirect jobs (FEDEBIOCOMBUSTIBLES, 2010b).

Crop expansion of palm trees has been remarkable during the last 3 decades. In 1980 the planted area accounted for 31 thousand hectares, while in 2008 plantations covered around 335 thousand hectares. This would imply that the area planted has increased by practically eleven-folded in a period of 18 years, which is an average growth rate of 8.87%. It is important to keep in mind that these areas provide oil for both cooking and biodiesel use.

During the 1980's, planted areas grew on average 7690 ha/year, whereas during the 1990's this number dropped to 4790 ha/year. However, since 2001, due to vigorous promotion on the benefits of palm agriculture the statistics shown production reached an average of 24,518 ha/year. This represents an introduction of nearly 180 thousand additional hectares, so 54% of the current area was planted during this period. Two zones with the highest participation in this outstanding advance have been the ones located in the eastern region (38%) and northern region (30.4%) of Colombia. The contribution of the central zone has been important as well (23.6%), while the south-western region has shown some progress but not as significant as the other regions (9%). Thus, trend suggests a concentration of diesel bioenergy projects in the northern and eastern regions, followed by the central region.

Despite the fact that most land for new plantations has been taken from cattle farming, it is also true that to a minor extent, some land previously dedicated to rice crops have turned to bioenergy production, particularly in those northern and eastern regions in Colombia. Yet, the total area utilized for rice growth has not decrease. On the contrary, it has increased, between 2002 and 2011 it went from 408 to 430 thousand hectares

(FAOSTAT, 2011). The accelerated growth of palm plantations is a result of several factors:

- Rampant international prices for vegetable oil, in particular palm oil, which started in 2001 and maintained its level until 2008. This fact had a positive impact on the profitability of the biodiesel industry.
- Upbeat policies, news, and expectations around the sector created an attractive environment for investing.
- Being part of the eligible crops within the ICR[1] destinations, boosted initiatives to start new plantations. In addition, flexible credit systems for the sector eased the access to required lands, resources and equipment.
- The decision taken through law 818 of 2003 to create exemptions to those slow-maturing crops covers palm oil, and with the benefits lasting 10 years from the beginning of production, the farmer (or investor) has enough time to recover financially. However, it is important to bear in mind that this incentive can be applied only to those plantations that have not benefited from any other public resources.
- The improvement of safety perception in rural areas has raised interest in new investors. In addition, several firms have allowed access to this market to third parties to act as feedstock suppliers, contributing to an improved social and economic environment for the surrounding population.
- The implementation of incentives to create productive alliances between small-scale, medium-scale, and large-scale feedstock producers, and processing plant owners, predominantly those flexible and long-run credits with publicly subsidized interest rates.
- The possibility to have new markets for palm oil, apart from the already exploited (vegetable oil). So biodiesel and its by-products are an attractive option for agricultural developments.

Because palm oil trees are considered a variety of slow-maturing plant, planted area can be classified into two different categories: the one that is in a developing stage, and the one that is production already. There is an initial period of about 3 years where the palm is unproductive. Afterwards, productivity will gradually increase until its potential is fully developed for approximately 30 years.

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[1] Incentivo de capitalización rural – Rural funding incentives.

Despite the fact that palm plantations have extended rapidly throughout Colombia, there is no corresponding effect in terms of productivity, particularly during the last 15 years. If truth be told, it was observed that between 1994 and 1999 the average yield of crude palm oil was 3.6 tons/ha. Right after 2000, productivity rates grew to 4 tons/ha, and was maintained until a period between 2006 and 2008 where the rate dropped to 3.56 tons/ha, which is quite similar to the level experienced during the last part of the 1990's.

This productivity level is comparable to that achieved in other countries such as Costa Rica and Indonesia, that produce nearly 3.7 tons/ha. But, competitiveness in terms of yield per area in the palm sector are led by Malaysia (4.2 tons/ha) and Papua New Guinea (4 tons/ha) (Mielke, 2008). According to FEDEPALMA projections, Colombia is ready to reach 5.5 tons/ha by the year 2020 (Fedepalma, 2000).

There is a very wide range of outputs per hectare in Colombia. The predominant factors are:

- to what extent farmers are capable of introducing appropriate technologies
- and to what extent they are willing to put into practice advanced agricultural methods on the field.

So, there are reports of some plantations with 2.5 tons/ha of crude palm oil, while at the same time, there are others with 6.3 tons/ha. Such divergence in the outputs has been explained by the fact that some low-yield varieties were introduced at the beginning of the program as an experiment. Additionally, the majority of the farmers could not use good quality seeds, due to a low availability, taking into consideration the necessity to adapt to the particular conditions of different productive zones (Mosquera Montoya, Bernal Hernández, & Silva Carreño, 2009).

Furthermore, those programs directed to enhance seeds genetically are under the control of CENIPALMA, who have only recently been active, and have been facing several barriers. Among them, is the low availability of material with the required agro-industrial features, but also underuse of available genetically modified material already developed. These progresses in the genetic front would help not only to widen those varieties that are commercially accessible in Colombia, but also to gain resistance to diseases such as pudrición de cogollo (bulb decay) and marchites letal (lethal withering) (Cenipalma, 2000; Fedepalma & MAVDT, 2011).

The only zone that has been capable of continuously improving its productivity is the one located in the central region. By 2010, this region had achieved its highest average yield (4.6 tons/ha), and unlike other regions, it has not been affected by the decreasing trend of the recent years found in other regions. Meanwhile, in those plantations located in Nariño the productivity has reported the lowest average yield, near to 2.9 ton/ha, whereas in Eastern and Northern regions registered yields have exhibit 3.3 and 3.5 tons/ha respectively (Infante & Tobón, 2010). These reductions have been caused mostly by the diseases mentioned early, which has had substantial impact on the south-eastern region. Another factor that contributes to such yield diminishment has been the notorious change in climate behavior, in particular the presence of lengthy rainy season leads to biomass decomposition.

These observations are not isolated whatsoever: the low yield phenomenon in the processing stage has accompanied the low yields in the agricultural stage, i.e. fruit output per harvested hectare. The average as reported between 2000 and 2005, was 19.3 tons/ha, but between 2006 and 2008 this yield dropped to 18 tons/ha.

Thus, the current state of affairs indicates that the introduction of high oil content fruit has not had the expected effect on commercial output. As a matter of fact, the ratio of the amount of vegetable oil per ton of fruit has remained steady for the studied period. This indicator is vital to analyze the performance of the industry as a whole, because it includes both the agricultural and the processing performance.

Based on the aforementioned, it can be concluded that in the last 17 years, there have been no substantial advances in the processing stage, in charge of oil extraction (Infante & Tobón, 2010). By incrementing efficiency in extraction plants it is possible to maintain oil yields, despite low fruit outputs. This data represents a huge opportunity for the Colombian biodiesel industry, given that most of the extraction plants are not concentrated in a kind of cluster, but instead they are spread out, and they usually work under a small-scale scheme and in some cases their production capacity has been underused.

