

Opportunities and challenges for biofuel production in Latin America

A forester's perspective

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Introduction

In the last few years, biofuels have become an issue of great interest and action at global level: major political decisions have been made and big players are coming into the field.

In 2003, the European Parliament issued Directive 2003/30/EC 'on the promotion of the use of biofuels or other renewable fuels for transport'. It set a target for 5.75% of all transport fuels in Europe to be biofuels by the end of 2010 (Cox and Chrisochoïdes 2003). In December 2008, a new draft Directive was approved 'to establish a binding target of 20% for renewable energy's share of energy consumption in the EU by 2020, and a binding 10% target for the share of renewable energy in transport petrol and diesel' (CEC 2008).

In December 2007, US President Bush signed the Energy Independence and Security Act, to 'improve vehicle fuel economy and help reduce US dependence on oil ... expanding the production of renewable fuels, reducing dependence on oil, and confronting global climate change' (White House press release 2007), following his 'Twenty in Ten' initiative, aimed at 20% fossil fuels substitution by biofuels in 10 years. And Senator Barack Obama declared in October 2008 that biofuels could provide five million jobs in the USA in the next 10 years.

It is clear now that biofuels are not only fuels for poor countries—or poor people. Rich countries, large-scale consumers with huge purchasing power, intend to use



Agrarian frontier in Misiones, Argentina (Photo by Enrique Riegelhaupt)

vast amounts of biofuels that they cannot produce themselves. Thus, some questions arise:

- Where and how can these biofuels be produced?
- Is there enough available crop land for biofuels? (including issues of property rights as well as land aptitude and physical accessibility)
- Will biofuel demand displace food crops, or impair food supply by raising prices or consuming staple foods?
- Will biofuel crops put additional pressure on forest lands, increasing deforestation and forest degradation?
- and last but not least, Can these new market demands open possibilities to forestry?

This new and complex problem poses several challenges to the forest sector. Previous experience and knowledge accumulated by foresters all over the world is probably insufficient to solve it. Much of the future depends on the paths and the pace of a seemingly inevitable global energy transition, in which forests' roles may be quite different from what they have been in the past. The paths of this transition will depend on technological developments, mostly in the field of second-generation biofuels that can make more ample use of lignocellulosic feedstocks and woodfuels. But its pace may also depend on the ability of the forest sector to produce biofuel feedstocks and forest fuels at competitive prices in sustainable ways.

Biofuels and the energy transition

In the face of the risks posed by climate change and diminishing oil production, an energy transition looks inevitable. But what changes can be expected in Latin America?

From fossil sources to renewable, low carbon sources of energy

Biomass and biofuels may have an important role in this transition, but other sources like solar, wind and geothermal will also have their part. Latin American countries are rather slowly developing solar, wind and geothermal sources for power generation. Transport—still relying on liquid fuels—is the sector with the fastest growth rate. Thus, transport biofuels may be one of the first priorities to address domestic energy demands, provided they are really 'low carbon' fuels—a point hotly discussed.

From centralised to decentralised systems of production and distribution of energy

Biomass and biofuel production systems are by nature decentralised, even if distribution networks of liquid fuels may remain more or less centralised. Biomass power generation is more viable in small to medium-sized plants, which must be dispersed to be located in the vicinity of supply sources. Forest fuel production will always be decentralised, although its distribution to industrial consumers will need some concentration.

From energy monopolies to many small- and medium-scale producers

Biomass production is much less prone to monopolisation than oil, gas or hydropower. So, many new small- and medium-scale producers can and probably will be engaged along the energy transition.

It must also be realised that biofuels for transport—such as bioethanol and biodiesel—are just one option in a wide portfolio of alternatives for the energy transition. Renewable fuels for power generation and industrial use—such as wood pellets and briquettes, and charcoal—are also part of the picture.

Drivers and constraints

The main drivers for biofuels and bioenergy development, and also for their rapid penetration in global and national markets are:

- The need to reduce greenhouse gas (GHG) emissions
- Energy security concerns
- Rising oil prices
- The opportunity to support the countries' rural economy.

In developed countries, the transport sector—highly dependent on oil-derived, mainly imported liquid fuels—presents the strongest current demand for biofuels. However, power and industrial sectors also have to reach reduced GHG emissions targets and are thus seeking low-carbon sources of energy.

