CHAPTER 8

GENERAL CONCLUSIONS
Bioenergy in general, and biofuels in particular, have come up to the renewable energy stage with some peculiar strength, overall in terms of alternatives for transportation. Some of the drivers behind this option are shared on a global scale, such as the reduction of GHG’s emissions, and enhancement of energy security conditions. Some others have a more local nature, like a diversification of markets for agricultural commodities, dynamization of rural areas, improvement of micro and macro-economic indicators (for instance, income of the rural poor and national balance of payment), among others.

However, production, commercialization, and use of biomass based energy have a really complex set of relationships regarding economic, social and environmental effects. Therefore, even though biofuels are associated with several positive consequences; they are also linked to convoluted issues that require the attention of scholars and policy makers, in order to avoid catastrophic outputs from a poor implementation of a bioenergy agenda. Among those negative results are:

- a potential net energy loss (assessed in non-renewable sources),
- a constant threat to food security given that some feedstocks (in fact, the most used ones) can be employed for food and/or energy purposes at the same time,
- a potential increase of carbon emission through LUC and iLUC effects,
- an eventual worsening of the current social or economic situation for vulnerable population,
- and the imperilment of natural ecosystems.

This reality is the one that Colombia has confronted, since 2005, when it started to walk the path of liquid biofuels for transportation. Given agricultural circumstances for this South American country, sugarcane and palm oil were the main chosen feedstock to start this journey. Of course, it does not imply that other alternatives cannot be explored in the immediate or mid-term, but most bioenergy initiatives in Colombia, nowadays are focused on these two options.

A comprehensive analysis of Colombian biofuels chains and their actual and potential effects, regarding their social, economic and environmental behavior was required in order to establish to what extent liquid biomass-based fuels are sustainable. Actually, that is the reason and core of this thesis document.

The results can be summarized as follows:
Among renewable energies, bioenergy and in particular biofuels, represent a transitory and immediate alternative to solve the stress caused by fossil alternatives. Handled properly, biofuels can become in an appealing alternative to both industrialized and developing countries. The latter can take advantage of latecomer position, improve the socio-economic situation of the population, and may alleviate environmental issues caused by traditional energy sources.

Biofuels can be classified by their state of nature and by the degree of technology advance. Within this document current and potential impacts of production and use of those liquid biofuels are studied (alcohols and oils) that are produced within the Colombian territory.

Biofuel production is well justified in this case, given that existent energy sources (hydro, coal, gas and oil) properly cover energy needs, except for transportation. Colombia is not a net importer of oil, yet, but new reserves have not been found and export rates lead one to think of a shortage scenario in the midterm.

Despite that, Colombia produce commercially 1GBf (sugarcane–based ethanol and palm oil–based biodiesel) and those are highly criticized because of the food vs. fuel dilemma, a study needs to be carried out to understand to what extent these alternatives represent a threat, and if they do not, how much and where can they expend. Per se, 1GBf is not bad, but local analysis is required to see the full implications of their implementation. Therefore, biofuels production cannot be ruled out, and on the contrary must be encouraged. The problem here is establishing conditions to guarantee their sustainability without jeopardizing surrounding ecosystems, food provision, and the socio-economic conditions of the population. Actually, Colombia has managed some initiatives (at exploratory level) that aims to better biofuel under better technologies as it can be seen in the final appendix. This document argues that, in fact, Colombian biofuels, under current circumstances, are sustainable based on the following rational:

First, Colombia has set firm foundations in terms of biofuel policies (with a set of mandates, tax exemptions and other tributary and financial aids), following the example given by industry leaders such as Brazil. Drivers are properly adjusted and incentives in term of mature commodity markets ease development for these initiatives. Unlike most countries in the region, along with Brazil and Argentina, Colombia is the only country within the LAC region capable to cover domestic supply and eventually think of export possibilities. Regulations still require some fine-tuning and they need to target sustainable
certificates that boost a proper entrance to a global green oil market. A constant threat to bioenergy is oil price fluctuations, but R&D efforts can overcome this issue in the long term.