Agricultural structure of palm oil production

According to data published by the RNP Registro Nacional Palmero (National Records for the Palm oil industry) in 2008 it was reported that 3245 palm oil productive units existed (i.e. agricultural land arrays for palm trees plantations, regardless of the ownership of a processing plant). The majority of these units have a relatively small area, meaning that more than 80% of them have less than 20 hectares of land.

One possible interpretation of such a phenomenon is that the participation of small farmers within the palm industry is significant, however, data proved otherwise. By 2008 land distribution among the units was extremely uneven, up to 76.7% of land concentration was in less than 10% of the productive units, which have more than 200 hectares. As a matter of fact, those large-scale plantations that use more than 1.000 hectares represent barely more than 1% of the units and yet, they have slightly less than 40% of the whole area (225,474 hectares).

In general terms, it has been established that the average plot size for palm plantations in Colombia is 70 hectares, which is quite small if it is compared with the world top producer, Malaysia, which has an average plot size of 1800 hectares (Sumathi, Chai, & Mohamed, 2008). Recent plantations show a trend of increasing in size for biodiesel purposes, reaching levels of 5000 hectares.

High concentration arrays are resulting as a consequence of the oil extraction industry, which has established an optimal standard of efficiency that is reached when the surrounding plantations covers between 7,000 and 10,000 hectares. Such technical assessment leads to two potential strategies:

- the first one would imply building a policy framework that eases the purchase of enough land for these large agricultural arrays,
- the second would operate by encouraging and engaging small landowners around processing plant to work together to create large parcels and act as a common production unit.

Contractual arrangements in palm oil production

The relationships established between oil extraction plants and feedstock agricultural suppliers are quite informal. In general, they are characterized by the lack of formal tools and documents that regulate and provide stability to both parties. Such situations, in principle, make it difficult to record and analyze these verbal and goodwill arrangements. There are three possible ways to organize the fruit supply system to oil extraction plants:

1. by acquiring crops to be processed by the plant owner under a single proprietorship of the whole chain,
2. by creating an association of feedstock supplier-manufacturer (either way resulting in productive units with extraction plant),

3. an arrangement where independent farmers can have access to extraction plant facilities to process palm fruit. Under this procedure the agricultural producer owns the extracted oil, and there is no obligation to sell it to the plant owner. However, plant owners can act as vegetable oil intermediaries and they can eventually purchase the oil produced by the farmers.

In 2008, only 44 out of 3245 production units were associated to extraction plants. The land occupied by these units accounted for 85,183 hectares. The remaining units hire the plant services to process their fruits, obtained in a surface area of 140,291 hectares.

5.1.3 Sugarcane production

The Cauca Valley has optimal conditions for growing sugarcane. It is located at an altitude of nearly 1000 meters, is has an average temperature of 25°C, relative humidity of 76% and an annual precipitation of 1000 mm. Cauca Valley boasts great fertility in its soil and good physical conditions. This region is one of the 4 zones in the world where it is possible to grow sugarcane all year round.

Currently there are 495,000 hectares covered with sugarcane crops. These plots can be categorized in 2 different types. The first one is used for panela production and it has a dedicated area of nearly 253,000 hectares. Panela is an unrefined crude sugar with a high content of sucrose and fructose, which is sold in a brick shape, and is obtained from the evaporation of sugarcane juice. The second category planted with sugarcane (approximately 41%) is utilized for refined sugar production (H Martinez, Espinal, & Ortiz, 2005).

These two varieties of sugarcane are different in their purpose but also in location, yield and sugar content. In fact, the Cauca Valley region has been traditionally used for sugar production since the 16th century (Asocaña, 2009), whereas the predominant region for panela production has been in the central region of Colombia, in the departments of Santander and Boyacá (along the basin of Río Suárez) (H Martinez et al., 2005).

Sugarcane for panela production is one of the main segments in Colombian agriculture, and it is mostly developed by small-scale farmers. Because establishment of these initiatives is quite informal, it is difficult to collect reliable statistics for the sector, however, it has been estimated that this form of agriculture has nearly 70 thousand productive units. The way to process biomass (obtain its juice) in this case is by using old-technology, i.e. animal powered mills in most cases, and afterwards juices are boiled, clarified, beaten, and left until cooled. The whole processing station from juice extraction to panela packing is called trapiche. According to an FAO report, it is believed that by 2008 there were roughly speaking 15 thousand trapiches. Therefore, the impact of this activity on rural jobs is very significant, based on rural statistics collected by the Ministry of Agriculture: by 2005 the panela sector employed more than 350 thousand farmers, putting the sector as the second largest employment generator in the countryside, right after the coffee industry (H Martinez et al., 2005).

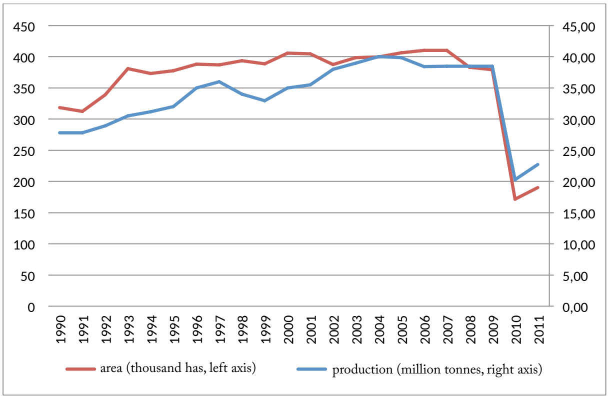
Sugarcane crop for panela purposes has been widespread in Colombia because it has high adaptability to different ecosystems and environments. For example, it is able to be planted on steep mountains, unlike other products. So, this crop is harvested all year round in nearly every department within Colombia, however, at least 70% of is production is concentrated in Antioquia, Cundinamarca, Nariño, Santander and Boyacá.

One of the policies of the central government has been to engage the panela production sector into bioethanol manufacture. Several efforts have been implemented to boost this possible alliance. Research programs and technology transfer dynamics have been put into motion to enhance productivity and to provide farmers with managerial and entrepreneurship training. In fact, some of the actions have been addressed to apply a bioethanol production model specifically with panela-sugarcane, to the extent of building pilot plants based on such feedstock. The results achieved so far have not been as expected. In Barbosa, Santander, a pilot plant was established after an investment of US$3million and with an installed capacity of 5000 liters/day, and with the purpose of using 200 hectares of land. Nevertheless, this experimental plant had to be closed because vinasses (waste product) could not be treated properly and caused land and water pollution. It is being discussed what to do with the plant, and one of the contemplated alternatives is to allow the Industrial University of Santander to carry out some experiments ("Plantas de etanol…", 2010). If some of the main setbacks can be explored and overcome, the plant can be used for demonstration and then start a dissemination process of these technologies around Santander region. There is a similar plant under construction in Frontino, Antioquia, however, in this case it was planned from the beginning to be managed by the University of Antioquia ("Plantas de etanol…", 2010).

According to the Asocaña database, sugarcane production has grown steadily. Since 1980 sugarcane production has increased from 11.5 million metric tons to nearly 22.2 million. Sugarcane growth has accelerated particularly in the period between 1986 and 2004, with a small exception during 2001, which exhibited a production slump (ASOCAÑA, 2012).