All Latin American countries are non-Annex I countries in the Kyoto Protocol. The need for GHG emissions abatement in Latin America is not yet pressing. But energy security and rising oil bills are powerful drivers for those countries with scarce oil reserves, such as Chile, Colombia and all the countries of Central America. And a strong driver for all Latin American countries is the interest to develop new sources of wealth, employment and income—especially in rural areas—by engaging in biofuel production for domestic and global markets, a concept relying on two main assumptions: first, that there is available unused, degraded or underproductive land to produce biofuels; and second, that unemployed or underpaid rural labour could be used for biofuel or biomass production.¹

An important potential constraint for biofuel expansion in Latin America is the ongoing discussion on criteria for sustainable production, energy balances and GHG savings of biofuels, which could become protectionist barriers discriminating against supplier countries. The European Union has just passed new regulations requiring a minimum 35% net reduction of GHG emissions for biofuels² along with specific requirements on environmental and social impacts, which may pose new challenges for imports of

ethanol from maize or biodiesel from soya. Also, if carbon emissions from land use change are accounted for and high carbon density lands are cleared for biofuel production, most crop-derived biofuels will not qualify to be sold in Europe.

Supply potentials

To avoid the food-or-fuel dilemma, biofuels should be produced from food crops only after additional feedstocks are made available for this purpose. This can be achieved by either attaining higher yields in currently cropped areas, or expanding cultivation. But expanding into marginal lands means that much more area will be needed, since these are inherently low-productivity lands. And specific, low-cost technology packages will have to be set up for marginal lands.³ Thus, the obvious question

arises: how much biofuel could be produced from dedicated crops in Latin America?

A recent study (Arias 2009) assessed bioethanol production from sugar and starchy crops in eight Latin American countries concluding that (Table 1):

- With first-generation conversion technologies and sugarcane production expanding by a factor of 2.34 (mostly on pasturelands), bioethanol output could reach 119 million m³ per year;
- The expansion of starch crops output by a factor of 1.43 could offer additional feedstocks to produce 30 million m³ bioethanol per year with current technologies;
- Total additional ethanol output might double the current consumption of petrol/gasoline.

Table 1. Crops and bioethanol production in Latin America with first-generation technologies (Arias 2009)

| | Country or Region | | | | | | | | Expansion Factor | |
|---|-------------------|------------|-----------------|-------------|-------------|-------------|-------------|------------|------------------|-------|
| | Brazil | Mexico | Central America | Argentina | Colombia | Ecuador | Peru | Chile | | Total |
| Sugar crops* | | | | | | | | | | |
| Current production (million t/year) | 483 | 50 | 44 | 21 | 21 | 8 | 8 | 1 | 637 | |
| Potential production (million t/year) | 900 | 256 | n.a. | 200 | 66 | 15 | 46 | 4 | 1487 | 2.34 |
| Additional ethanol (million m ³ /year) | 33 | 16 | | 14 | 4 | 1 | 3 | 0 | 119 | |
| Starch crops** | | | | | | | | | | |
| Current production (million t/year)*** | 78 | 32 | 4 | 49 | 7 | 3 | 6 | 3 | 182 | |
| Potential production (million t/year)*** | 100 | 43 | n.a. | 86 | 15 | 6 | 10 | 7 | 262 | 1.43 |
| Additional ethanol (million m ³ /year)*** | 7 | 3 | | 14 | 3.20 | 2 | 1 | 1 | 30 | |
| Total ethanol = sugar + starch crops (million m ³ /year) | 40 | 19 | 0 | 28 | 7 | 3 | 4 | 1 | 149 | |
| Petrol demand, 2005 (million m ³ /year) | 17.0 | 40.2 | 3.9 | 4.0 | 5.2 | 1.1 | 1.1 | 2.9 | 75.4 | |
| Total Ethanol/ petrol ratio | 237% | 48% | | 700% | 130% | 230% | 325% | 46% | 198% | |

* Potential in Chile corresponds to sugarbeet.

** Includes maize, wheat, sorghum, oat, potato and cassava; in Argentina only maize and wheat; in Brazil only maize.

*** Maize is excluded in Mexico.

The same study calculated the feedstock production for biodiesel from lands potentially apt for oil crops (soya, oil palm, castor, peanut, sunflower, rapeseed and jatropha; Table 2. Even increasing production by a factor of 2.3—by a combination of higher yields and expansion of cultivated areas—the biodiesel output from additional oil crops would be less than half the current consumption of petrodiesel in Latin America.