Secondly, Colombia must take into account the environmental context to implement a wide bioenergy project, due to the strong connection that this alternative possesses with global warming problems and agricultural management.

In this regard it is fundamental to stress the importance of biodiversity protection, land degradation, and land management issues that emerge with monocultural practices. If the latter are carried out it becomes crucial to include policies in the local planning schemes for implementation of crop intensification in order to avoid LUC and iLUC effects and expansion of the agricultural frontier.

Most of the problems related with air pollution, and climate change is closely linked with mobile sources of contamination, i.e. the transport sector. For that reason, biofuels production and use are able to mitigate such effects, if it is taken into account that photosynthesis captures carbon emissions during the agricultural stage of biofuel creation. When biofuels are blended with regular gasoline the burning process is cleaner, resulting in a lower level of contamination.

Nevertheless, it is also important to recognize the role played by ergoculture as GHG’s emitted by account of agricultural practices. Use of fertilizers and pesticides, along with forest clearance might unleash a high pressure on the atmosphere. Therefore, expansion of energy crops must be implemented carefully, as is explained in the last chapter, which overtakes this kind of hindrances.

Environmental pressure can also be reduced by supporting an active biofuel industry, if more opportunities for development are brought to rural areas, avoiding migration processes.

Thirdly, in economic terms, competitiveness of Colombian biofuels, in international markets, can be imperiled by high cost of labor, despite high yields of agricultural commodities. Some other biofuel producing countries pay less than half the wage established in Colombian territory.

Biodiesel costs throughout Colombia are quite standardized. They are mostly explained by feedstock costs that have been calculated between US$482 and US$618 per ton. Benefits should be shared between farmers and plant owners, and are linked to the amount
of oil obtained from each ton of fruit.

Conditions for the final price are discussed informally in this industry, if there is no formal contract that establishes otherwise. As reference, the PSF is used which is usually presented in advance, so levels of uncertainty are reduced.

In the case of sugarcane ethanol, it is required to improve competitiveness in terms of final prices, regarding direct international competitors. Most of the cost, just like in the biodiesel industry is explained by feedstock acquisition cost. A way to solve this issue is via capital investment, but intensive machinery would imply several job losses (8 million shifts if a total conversion is carried out).

In a general sense, the sugar industry (and by-products) is much more organized than the biodiesel industry. Thus, calculation of payments are fully described and distributed between farmers and plant owners. A compensation fund FEPA intervenes in price formation, and act as a kind of insurance for farmers and manufactures.

Recognition of final price in terms of ethanol elaboration, despite having formalization, has created controversy between farmers and sugar processors. On the one hand, a processor wants to give only one third of the final price to a farmer (according with those rules describe in chapter 4), whereas the latter try to get at least 50% of the final price. These discrepancies have brought tension to the ethanol industry. Regulation in this regard, along with some other fine-tuning in terms of compensation of divergences between sugar and ethanol must be introduced and reviewed in further policy analysis.

Fourthly, in this manuscript Policy for Biofuels in Colombia (PNBs) has been studied and it has been concluded that it requires between 6.4 and 9.2 million hectares in order to achieve government plans. According to government target, this land would be taken from fallow and livestock farming land. In chapter 7 it is proven that those levels can be reached, only under severe restrictions (overall in terms of current road infrastructure).

The palm oil industry (and by-products) has grown recently by account of a set of factors (elevated vegetable oil prices and the possibilities of new markets), and domestic conditions (supporting policies for biofuel industry). Yield per hectare has reached near to 4 tons of oil on average, but according to Fedepalma it would be possible to obtain 5.5 tons by 2020, overtaking some countries in South East Asia. It is highlighted that the possibility to concentrate the industry in clusters in order to increase efficiency in the industrial stage and therefore gain competitiveness.
Participation of small farmers is significant but there is a high level of land concentration in this sector. There are just few plantation units that exceed 1000 hectares, but they have almost 40% of the planted area.