During 2006, the level remained stable but the subsequent two years experienced a serious downturn as a consequence of an increase in rain levels. This situation also coincides with a conflict with the plantation workers, in mid–2008.

Figure 5.1. Sugarcane production in Colombia



Compiled by the author. Data source FAO 2013

In 2010, due to "La Niña", plantations were severely affected by unfavorable climatic conditions, affecting expected yields, not only in Colombia but in the rest of South America as well (Asocaña, 2011).

Growth of sugarcane production comes as a result of a continuous increase in the planted area, along with more efficient land management methods. On one hand, the cultivated surface maintained a steady increase between 1980 and 2008, undergoing a change from 133 thousand cultivated hectares to 206 thousand.

There is of course a gap between the area that has actually been planted and the one that is actually harvested. This difference is due to different factors, such as plagues, diseased crop, climate alterations, among others.

Based on the trend of cultivated area, it is possible to separate the agricultural behavior of sugarcane in 3 sections or stages:

1. During the first stage, from 1980 to 1989, there is no a substantial increase of the sown surface, maintaining an average of 136 thousand hectares. At the beginning of this stage, the harvested area was nearly 43 thousand hectares below the cultivated level, which implies that two thirds of the cultivated area was productive. At the end of the stage, this gap closed and the difference between cultivated and harvested areas was only of 24 thousand hectares, reaching a profit on cultivated area of 83.2%.

2. Between 1989 and 2002 the second stage was developed, which registered the highest growth rate within the three studied decades. In fact, cultivated area was enlarged by 41% during this period. The main reason for this is that sugarcane progressively occupied more of those terrains that were initially used for other purposes, such as soybean, sorghum and cotton, due to the low profitability of these crops, exacerbated by the political decision called "apertura económica" in 1991, retracting the mechanism to protect these lower value crops which was accentuated for the political decision of the economic opening promoted by the Constitution of 1991. Along with the reduction of possibilities for some of these commodities, some opportunities appeared for other products; and in this case, the sugar industry was favored by the liberalization policy, because it expended in to new markets, different to those already established (CAN and American quota). This stage was characterized by high fluctuation in harvested output, and it was possible to achieve productivity close to 100% of the planted area on two occasions: in 1996 and 2000, near to 180 thousand hectares in both cases.
3. Before the end of the second section stage, there was a subtle reduction in the cultivated area (in 1999) and the effect of this setback was felt during a part of the last stage, which goes from 2003 onwards. This situation was evident until 2006, and afterwards it recovered its pace only slightly. This stagnation might have been due to a shortage of available land in the Cauca Valley. Nowadays, most of the growing trend is explained by using marginal lands.

It is worth mentioning that the introduction of bioethanol plants in 2005 has not had a substantial impact on the planted and harvested areas. Basically, alcohol fuel has been produced based on the already cultivated surface and, as has been mentioned previously, the required feedstock comes from sugarcane that would otherwise be used for export.

The productivity of this crop has fluctuated around 120 tons of sugarcane per hectare. There have been some moments, like in 1995 and 2001, where this productivity fell, reducing the average to 105 tons/ha. It is presumed that such low performance can be explained by poor agricultural management. Notwithstanding this, since 2002 the yield has remained relatively stable.

With this in mind, productivity (in terms of the yield of sugarcane per hectare) has not exhibited substantial progresses. Crop productivity performance (in terms of the yield of sugar per hectare) leapt from 8 tons/ha to 12.4 tons/ha from 1980 to 1992. Since 2002 this level has kept above 13 tons/ha, that means an increase in sugar productivity near to 60%.

Another indicator of crop performance is the amount of sugar that is obtained by every ton of sugarcane used. This value would give an insight of the commercial yield and the industrial efficiency of the crop. In 1980 this ratio was 9.4% and it rose to 11.9% in 2006.

An analysis of this situation leads to the conclusion that farmers have achieved a better output of sugar per hectare, which indicates an improvement in soil productivity. This has been a direct result of implementing better agricultural practices, which includes the introduction of varieties with higher sucrose content and short-maturing kinds.

The addition of new techniques and technologies to the sugar processing industry from its agricultural stage to its manufacturing comes as a result of a very solid system of technology transfer, led by CENICAÑA, and by ingenios themselves, in order to disseminate and put into practice those agricultural advancements that increase the amount of cane per area and shorten the maturing cycle of the crop. Some other factors than have positively affected industry performance as a whole, are:

- the rise in the educational level of the nearby population, agro-entrepreneurial training,
- innovative capacity and economic solvency of the farmers, which is predominant in the Cauca Valley region.

Agricultural structure of the sugarcane production

In the sugarcane crop industry there are at least 2200 productive units, which are mostly represented by medium-scale farmers, with an average size of 92 hectares per unit. It has been calculated that 40% of them have a size between 50 and 200 hectares, and occupy 44% of the entire area used for this purpose in the region.

Thus, close to 50% of these units have an area less than 50 hectares, and they employ 14% of the whole surface used for sugarcane cropping. This suggests two phenomena about the sugar industry: the first one is that land concentration still remains high, and the second one that small-scale agricultural entrepreneurs have an important participation in the market. The latter corroborates that there has been a continuous division of properties and large agricultural arrays that were predominant in the times of the colonial Spanish influence. Today those parcels that exceed 500 hectares for sugarcane cultivation represent only 12.5% of the agricultural units. Those lands used for sugarcane crops in the Cauca Valley region benefit from a great irrigation infrastructure, given that 48% of the sown surface has access to superficial water sources, and 16% use underground water springs. Only a small fraction of land does not receive irrigation (1.2%). The remaining fraction uses a combination of both shallow and underground water. In the Cauca Valley region road infrastructure and supply utilities are appropriate to cover the industry needs.

Contractual procedures in sugarcane production

Unlike the case of the palm oil industry, the supply system of the sugarcane provision to processing plants, either for sugar manufacturing or alcohol fuel production, is well organized and its structure has foundations in several agreements between farmers and processing plant owners. These agreements have been designed and evolved during a number of years and they take into account technical, economic, legal, commercial and cultural elements, providing a flexible framework adaptable to the conditions described or required for each agreement mode.

It is crucial to understand land proprietorship and distribution around those grounds linked with the productive process. Ingenios (or sugarcane processing plants) own 24% of the total cultivated area. So, the remaining land is owned by third parties under different management agreements. In fact, slightly less than 103 thousand hectares out of 152 thousand hectares are directly managed by independent owners, representing 51% of the whole area for cultivation. Ingenios handle the rest of it through diverse kinds of associations (described below).

In terms of Colombian agriculture, the sugarcane industry presents a truly peculiar characteristic – there are just a few cases where there is no formal contract between farmers and manufacturers (these examples account for less than 4% of the total cultivated area).

Sugarcane price is inextricably linked to sugar price; hence, the price of feedstock does not follow supply and demand dynamics. Usually payment to farmers is through a contract where there is a shared risk, which is a common system utilized around the world (Buchanan, 1975; Keerthipala & Thomson, 1999; Moor & Wynne, 2001).

