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Soybean and oil palm expansion in South America

A review of main trends and implications

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CIFOR

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Oil Palm in the State of Pará, Brazil.

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Abbreviations

ADM	Archer Daniels Midland
ANP	National Fuel Agency (Agência Nacional do Petróleo)
BNDES	Brazilian National Development Bank
CBI	Caribbean Basin Initiative
CPO	Crude Palm Oil
FAO	UN Food and Agriculture Organization
FAOSTAT	UN Food and Agricultural Organization Statistical Database
FEDEPALMA	Colombian Federation of Oil Palm Cultivators
ICR	Incentive of Rural Capitalisation (Incentivo a la Capitalización Rural)
IIASA	International Institute for Applied Systems Analysis

1. Introduction

Arable land under cultivation has expanded in recent decades, in some cases associated with growths in yields, thus leading to a net increase in total food supply around the world. By 2010, most arable land cultivated grains such as wheat, rice and maize (532 million ha). Annual growth rates were relatively modest, except for maize, which grew by 1.6% per year between 2001 and 2010 (FAOSTAT 2011). In the same period, soybean cultivation has expanded significantly, reaching 102 million ha in 2010, with an annual rate of growth of 2.9%. Oil palm represents less cultivated land but experienced high growth in the same period (14.9 million ha; 3.5%); oil palm and rapeseed (31.6 million ha; 3.4%) are the two crops with the largest growth rate in cultivated areas (FAOSTAT 2011). It is worth mentioning that an important portion of this agricultural expansion has been taking place in South America; this is primarily due to the expansion of soybean and sugarcane and, to a lesser extent, oil palm, rather than from the growth of conventional grains, cereals and tubers.

In South America, while traditional agriculture has been relatively stagnant during the last few years, commercial agriculture has grown to unprecedented levels. This has led to important trade-offs for economic development and conservation. On one hand, the expansion of commercial agriculture has significantly contributed to local and national economic growth. On the other, it has also produced negative local and global environmental impacts, mainly associated with the loss of biodiversity and the increased carbon emissions with effects on climate change. This growth is not only associated with agricultural modernisation in areas under established commercial agriculture, but also with a quite vigorous expansion of the agribusiness sector into 'new' lands, some of which were forestlands. This expansion is primarily related to the growing amount of land under soybean cultivation in Brazil and Argentina, with expansion into Paraguay and Bolivia, as well as the expansion of oil palm in Colombia, and to lesser extent, in Ecuador and Peru.

The expansion of commercial agriculture for soybean and oil palm cultivation stems from multiple factors surrounding policy and market conditions that are both exogenous and endogenous. The main exogenous factors are a relatively steady growing demand for commodity markets (primarily global, but also national) for food, fodder and biofuels, coupled with an expansion of investments in production, storage and processing facilities aimed at meeting this rising demand. Key incentives are also important such as those policies affecting demand on the one side (e.g. blending targets of fossil fuels with biofuels) and policies stimulating supply on the other (e.g. cheap credit, tax breaks, price controls, trade incentives). Main endogenous factors stimulating commercial agriculture development are related to important processes of adoption of improved technologies, development of road networks and changes in tenure arrangements. The combination of these processes tends to shape different dynamics of agricultural expansion, which present different regional variations.

The outcomes of this expansion are still under debate. In some cases, it has had positive impacts through the generation and distribution of income, as well as through helping develop processing industries down the value chain. In other cases, its effects have been more controversial as it has contributed to land concentration and favoured traders and industry owners, with limited inclusion of smallholders in the value chains. In addition, it has led to the conversion of previous land cover – a portion of which were forests – towards more homogeneous landscapes linked to the massive adoption of large-scale mechanised and capital-intensive agriculture. Given the lack of sufficient empirical evidence, it is difficult to argue that economic gains have outweighed environmental and social costs. More nuanced analysis is required to devise development pathways that can improve distribution of social and economic benefits under low carbon emissions.

A growing body of work focuses on the factors underpinning the expansion of commercial agriculture for soybean and oil palm cultivation, as well as their socio-economic and environmental impacts. Yet the available literature is relatively fragmented since it focuses either on a specific crop or specific geographies. This paper aims to overcome those constraints by providing a more comprehensive assessment of the main production trends linked to specific policies and market conditions. This paper is based on secondary information for the whole region, complemented with two case studies, viz. soybean in Brazil and oil palm in Colombia. We have chosen these two crops since they constitute the main engines of agricultural growth and the most significant drivers of landscape change in the region; we have selected these two countries since they comprise the largest amount of acreage expansion in the region through these two crops.