There are three types of contractual arrangements for palm oil extraction. Every one of them implies different rights and responsibilities as is explained in chapter 5. The importance of this is the flexibility offered to farmers of any scale. Colombia needs to improve extraction methods, given its low productivity. Colombian plants can process on average 25 tons/ha, whereas Malaysia and Indonesia exceed 30 tons/ha. Evidence has shown an underuse of the installed capacity.

Strategic alliances are a possibility of distributing both risks and benefits of the industry, and they have proven to provide more stability and access to financial resources in an easier way. By training farmers and extractors they get better results and security in feedstock quality and quantity.

Vegetable oil provision has not been jeopardized so far with bioenergy project implementation; therefore, there is no evidence to point out biodiesel as trigger for food scarcity.

In the case of sugarcane, the industry related to ethanol production in based in Cauca valley, despite other regions that have sugar plantations (like Santander, Antioquia, Nariño, among others). Technical assessments have led to this conclusion by demonstrating that this variety of sugarcane (caña panelera) is not suitable for competitive ethanol production.

Crop performance has improved in terms of sugar content (reaching 13 tons per hectare since 2002), despite yield of sugarcane per hectare has been relatively stable (close to 120 tons/ha). This is proof of enhancement of soil performance and therefore less pressure on surrounding lands for expansion purposes.

There is also land concentration in this industry, but not as strong as in the palm sector. One fourth of land belongs to the ingenios and the remaining land to other owners. Proprietorship and management can be combined, thus 51% land is managed by independent owners. The remaining 49% is managed by different kinds of formal contracts presented in chapter 5.

Based on the existing surplus of sugar since 1987, the ethanol initiative was supported. In this way, food security was not put at risk. 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.

Current capacity of potential ethanol processing (1.07 million liters/day) is far from the one established originally by the government (2.7 million liters/day) in order to reach a level of E20 in the entire Colombian territory; however, expansion is still possible under some assumptions exposed in chapters 6 and 7.

Chapter 6 present a LCA for Colombian biofuels: Average environmental impact of the evaluated biofuels was compared with international standards of sustainability, which provide a first approach on a key factor in regards to the export potential for Colombian biofuels. iLUC effects were evaluated in this assessment, by establishing that those crops which satisfy sugar demands in international markets can be set somewhere else.

When the iLUC effect was left out, it was concluded that ethanol made out of sugarcane was generating close to 26% of GHG’s emissions in comparison to pure fossil gasoline. However, when it was included 156% of GHG’s was created if and only if crops were to be grown in tropical forest.

RED standards use as reference 40% of GHG’s savings in order to consider a bioenergy alternative as sustainable. In this case Colombian ethanol saves up to 74% in the best scenario; therefore the requirement is fulfilled.

In terms of biodiesel, approximately 40% of GHG emissions per vehicle can be saved by using current technology and average cultivation practices, in comparison to fossil diesel alternatives (if LUC and iLUC effect are not considered). These results can be improved if methane is captured using residual waters.

Palm oil tree cultivations are able to store relatively great amounts of carbon in comparison to other use of lands, thus carbon balance has a propensity to be enhanced even more, up to 83% (using average technology) and up 107% (if advance or optimized technology is employed), due to the fact that most palm tree plantations took place in areas that formerly were destined for grazing purposes or agricultural production. This result strengthens the positions of some scholars (Mathews and Tan), and invite one to review results obtained by others like (Searchinger et. Al.). Based on the aforementioned, it can be asserted that Colombian biodiesel made out of palm oil offers a good performance in comparison with some other biofuels produced
internationally, and it accomplishes 40% of GHG’s emission savings defined by several international standards.

The non-renewable energy demand for biofuels based on highly productive crops (as the palm oil crop) is considerably less in comparison to other biofuels, especially when lingo-cellulosic biomass is used to provide energy in processing facilities. It is important to note that if the lingo-cellulosic is used for second generation technologies a more efficient result might be reached as well, in terms of fuel generation but co-generation potential and compost elaboration will be affected negatively.