The type of contracts mentioned above, have been categorized in some official documents (IDB, MME, MADR, MAVDT, & DNP, 2012; Infante & Tobón, 2010; Londoño, 2012) and are described as follows:

Contract of sale:

This sort of contract is applied to those farmers that undertake all these tasks related with production: land preparation, required infrastructure provision, payment related with the agricultural process, application of agricultural practices recommended by CENICAÑA, etc. In this case these farmers, acting as independent suppliers, have an entirely commercial relationship with the processing plants.

In such contracts, sugarcane payment is done under a fixed predetermined amount of 58kg per ton of sugar. This number has been calculated based on assessments of sucrose content (which is 11.6% in Cauca Valley conditions). Thus, 50% of sugar yield value belongs to the farmer, and the other half is paid to the ingenio as reimbursement for its processing services.

If it is taken into account that farmers and manufacturers income hinge on the sugar market, then sucrose content and not sugarcane weight indicates the real remuneration factor. Nowadays, near to 48% of cultivated area operate under this “contract of sale” mode and include clauses that make it explicit that the payment would be based on the content of sucrose rather than the sugarcane weight. Thus, any parameter that directly affects this indicator, such as sugarcane handling, storage, and transport, should be considered in the contractual conditions.

The duration of these sorts of contracts are directly related to the productive cycle. They are generally negotiated to finish simultaneously with the life span of the sugarcane stock, which is close to 8 years. In most cases some sale exclusivity clauses around the feedstock are established.

Contracts in participation accounts

Under this mode farmers give their land to processing plant owners and the latter assumes full responsibility of the sugarcane life cycle from the planting stage until the harvest. Unlike what happens in regular sale contracts, landowners do not take part in the production process whatsoever. In this mode ingenios carry out all duties required for sugarcane production, likewise they bear the burden of all associated costs. Land proprietors receive a remuneration based on the content of sucrose, i.e. the number of kilograms of sugar that can be extracted from a ton of feedstock. A reference parameter that is commonly used is 25kg of sugar per one ton of sugarcane.

Just like the contract of sale, in contracts of participation accounts, sugarcane payment will change according to each area’s production capacity and cost of cutting, handling, transporting and storage, so the range of payments can start from 20kg up to 35.3 kilograms, after the corresponding adjustments and discounts.

For this kind of contract there is an additional factor that defines terms of negotiation – the required investment for land preparation. Thus, if the processing plant incurs a large financial outlay, there will be a proportional discount in the payment that the landowner will receive. The lengths of these sorts of agreements are generally for a fixed period of 10 years. At the end of the period the ongoing stocks will be property of the land owner.

Contract of land leasing

Under this type of contract landowners will receive a fixed value or lease rental per planted hectare, based on the amount of kilos of sugar per ton to be paid by the lessee to the land owner. The reference parameter that is normally used is 120 kilograms of sugar per rented hectare monthly. Nevertheless, this number is used only as reference because there are several contracts that agree to pay a different sum with a wider variation than the former 2 modes.

Contract of land administration

This sort of agreement is applied to a very specific and small number of suppliers, which in most cases have a direct connection with the ingenios. Under this mode the processing plant owner takes over the crop administration, so all the responsibility of the sowing, maintenance, and harvesting falls on the ingenio. In return the ingenio receives a commission, based on a percentage that is negotiated at the beginning of the season. The calculation of the percentage is associated with the cost that the ingenio assumes for running the crop. Frequently this number varies between 5% and 8% of the total production.

In all contract modes sugarcane payment is based on the amount of sugar that can be drawn from a ton of sugarcane. For each there is a reference parameter which provides a guide for individual negotiations, which are in fact, adjusted by various technical and economic factors that are inherent to the sugarcane productive process. Regardless of the contractual type, sugarcane bagasse and molasses are by-products that come from the industrial stage, therefore, they are considered property of the processing plants.

The relationships between agricultural producers and ingenios have been founded on competition, convenience, and mutual trust. Such pillars, along with cultural and familiar aspects, have built a solid economic structure with a great social scope.

5.2 AGRO–INDUSTRIAL TRANSFORMATIONS OF FEEDSTOCK

5.2.1 Transformation of palm fruit into crude vegetable oil

In Colombia there are 53 palm fruit extraction plants, and most of them have a processing capacity below 25 tons per hectare, in fact only 24% of these plants are able to exceed this limit. This more than anything shows that the Colombian palm processing industry is far behind the world's top producers, such as the Malaysian and Indonesian industries, which achieve average levels of 30 ton/ha and 40 ton/ha.

At present time, each plant is capable of processing an average of 4250 ha, which does not correspond to an optimal size. Based on these facts, it is possible to conclude that there is a mismatch between the processing capacity and the processed feedstock, being that the latter is inferior to the former. It has also been reported that the average size of these plants is not big enough to reach minimum standards of efficiency. According with the Ministry of Agriculture's calculations the ratio between the actual use and the installed capacity yields a usage index of 52%, which indicates that the palm processing industry is inefficient due to unnecessary and higher processing costs (MADR, 2005).

In order to achieve greater efficiency and use all inputs, products and by–products in a proper way, it is considered that the optimum size should be near to 30 ton/ha of palm fruit. The reason for this is that such a size justifies the incorporation of heavy machinery for processing tasks, in particular, the use of turbines. Through the use of turbines it is possible to transform the steam that comes from a boiler in electricity, reducing costs, making use of different processes to create new by-products, and possibly eventually commercializing electricity surplus to the nearby population, or even become a power supplier to a local energy grid. However, should the plant not achieve the minimum level of production, it cannot justify the installation of a turbine, which is very expensive.

A plant of 30 ton/ha can operate with a medium level of efficiency if it is able to process the fruit that comes from a plantation of 7 thousand hectares of palm and with high efficiency if it is supplied with the fruits of plantations between 7 and 10.5 thousand hectares.

Plantations must be located around extraction plants, forming a core that simplifies and hastens the coordination between agricultural processes and the first stage of the industrial transformation. This fact is crucial, due to the continuous ripening of the fruit, which results in deterioration caused by increasing acidity levels 10-12 hours after harvest.

Based on the aforementioned, plantation size, distance between palm trees, availability of communication methods and road infrastructure that connects different plantations and plant facilities that ease fruit delivery after collection, are fundamental factors for industry performance, and of course, they guarantee that extraction plants are located on zones where there is enough fruit provision to use plants at full capacity (Fedepalma, 2006b).

It has been suggested the establishment of alliances as strategic interaction between actors along the chain, so plant owners can come to an agreement with small landowners, with available lands. By doing this, new farmers engage in the process and increase palm fruit volumes aiming to achieve the needs of the processing plants. No all of the extracting plants are able to cover plantations costs, given that investment required for a palm oil agricultural array could be substantial (US$3600 without including the cost of land).

So far, some alliances have been established with all sorts of entrepreneurs that include large-scale, medium-scale and small-scale farmers. They have been created with an orientation towards different goals. For instance, some alliances moves toward efficiency and productivity, whereas others that try to look for economic and social stability for the population located where crops are expanding (Ministerio de Agricultura, 2007, 2011).