Fuelwood for recycled paper plant, Recife, Brazil (Photo by Teresita Arias)

Table 2. Crops and biodiesel production in Latin America with first-generation technologies (Arias 2009)

| | Country or region | | | | | | | | Total | Expansion Factor |
|---|-------------------|------------|-----------------|-----------|------------|------------|------------|-------------|------------|------------------|
| | Argentina | Brazil | Central America | Chile | Colombia | Ecuador | Mexico | Peru | | |
| Current production (million t/year) | 52 | 53 | 2 | 0 | 1 | 2 | 0 | 0 | 110 | |
| Potential production (million t/year)* | 105 | 96 | n.a. | 1 | 2 | 5 | 19 | 25 | 253 | 2.30 |
| Additional oil crops (million t/year)* | 53 | 43 | 0 | 1 | 1 | 3 | 19 | 25 | 143 | |
| Additional biodiesel (million m ³ /year) | 11 | 9 | 0 | 0 | 0 | 1 | 6 | 7 | 34 | |
| Diesel demand 2005 (million m ³ /year) | 11 | 38 | 3.5 | 6 | 3 | 2 | 19 | 3 | 86 | |
| Biodiesel/diesel ratio | 100% | 22% | | 5% | 12% | 39% | 30% | 232% | 39% | |

* Includes soya, oil palm, castor, peanut, sunflower, rapeseed and jatropha.

The evaluation of forest residues that could be used for biofuel production with second-generation technologies, such as 'Biomass to Liquid' (BtL) for biodiesel and 'Hydrolysis and Fermentation' (H&F), for ethanol indicated that:

- currently available residues could be converted into 37 million m³ ethanol per year, or 19 million m³ biodiesel per year, equivalent to 49% and 22% of present demand for petrol/gasoline and petrodiesel, respectively (Table 3);
- additional residues from enhanced forest management and some plantations might produce 89 million m³ of bioethanol or 36million m³ of biodiesel, substituting 118% of current petrol consumption or 42% of present petrodiesel use.

Thus, forests can supply at least 166% of the petrol, or 65% of the diesel demands (in volume), if and when second-generation technologies are available and economically feasible.⁴ In principle, and under appropriate regulations, forests may be able to supply biofuels with few detrimental land use changes—one of the main GHG emission sources in Latin America—and also lessening competition with food production compared to first-generation biofuels.⁵

Table 3. Forest residues and biofuel production in Latin America with second-generation technologies (Arias 2009)

| | Country or region | | | | | | | | Total |
|--|-------------------|------------|-----------------|-------------|-------------|------------|--------------|------------|-------------|
| | Argentina | Brazil | Central America | Chile | Colombia | Ecuador | Mexico | Peru | |
| Current output (million t DM/year) | 3 | 39 | 3 | 15 | 5 | 2 | 3 | 3 | 73 |
| Bioethanol eq. (million m ³ /year) | 2 | 19 | 2 | 8 | 2 | 1 | 1 | 1 | 36 |
| Biodiesel eq. (million m ³ /year) | 1 | 10 | 1 | 4 | 1 | 1 | 1 | 1 | 20 |
| Additional output* (million t DM/year) | 13 | 14 | n.d. | 3 | 37 | n.d. | 111 | n.d. | 178 |
| Bioethanol eq. (million m ³ /year) | 7 | 7 | | 1 | 19 | | 55 | | 89 |
| Biodiesel eq. (million m ³ /year) | 3 | 3 | | 1 | 7 | | 22 | | 36 |
| Total Bioethanol eq. = current + additional (million m ³ /year) | 9 | 26 | 2 | 9 | 21 | 1 | 56 | 1 | 125 |
| Total Biodiesel eq. = current + additional (million m ³ /year) | 4 | 13 | 1 | 5 | 8 | 1 | 23 | 1 | 56 |
| Petrol use 2005 (million m ³) | 17 | 40,2 | 3,9 | 4 | 5,2 | 1,1 | 1,1 | 2,9 | 75,4 |
| Diesel use 2005 (million m ³) | 11 | 38 | 3,5 | 6 | 3 | 2 | 19 | 3 | 86 |
| Total bioethanol / petrol | 53% | 65% | 51% | 225% | 404% | 91% | 5091% | 34% | 166% |
| Total biodiesel / petrodiesel | 36% | 34% | 29% | 83% | 267% | 50% | 121% | 33% | 65% |

* Figures for Argentina, Brazil and Chile include non-harvested growth plus logging residues and industrial waste from existing commercial plantations. In Mexico and Colombia, only logging residues and industrial waste from new plantations are included in the figures. DM = dry matter.

Roles of forests and forest lands

In order to achieve future biofuel demands, forest lands can be either cleared to plant biofuel crops, or kept as productive forests and harvested for sustainable wood-for-energy production. Leaving sustainability considerations apart, both alternatives are technically viable. However, it is not yet clear which one will be more profitable in the emerging biofuels market.