In general, if all existing biofuel producing plants work at their maximum capacity, it is possible to save 1.8 million tons of CO2 eq per year. That is equivalent to 3% of total emissions of CO2 in Colombia in 2008 or 8% of those emissions caused by the Colombian transport sector (UN, 2012).

Compared with some other international biofuels, Colombian biofuel exhibits a good performance and it reaches 40% of minimum GHG’s emission savings suggested by several bioenergy fuel standards.

**Biofuels exported from Colombia can be favored by various mechanisms for subsidies in “sustainable” international markets for biofuels.** However, sustainability assessments should be applied for each producing firm and plantation in an isolated way, given that the present study provides only an insight for the average Colombian case, and it evaluates its range of impacts.

The relatively low demand of fossil fuels of sugarcane–based ethanol and palm oil–based biodiesel is explained by the fact that most of lingo–cellulosic material is employed for co–generation.

Finally, the last chapter was shown as exercise to map the potential expansion of palm oil and sugarcane crops for increasing biofuels production. After a biophysical analysis was carried out, several sustainability filters were applied to Colombian territory through GIS tools:

- In those lands produced biofuels must save at least 40% of GHG’s emissions in comparison to fossil reference (GHG’s net savings).
- Territories of black communities and indigenous reservations are considered as not suitable for commercial biofuel initiatives exploitation.
Chapter 8 – General Conclusions

- Natural reserves, such as forests, were left out because of biodiversity preservation, and resource maintenance.
- Land with current agricultural purposes was left out to guarantee food provision.
- Land without proper road infrastructure was not included to provide a more accurate expansion scenario in the short and midterm.

For palm oil crops, sustainable expansion area is reduced to the northern section of the Llanos (in the eastern side of Colombia), central areas in the Andean Valleys, non-forest land in the eastern zone and small spots in the south-western area of Colombia.

In total 1000000 hectares where identified as highly suitable for palm oil cultivation and near to 2,900,000 hectares as moderately suitable. The larger area for the highly suitable zones is located in the base of the Eastern branch of the Colombian Andean mountain chain, in the departments of Caquetá and Meta. Potential area for expansion goes from 4 million hectares to more than 9 (being flexible with the results). However, it needs to be stressed that this high potential is only possible if it is accompanied by proper investment in roads and some other infrastructure.

In the case of sugarcane, the area for a sustainable expansion is reduced to northern plains and some areas in the Andean Valleys and the non-forest area in the eastern region. This study concludes that there is a high potential of expansion up to 1,518,000 hectares of high suitability and 3,400,000 hectares with moderate suitability.

The largest areas with moderately suitable lands are located in the eastern base of the Andean mountain chain in Meta and partially in Caquetá.

Suitable areas for sugarcane cultivation suggested by the Ministry of Agriculture are approximately 3,892,000 hectares (Fernández Acosta, 2009) (Fernández Acosta, 2009) (Fernández Acosta, 2009) whereas in this study found 10,973,000 hectares as suitable land (Fernández Acosta, 2009). Albeit, if those lands that are highly suitable and moderately suitable were considered, which should be the ideal case, given that crops held in suitable lands with severe restrictions are not economically attractive, results dropped, hence drawing a similar result to the Ministry report (4,919,000 ha).

In low biomass areas of Vichada and Meta, areas of potential expansion were presented. Nevertheless, these areas, at the present time have difficulties regarding road network infrastructure, hence, they are considered as non-suitable. However, through investment
in transport infrastructure these areas might be suitable for sugarcane cultivation.

In summary, in the case of the feedstock for biodiesel production there is a predilection for the departments of Caquetá and Meta; and contrarily sugarcane exhibits a bias for the conditions found in Magdalena, Cesar and Córdoba. Likewise, the region of the department of Vichada showed to be moderately suitable for biofuels feedstock production in general, but first access to the region must be improved significantly, i.e. investment in the road infrastructure network.

It is absolutely required to complete a land use planning and put into practice some specific agricultural routines that might alleviate land pressure (such as intensive cropping or grazing), or simply avoiding the use of already active (high productivity) land to dodge iLUC effects.
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