These alliances work on the basis of mutual convenience between the parties, being in most cases a palm processing firm that is linked to the extraction stage, representatives of a set of small-scale agricultural producers that act together to engage in the productive process, sharing both risks and benefits of such endeavors (MIDAS, 2010; Ministerio de Agricultura, 2011).

Both, managing party and agricultural organization, obtain obvious benefits out of this type of alliances:

- Better stability and security: the improved possibilities of income increase for both parties. Agricultural producers engage with a highly recognized for-profit organization. These firms work under clear and established rules accepted by everyone. Under this sort of alliance access to market is basically secured and additional complementary economic and social services are gained.
- Access to the ICR, which helps to subsidize up to 40% of the plantation planting. A farmer that does not belong to an arrangement of this kind will face extreme difficulties gaining access to those benefits to fund a private project.

- Those funds that are used to finance the alliances have access to the FAG (Fondo Agropecuario de Garantías) – Agricultural and Guarantee Fund - that covers up to 80% of the total value of the credit granted for crop sowing and maintenance purposes. Furthermore, in some cases the managing party finances the remaining 20%.

- The agricultural party has access to technology and technical assistance in order to enhance crop productivity. The alliances often receive this automatically, either directly or through offers that come from big-scale plantation owners or extraction plants that are linked to the initiative.

- They promote and encourage small-scale farmers to take part in the crop related assets, thus in some cases the managing party transfers land ownership to these peasants, or in other cases they provide support and assistance in the entitlement and legalization processes of properties in favor of the most vulnerable population. In the same way, those alliances that have exhibited an advanced level of development encourage the participation of small-scale farmers to become shareholders of the extraction plant, which in some cases have been up to 49% of total ownership.

- Through initiatives of this nature, members have access to additional complementary social and economic services that improve living standards. One of the most important is perhaps the right to use or eventually acquire housing facilities.

On the other hand, managing parties can get some timely benefits, the most important one being the possibility to secure and to stabilize feedstock supply, and reduce the amount of time the plant is idle. In addition, the managing party, under specific circumstances, may have access to more government financial help. For instance, coverage given by the ICR can be increased 20% to 40% over the investment amount, just like the small-scale farmers, using the full extent of governmental support for palm crops.

One additional advantage of being a managing party is to reduce those costs that otherwise they would have to assume if the participation of ownership was greater. Under these alliances the entrepreneurial structure is lighter, but with reduced risk given that, to some extent, there is certainty in terms of quantity and quality of the feedstock that is available for their plants. This fact is mostly a consequence of an active engagement in crop planting, in the technical assistance for their allies, and technical coaching and training to arrange more productive processes that are convenient for the 2 parties.

Alliances have been demonstrated to be a tool with a tremendous potential to improve the socio-political environment where they take place. Furthermore, they are a target for corporate social responsibility activities, boosting stability and sustainability in the industries that decide to put them in to motion.

Productive alliances can be a tool that does not reduce competitiveness in the productive chain. There is some evidence that shows a reduction in costs in established agricultural units, in both plantation settings and also in production cost per unit (Fadul, N.D.; Ministerio de Agricultura, 2007).

These findings strengthen the idea that small-scale farmers can take part actively and efficiently in developing economies of scale that emerge from palm plantation initiatives, contributing to agricultural competitiveness.

Still, these alliances have been useful in moving forward the formalization of contractual relationships in a sector that is characterized for being highly informal; which is even more valuable, when what is at stake is the establishment of clear guidelines and rules between large-scale entrepreneurs and small-scale agricultural producers. It is also fundamental to move ahead in the setting, standardization and formalization of commercial links in the long run.

Those agricultural units that have been managed under this mode, are neither completely independent nor subject to maintenance standards, which are very common for small–scale farmers in Malaysia and Indonesia (Basiron, 2007; FPP, 2007; Sumathi et al., 2008). On the contrary, in the Colombian case by will of the small-scale agricultural producer, palm plantations can receive technical supervision from the managing party, which have more trained staff and more expertise. This aspect turns out to be one of the most important for land preparation, fertilization, and crop maintenance tasks.

Undoubtedly, the Colombian experience in this matter has been interesting and constructive. Alliances must be adopted and need to become into a core element in policy designs, oriented to guarantee an equitable distribution of all the benefits obtained by the development of biofuels initiatives, or any other agricultural product that should be supported.

In those frontiers where it is not possible to implement this sort of alliance with small-scale agricultural producers, other alternatives should be considered, such as the Financial Social Model (FSM) explained previously.

In recent years, alliances with small–scale agricultural producers have seen remarkable growth, given that at least 62 thousand hectares have been managed under this method. This number includes approximately a third of the planted area within the national territory between 2000 and 2008 (180 thousand hectares) (Ministerio de Agricultura, 2011).

As a result of the frantic palm oil production growth, palm oil production and palm kernel cakes has increased. In particular, crude vegetable oil has shown a steep rise during the last 20 years, starting with 232 thousand tons in 1989, and reaching more than 778 thousand tons (2008), which represents a growth rate close to 6.5% per annum.

This rapid production evolution has been able to keep pace with the increasing demand in domestic consumption, given that the average personal intake has experienced a noticeable increase from 9 kg in the early 1990's to 10.3 in recent years. Additionally, the abundant supply of vegetable oil has created a substantial volume of surplus for exports. The quantity of vegetable oil that is not consumed domestically has reached levels of 341 and 318 thousand tons in 2007 and 2008 respectively. In fact during the last 7 years exports represented up to 40% of total production of the crude palm oil.

5.2.2 Transformation of crude palm oil into biodiesel

In Colombia biodiesel production started during the second half of 2008, firstly at an experimental level, and at the end of the same year it began the blending program with fossil diesel on a commercial scale. Although, there were some efforts to use other feedstock, nowadays, biodiesel production in Colombia is based completely on palm oil. Some other alternatives have been explored such as castor oil, algae, and jatropha curcas (Campuzano, 2011; Corpoica, 2011; Patiño, 2010), but they have not been expanded to commercial scale. At present times there are 7 plants for biodiesel production, which are located in the northern and eastern region of the country. This will be explored in a later section.

5.2.3 Transformation of sugarcane and its apparent consumption

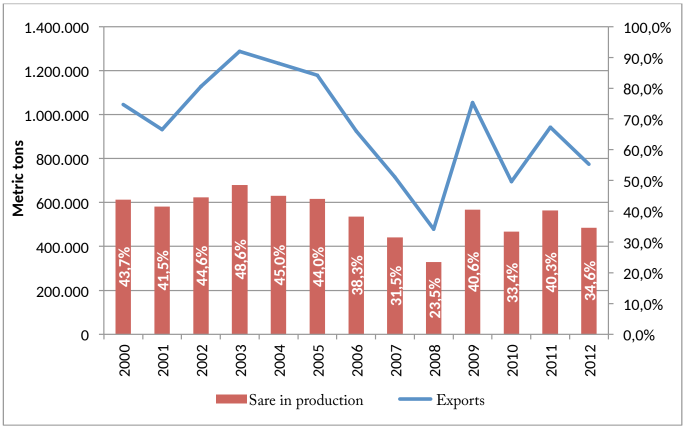
Sugar production in Colombia has had an important growth in the last decades, given that it has increased from 1.2 million tons in 1980 to 2.7 million in 2004 (expressed in equivalent tons of crude sugar). Nevertheless, from 2005 it has suffered a considerable reduction in sugar production, reaching levels of 2 million tons in 2008. This implies a reduction of 25% on the levels exhibited in 2004 and it represents a difference of nearly 700 thousand tons.