In recent decades, clearing forests for cropping or cattle raising has looked much more profitable than managing them as a productive asset in all of Latin America. This is the main cause of the continued,

reckless deforestation that is still going on, in spite of laws, bans and incentives existing in Latin American countries.

To prove that productive forest management is a viable alternative to forest clearing when it comes to biofuels supply, forest producers must first demonstrate that they are able to offer sizable quantities of cost-competitive woody feedstocks and woodfuels. This has been proved in Brazil, where a large iron industry relies on charcoal. But this is not a very good case, since most Brazilian charcoal comes from forests that are cleared for crops or pastures expansion, thus the supply is unsustainable. And the sustainability of woodfuel production must be proven if global markets are targeted.⁶

State-of-the-art technologies for wood processing (into chips, pellets, briquettes, etc.) are quite efficient and relatively cheap, enabling supply of clean, low-cost fuels to the industrial and power sector. This opens a clear and immediate opportunity for the forest sector to take part in both local and global solid biofuels markets. If oil prices are high, profits can be made by producing wood-for-energy quite distant from end users' locations. And net GHG mitigation is very high in this case, because little fossil energy is used in the process. The high ratio of renewable to fossil energy is a big advantage of forest fuels and woody feedstocks for biofuels when compared to agricultural crops, along with their very light environmental footprint, since most biodiversity and environmental services can be preserved in well-managed forests. The calculations in Table 3 are based on this assumption, i.e. that only Mean Annual Increment will be harvested, conserving current levels of carbon stocks in native forests.

Second-generation technologies will (sooner or later) allow for liquid fuel production from lignocellulosic feedstocks at competitive cost. For example, biodiesel can already be obtained from wood, using a biomass-to-liquid (BtL) process that yields 240 litres of biodiesel per tonne of dry matter (Choren Industries nd), at a cost of about 1 euro per litre, while paying about 60 euros per tonne for delivered wood (dry matter). Bioethanol can also be obtained from lignocellulosic materials; even if current technologies are rather costly and not competitive with ethanol from sugarcane or maize, much research is underway and this technology might be competitive in 10 years or so. Ethanol from wood has many advantages: it uses very little fossil fuel and allows for cogeneration of surplus electricity.

A first step to engage the forest sector in the energy and biofuels industry should be processing waste from wood-based industries.⁷ This is a standard practice in the pulp and paper industry, which supplies its own power needs and generates electricity to the national grid in many European countries (and is also starting to do so in Argentina and Brazil). Sawmills and other wood industries can take this option or put some thinking and investment into processing woodfuels for the market.

In a second step, logging waste could be harvested. In tropical native forests of Latin America, only about 20% of total growth is considered worth harvesting and only about 50% of the volume of logged trees enters the mills. In addition, only 50% of the wood that enters the mill ends in wood



Fuelwood for rice mill, Paso De Los Libres, Argentina (Photo by Enrique Riegelhaupt)

products. This means that we are actually using less than 10% of total wood growth for woody end-products (Bámaca Figueroa *et al.* 2004). There are good reasons for this: there are many noncommercial species; much of the growth corresponds to undersized, crooked or defective logs; and there are high mortality rates in growing stock coupled with long cutting cycles.

The sad fact is that management systems applied in tropical forests only allow the harvest of a small fraction of total forest growth, because there is not yet a strong market demand for woodfuels. But in the new biofuels market, wood-for-fuel may have demand and price levels that will make full harvest possible. We deem that the impact of more intensive management on forest productivity, timber quality and added value will be large and positive. However, the sustainability of this type of management is a key requirement and will have to be clearly defined and ensured. Certification systems can be useful tools to achieve this purpose, since many of them have had several years of practice and good public acceptance.

Challenges

In previous sections, we have made a brief outline of new opportunities for Latin American countries in the context of the energy transition and emerging biofuel markets. It is worth noting that these opportunities are also coupled with new challenges and concerns, posing problems to which the forest sector may offer some solutions.

1. Cropping for biofuels may lead to increased direct or indirect deforestation

This has already happened in Central America, Mexico and Brazil, when beef, soya meal and soya bean oil demand caused intensive forest clearing for cattle raising and soya bean cropping. The greater demand for vegetable oils needed for biodiesel might push the farming frontiers even further. And conversion of pastureland to sugarcane might displace cattle to new grazing areas, promoting deforestation.