This setback in sugar production is directly associated with the disruption to the rain season frequency, and a decrease in the harvest due to a labor strike by the sugarcane cutters in 2008. Nevertheless, they were not the only factors that influenced this situation. During the third quarter of 2005, the new bioethanol plants were put into motion, and the cane juices originally destined for sugar production were used for biofuels.

Thus, it is possible to see that since 1987 the Colombian sugar industry has sufficiently supplied the domestic market, so has been exporting surplus ever since. The volume that is put on the international market has increase by a 4 factor, starting with 300 thousand tons (Infante & Tobón, 2010) and reaching a maximum of 1.29 million tons in 2003. In 2012 the commercial year ended with exports of 710 thousand tons (ASOCAÑA, 2012).

Such surplus production has been the principal boosting factor for sugar production in Colombia and, therefore, its rapid expansion to foreign markets. Yet, as presented in the graph, sugar exports have dwindled vastly since 2004, going to levels near to those experienced in 1992.

Figure 5.2. Sugar exports in Colombia

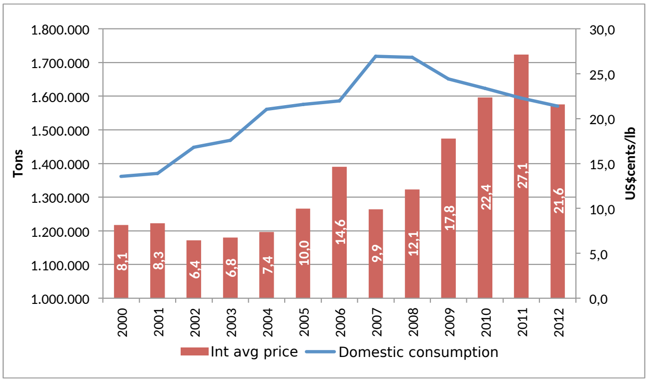


Compiled by the author. Data source: (ASOCAÑA, 2013)

It is obvious, that there is a clear correlation between the commencement of operation of bioethanol plants and the drop in export volumes. This is not unexpected, since this was precisely the purpose of the original biofuel policy plan – to use surplus production for ethanol production and use the latter for blending with gasoline. It was calculated that in pursuing this path, the potential impact, if any, on the Colombian domestic sugar market would be minimal in terms of imperiled supply or price explosion.

In this sense, sugar sales within the domestic market have risen 200 thousand tons between 2003 and 2008, whereas the ethanol production market has required at least 300 thousand tons of equivalent crude sugar per year. These two facts, along with the previous explanation of the reduction in sugar production during 2007 and 2008, clarify the exports declining behavior throughout the studied period.

Figure 5.3. Sugar domestic consumption in Colombia and international price influence



Compiled by the author. Data source: (ASOCAÑA, 2013)

So, one of the interesting findings is that neither the use of juices and molasses from sugarcane, nor the reduction in sugar production and exports since 2005, created any perverse effect on the sugar availability for the domestic market. On the contrary, the apparent consumption has risen steadily during the 3 years following the introduction of ethanol production(followed by a reduction due to the fall in production), not only because the sales trends of the processing plants have remained unchanged, but also because the imports of sugar have contributed to keep sugar availability.

Although, in relative terms the involvement of imports have been marginal, it is noteworthy to point out that from 2001 sugar imports have exhibited a perceptible increase, hence, nowadays (2012) they represent slightly more than 16% of the total domestic consumption.

Sugar imports in Colombia have registered 3 different periods of rampant expansion. The first one, between 2002 and 2003, international prices of sugar skyrocketed, and so did exports of this commodity. Under such acceleration of international trades, it is sound to think that as exports grow, fuelled by the rise of prices, so to do imports, in particular in the Colombian case, from those neighboring countries, or with those countries with whom Colombia has active commercial agreements. Under this period nearly half of the imports came from Ecuador and Bolivia.

Table 5.2. Sugarcane trade statistics for Colombia

year	Production (metric tons)	Sales to domestic market	Imports	Total domestic apparent consumption	Exports
	metric tons				
2000	2,391,324	1,348,822	12,889	1,361,711	1,045,349
2001	2,244,756	1,312,222	58,075	1,370,297	931,497
2002	2,528,756	1,361,914	86,372	1,448,286	1,127,229
2003	2,649,966	1,351,739	116,628	1,468,367	1,287,256
2004	2,741,363	1,523,427	37,853	1,561,281	1,232,782
2005	2,683,215	1,515,380	59,648	1,575,028	1,179,642
2006	2,415,145	1,459,872	126,010	1,585,881	925,565
2007	2,277,120	1,558,170	160,439	1,718,609	716,380
2008	2,036,134	1,549,845	165,384	1,715,229	478,442
2009	2,598,496	1,512,739	138,295	1,651,034	1,053,939
2010	2,077,613	1,438,973	184,311	1,623,284	694,396
2011	2,339,988	1,405,725	188,147	1,593,871	942,035
2012	2,236,605	1,318,870	251,276	1,570,146	774,779

Source: Elaborated by the author, Data source (ASOCAÑA, 2012)

The second period of imports expansion in Colombia took place between 2005 and 2008. This period coincided with the implementation of the ethanol plants, therefore it is not possible to rule out that this was the trigger for an increased sugarcane demand within the domestic market, and subsequently it created a reduction in sugar exports or an increase in sugar exports for direct consumption. The most recent expansion period took place from 2009 to 2012, due to complications in domestic production because of the "la Niña" climatic phenomenon.

Despite the fact that the structure of domestic supply within the national territory has experienced a change with the running ethanol plants, there are two factors that must be considered to fully understand such performance:

1. the level of dependence on the foreign market to supply the domestic market is still significantly small
2. that despite the fall presented in 2004, the surplus in sugar production remained predominant, given that exports surpass imports by far in this sector (see previous table).

5.2.4 Transformation of sugarcane into ethanol

Bioethanol production in Colombia has been developed using sugarcane as its principal feedstock, and to a minor extent cassava. For this reason, most plants have been located in the basin of the Cauca River in the Cauca Valley, where the sugar and alcohol industry in Colombia has had its roots for more than a century.

So far, there is no feasibility for using a different feedstock, like maize or sugar beet, if efficiency rates and competitiveness are taken into account.. The only commercial alternative that has been tried is a small plant located in Puerto Gaitán (in the eastern region of Colombia in the department of Meta). This plant processes the starch that is extracted from cassava or yucca, to be further treated to become ethanol. The area that is used to provide the feedstock for this initiative is about 1000 hectares.

As was mentioned before, there are some efforts to use a variety of sugarcane, that otherwise are used for raw sugar or panela manufacturing. However, some pilot tests have not produced successful results and some others are still in the trial stage, and under close financial and technical evaluation. Current experiments have not reached production levels that allow them to be fully incorporated to the domestic biofuels market.

The Suarez River Basin initiative, which is not fully working at present, represents an alternative to cover a portion of the future ethanol demand. It has a nominal daily capacity to produce 300 thousand liters, using 40 thousand hectares of panela sugarcane. Nevertheless, there is one concern on the impact that this initiative might have on the security of the sugar as a food source, given that panela production itself could be seriously reduced, and it is a resource that provides a good energy source in the national diet, and moreover is one of the pillars of the traditional diet for the rural population in particular.

The industry of sugar and alcohol in Colombia accounts for 13 sugarcane processing plants (Cabaña, Carmelita, Central Castilla, Incauca, Manuelita, María Luisa, Mayagüez, Pichichí, Providencia, Riopaila, Risaralda, San Carlos y Tumaco), and they work with more than 2200 units that are engaged with the plants to provide the feedstock, and they create 36 thousand direct jobs and nearly 220 thousand indirect jobs (Asocaña, 2011).

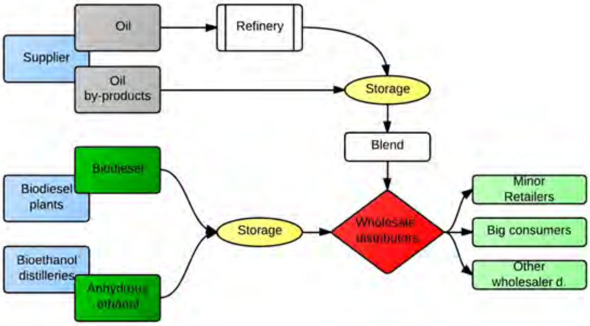
In Colombia, there are 6 alcohol distillery plants that are sugarcane-based, with a nominal installed capacity of 1.07 million liters per day, but in reality only 942 thousand liters per day, when bearing in mind that these plants work 320 out of 365 days of the year.

In June 2010 production capacity of alcohol fuel was actually 942 thousand liters/day, and was possible to be increased to 1,315 thousand liters/day. So the potential full capacity was 1.07 million liters/day as it was presented before. Despite of this, the national government set a goal of trying to reach a blend of E20 by the end of 2012. This would imply a production of 2.75 million l/d, which is far beyond the initial proposal of reaching E12, which was settled in the PNBc. Based on that, the question that emerges is - Is there enough sugarcane to cope with the current proposed target? If it is assumed that the plantations are going to be set on Cauca Valley soil, in order to guarantee the highest productivity, then, there would be the need to plant more than 128 thousand hectares of sugarcane, which is more than half of the planted area that is currently in that region.

Although there is a genuine interest from private investors in the biofuel industry, and with their support, it is possible to practically double the processing capacity of sugarcane for ethanol production purposes in Colombia, the main obstacle to be overcome in order to reach such levels set by the national authorities, is the surety of feedstock availability. This particular aspect is developed in a further section.

5.3 DISTRIBUTION AND COMMERCIALIZATION

Figure 5.4. Distribution and commercialization chains



Adapted from (Infante & Tobón, 2010; S. Trindade, 2005)

Colombian law establishes that biofuels must be blended with the corresponding fossil product by the wholesale distributor, and once such process is carried out these dealers can sell the blended fuel to fuel service stations, retail dealers, large consumers, or even other wholesale distributors. The blending process can be chosen by the trader as long the quality of the final product is guaranteed.

As can be seen from the figure above, both biodiesel and bioethanol plants sell plain biofuel to the wholesale trader, which must use special storage tanks to undertake the blending task, according to the standards established by the Ministry of Mines and Energy. When biofuel, already blended with the regular fossil fuel, is sold to the retail dealer, it must undergo quality controls, and they should provide proper storage condition for the mix, before is offered to the final consumer.

5.4 THE CONSUMER SECTOR

5.4.1 Projected consumption of biodiesel

So far, crude palm oil destined for biodiesel production has been diverted from exports and the difference was covered by national production. It is clear that a fundamental consideration to determine the degree of substitution between crude palm oil and biodiesel for domestic consumption is the resulting relationship between price of biofuel itself and price of exporting oil. Likewise, it must be taken into consideration the cost of giving up participation in international vegetable oil markets.

To illustrate this situation, the following table presents biodiesel demand during the period 2009-2015, based on the Ministry of agriculture data.

Table 5.3. Palm oil demand for biodiesel production

Concept	2009	2010	2011	2012	2013	2014	2015
Diesel demand (b/d)	110051.00	113684.00	117342.00	121079.00	125601.00	130587.00	135786.00
Blend Percentage (%)*	5%	10%	10%	20%	20%	20%	25%
Biodiesel demand (b/d)	5502.55	11368.40	11734.20	24215.80	25120.20	26117.40	33946.50
Biodiesel demand (t/y)	279.34	577.12	595.69	1229.31	1275.23	1325.85	1723.29
Crude palm oil (t/y)	285.62	590.10	609.09	1256.97	1303.91	1355.67	1762.06
Assumed yield (t/h)	3.60	3.70	3.70	3.80	3.80	3.80	4.10
Required productive has	79338.98	159486.06	164617.83	330780.84	343134.68	356756.15	429770.17

Recalculated by the author based on (Infante & Tobón, 2010; UPME, 2008)

Taking into account that by 2009 the proposed blend of B5 was fully achieved, it is estimated that 285.62 thousand tons of crude palm oil were used for the biodiesel blend. This target was easily achieved through diverting a substantial share of the export quota, in addition to an existing capacity capable of coping with the created demand.

According to FEDEPALMA projections, biodiesel sales in the domestic market were expected to increase on average 12,000 ton/year during the next 3 years after the commencement of the program (2008), whereas palm oil production could grow 136 thousand ton/year during the same period (Mesa-Dishington, 2007). Based on that, there would be an ongoing decline in the oil exporting surplus during the initial years of application of the B5 implementation. Once this period is finished the exporting level can be recovered, if one bears in mind that those palm trees that were planted a few years ago will enter into the production stage.

This is the main reason why it was thought that there was enough feedstock availability to move towards a mix of 10% biodiesel by 2010. In order to achieve this target, there was need for 568 thousand ton/year of crude palm oil supplied in the way that was described previously, and along with it 1,539 thousand hectares of production. Nowadays, biodiesel plants that are already working have reached a nominal production of 516 thousand ton/year.

The possibility of applying a biodiesel blend over 10% represents an immense challenge under current circumstances and it will depend on the extension of present crops in the upcoming years. Although, the initial target was B20 by 2012, it is clearly not impossible to fulfill. In order to do so, it would have been necessary to use an extensive portion of the domestic share of the crude palm oil, with obvious negative consequences on the food security.