2. Small-scale farmers and indigenous people can lose their lands

This is especially the case in forest lands, where propriety rights are less clear—or more subject to manipulation by powerful people. Higher land prices may also tempt many poor farmers to sell their holdings and migrate to cities—or into forested areas, so increasing the deforestation cycle.

3. Monocultures can be expanded or intensified in unsustainable ways

Soya bean, sugarcane, oil palm, maize, sorghum and cassava are crops that would need to be expanded in area and intensified—by means of more mechanisation, fertiliser and water use, and genetic modification—to produce biofuels. Little attention may be paid to sustainability.

4. Export-oriented feedstock production might impair food security

Attractive global markets might lead to more exports of cereals and oilseeds or their processing into biofuels, reducing food supply and increasing food prices.

5. Mismanagement of forests might lead to degradation by overexploitation

Growing demand and high prices for energy-wood can induce overharvesting of the more accessible forests in order to make short-term profits.

What can be done?

In the near future, provided that second-generation technologies become commercial, forests can be a major source of feedstocks for biofuel production. Some of their advantages against agricultural crops are higher energy ratio, lower GHG emissions, and much reduced competition for food and forage. However, direct competition with current use such as traditional fuelwood, and land use change pressure in the case of new forest plantations can arise as new problems. And high market demand for woody feedstocks could also be an incentive to harvest all the biomass in forests, instead of doing selective, sustainable logging. This is a major concern for many Latin American countries, which suffer from poor governance and weak law enforcement capacities as regards forest management.

Thus, the ‘forests for fuels’ option is not devoid of risks. Taking into consideration forest potentials and the urgent need for positive actions regarding global warming, we suggest the following steps.

Pay due attention to forest energy potentials when planning the energy transition

Most Latin American countries have great energy potentials in native forests, ready to use. These should be accounted for when options for the energy transition are analysed. Planning the land use allocation should be based on a careful assessment of the production potentials and GHG emissions associated with agricultural and forest use. Regulations are needed to ensure that cropping for biofuels does not lead to further deforestation.

Enhance the use of forest and agricultural residues for energy in industrial and power sectors

Residues from agriculture and forestry are immediately available at low cost. Appropriate policies giving active support to market and supply chain development, product standardisation, and fair pricing are needed to start their introduction into the energy markets.

Put in practice enhanced forest management for woodfuels production

With current technologies, woodfuels can supply up to one-third of primary energy demand in most Latin American countries. Specific forest management systems and practices for woodfuels production are to be tested and disseminated, to ensure long-term, sustainable and cost-effective supply for potential consumers in the power and industrial sectors.



Logging residues in Campeche, Mexico (Photos by Teresita Arias)

Convince the public that forest management can be safely and sustainably implemented

Public opinion is frequently against the use of native forest for energy purposes, fearing negative environmental consequences. Potential users also require assurance regarding future supply and environmental safety. Certification by independent bodies can help to create confidence in both the general public and energy consumers.

Promote and provide incentives for the development of all biofuels at the same level

Governments should give the same level of attention and support to forest and crop fuels in the energy transition process, and check that the negative and positive externalities of each alternative are fully accounted for.

Put more effort into research and development of biofuels from lignocellulosic feedstocks

A lot of money and thought are currently being invested in the development of fuels from agricultural crops. More attention must be paid to forests as a low-carbon source of energy in Latin America, since their potential is probably greater, and their environmental and social impacts are much less detrimental than those of agriculture.

Endnotes

- 1 In Brazil, sugarcane production is increasingly mechanised, so reducing the number of jobs per area. And sugar fields are expanding into pasturelands, forcing cattle growers to migrate to other areas or to increase the productivity of remaining pastures. At least in this case, it appears that both assumptions do not hold true
- 2 Minimum reduction of GHG emissions will have to be 50 percent by 2017 (CEC 2008).
- 3 *Jatropha curcas* and *Ricinus communis* are drought-tolerant crops that can grow in marginal lands. But yields are quite low in dry and poor soils, so precluding the application of existing high-cost cropping technologies. New, low-cost technologies will have to be developed.

- 4 The huge production potential from native forest management in Brazil and Colombia has not been included in this calculation.
- 5 The figures from this study include only existing commercial plantations in Brazil, Argentina and Chile, plus some expansion of plantations on grasslands in Mexico and Colombia.
- 6 Some positive cases of sustainable forest management can be found in Latin America, but still provide only a small fraction of the overall forest products in the market.
- 7 A study case in Guatemala found that only 13% of the carbon/biomass harvested ended up in products—the rest was 'waste' that could be used for energy (6).

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