If those palm crops that are already planted are taken into account, it was calculated that by 2012 the productive area should be near to 343 thousand hectares and annual production close to 1.34 million tons of crude palm oil, however, there is no official reports in that regard. A blend of B20 would requires near to 1.25 million tons of oil, occupying approximately 330 hectares for its production; therefore, if such a blend is pursued, a greater portion of palm oil production would be destined for biofuel manufacture, and there will be only a small remaining part of 130 thousand tons for human consumption.

5.4.2 Projected ethanol consumption

The strategy of producing ethanol based on the feedstock that once was destined for sugar exports entails some limitations that need to be considered. On one hand, to reach the goal of a mix of 15% ethanol with regular gasoline in 2010 and 2011 would have needed nearly 750 million liters per year, if the projections provided by the UPME were accurate (2008) (UPME, 2008). As it is presented in the following table, by the year 2008 alcohol fuel production only achieved a maximum of 258 million liters, so the full target is only 34% covered.

Table 5.4. Ethanol production in Colombia (thousand liter)

Year	2005	2006	2007	2008	2009	2010	2011	2012
Production	28.95	268.54	274.83	258.09	326.84	291.28	336.95	370.00
Sales	23.56	258.54	279.67	249.74	338.36	292.08	351.08	NA
Remaining stock	4.61	13.07	4.81	13.19	NA	NA	NA	NA

Adapted from (Infante and Tobón, Fedebiocombustibles 2012)

It is estimated that the annual production, with the current productive capacity, is 352 million liters, which is still less than the amount required to supply the whole national territory with E10, which was supposed to be implemented in 2009. Apart from that, sugarcane in Cauca Valley yields approximately 75 liter/year of ethanol, and in order to reach that required approximately 6.9 million tons of sugarcane, that if used for the production of crude sugar could generate 815 tons for export. So, 35% of the total sugarcane production within the region is allocated to ethanol production, therefore crude sugar exports are highly affected.

Table 5.5. Sugarcane demand for bioethanol production

Concept	2009	2010	2011	2012	2013	2014	2015
Gasoline demand (bbl/d)	91353.00	89823.00	88966.00	88732.00	88716.00	88954.00	89893.00
Blend percentage	10%	15%	15%	20%	20%	20%	25%
Bioethanol demand (bbl/d)	9135.30	13473.45	13344.90	17746.40	17743.20	17790.80	22473.25
Bioethanol demand (million l/d)	530.12	781.87	774.41	1029.83	1029.64	1032.41	1304.13
Sugarcane (thousand t/y)	7066.56	10422.32	10322.88	13727.63	13725.16	13761.98	17384.06
Planted area required (ha)	58888.03	86852.64	86023.98	114396.96	114376.33	114683.17	144867.21

Recalculated by the author based on (Infante & Tobón, 2010; UPME, 2008)

In the beginning, the possibility of implementing an E15 by 2010 was considered. Nonetheless, under such a scenario the calculations presented above will increase to

10.1 million tons of sugar cane, or 1.19 million tons of crude sugar. That scenario would imply using 40% of the total production of sugarcane and it would imperil further export possibilities.

It is possible to consider that a mix of E15 is the maximum theoretical blend that can be achieved with the current production capacity installed in the Cauca Valley. In order to do so it would be necessary to forgo the possibility of exporting the crude sugar, however, it is important to stress that domestic consumption would not be affected.

The following table shows an estimation of the alcohol fuel demand for the period 2009-2015. The projections were based on information supplied by the Ministry of Agriculture in regard to the calendar established for different blends. Taking into account that the adoption of a mix with 20% of ethanol was forecasted to be applied in 2012, some constraints emerge under this scenario – in order to fulfill this target close to 13.7 million tons of sugarcane is required, which is 3.3 million tons more than the numbers registered in the previous 2 years. Based on this, an even larger area of sugarcane is needed, with only two ways to achieve this:

1. by engaging those zones where panela sugarcane is produced (which is the only area available for augmenting ethanol production in the short run),
2. by sowing sugarcane in other regions within Colombia.

Each has their own setbacks. In the first case, as was mentioned before, there is a considerable difference between the productivity of these two varieties of sugarcane. Panela sugarcane offer much reduced output if it is compared with traditional sugarcane.(Panela sugarcane at 37ton/hectare vs. sugarcane at 100 ton/hectare). Despite the less efficient performance of the panela sugarcane, its adaptability conditions make this variety the most suitable one for the harsh characteristics of the Suarez River basin. Traditional sugarcane could be planted in that area but it is uncertain what yield in terms of tons of sugarcane per hectare per annum, or sucrose content could be obtained.

In the second case, there are two regions, far from the Cauca Valley region, where the cultivation of sugarcane takes place; however, in these two regions efficiency is substantially reduced. According to data from the Ministry of Agriculture, in the department of Cesar the productivity in terms of sugar per ton of sugarcane barely achieves 68% of the one presented in the department of Cauca Valley; whereas in the department of North Santander the same indicator reaches 83%. This reduction in efficiency is due to less content of sucrose within the canes and a reduced yield of sugarcane per hectare (between 80 and 90 ton/hectare).

Furthermore, as these regions are relatively far from the consumption core, it will require some important investment in road infrastructure and basic services, to boost proper productive scales. These sugar initiatives will engage new labor in the process, while also utilizing staff that have already been trained in the Cauca Valley region and, by doing so, easing the learning curve for energy plantations and processing plants.

Although there are some isolated initiatives on paper to start an expansion of alcohol energy crops in non-traditional zones, there is no particular public policy that offers tools that contribute to creating proper short term stimuli to increase the plantation areas and bring complementary investment. Such policies must coordinate the roles between national and local authorities to implement those tools.

A complementary action to this policy, are mechanisms that promote the identification, formulation, structuration and evaluation of investment projects; providing funds for foresight studies, which consider the financial, environmental and social impacts of these initiatives.

To move forward to E15 blends and above, securing sugarcane provision turns into the most imperative condition. Thus, it is fundamental to count on an articulated program that promotes the enlargement of productive zones, as well as the upgrade of the current ethanol processing capacity. There have been several endeavors to tackle the Colombian bioethanol needs, in addition to those already established in the Cauca Valley region; however, they have not been able to overcome the pre-feasibility stage. Some other enlargement projects in the Cauca Valley have also been delayed.

Another critical factor in the promotion of investments around ethanol industry is the stability and transparency in determining regulation policies, particularly those related to the sale price.

5.4.3 Current biofuel consumption

Since 2010 (April 1st), through issue of resolutions 182368 (29/12/2009) and 180523 (29/03/2010), the consumption of biofuel in Colombia has been managed as follows:

- Atlantic Coast, Huila, Tolima Santander and Putumayo will have a blend of biodiesel of B8;

- In the western region (Cauca Valley, Antioquia, Choco, Cauca, Nariño, Caquetá, Coffee region and North of Santander) the blend is B7,
- The rest of the country will have B5.

In the case of gasoline, just as the biodiesel scenario, from April 1st, the recommended level of mix from the government is E8 for Colombia (Fedebiocombustibles, 2010a).

Based on the previous information in the next incoming chapters will be developed LCA and GIS excercises in order to test the environmental sustainablility of biofuels and to sketch to what extent can be expanded current crops under sustainable (social, economic and environmental) conditions.