This paper is organized in five sections, beginning with this introduction. The second section offers a short description of the main production and market trends related to agricultural development in South America. The third section assesses the conditions underlying the expansion of soybean development by focusing on Brazil. The fourth section analyses oil palm expansion with an emphasis on the Colombian case. The last section provides a discussion and main conclusions, through a comparison of the two cases. The lessons learned can inform the regional policy debate seeking to enhance land and forest governance and, ultimately to manage the socio-economic and environmental impacts resulting from the expansion of commodity crops in South America.

2. Agricultural production trends in South America

2.1 Agricultural production and land-use change

Two main trends are taking place in the agricultural sector in South America: a relative stagnation of traditional crop production and a growing expansion of new crops, mainly oilseeds and sugarcane.

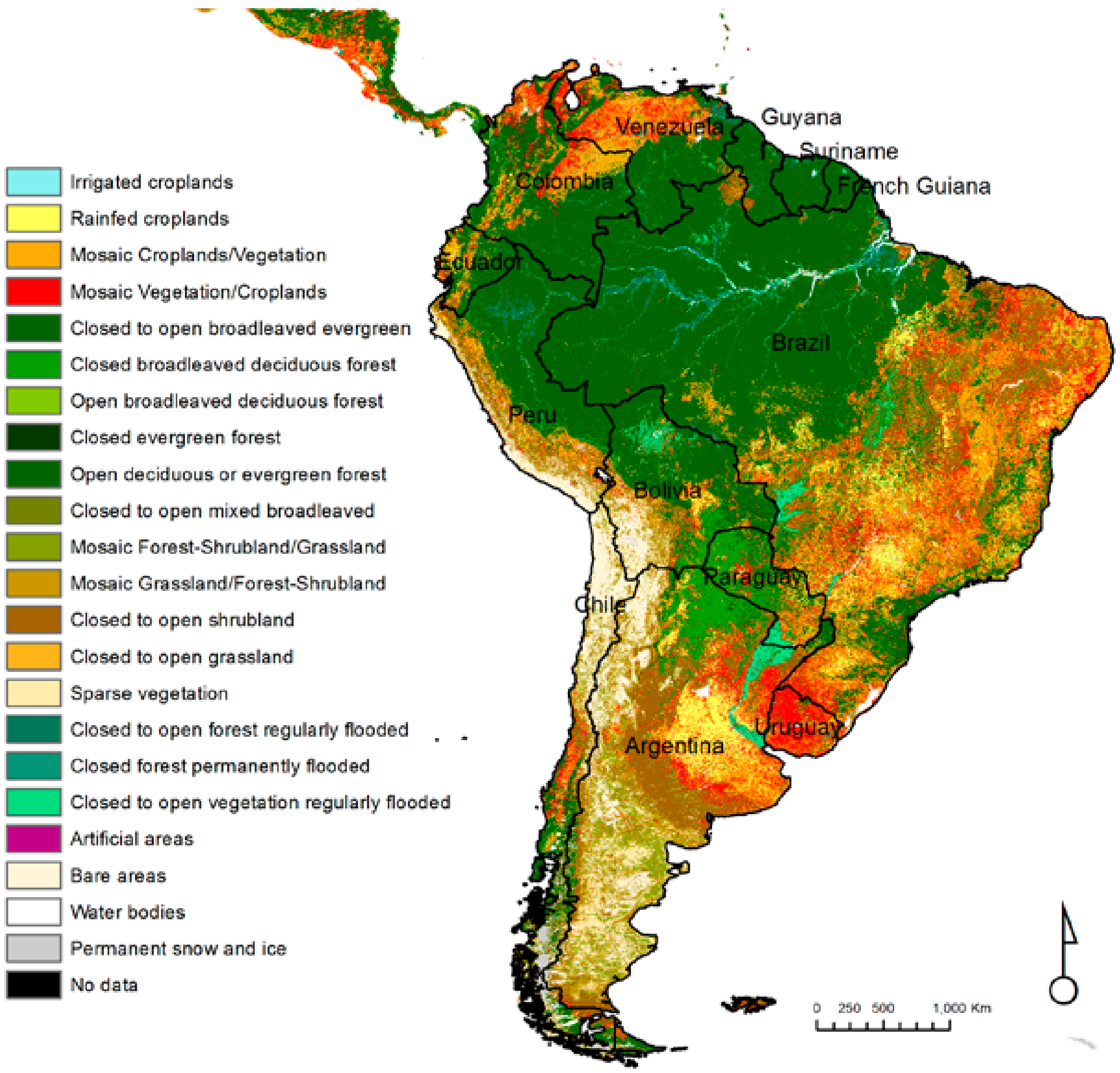

Figure 1. Land cover in South America

Source: Authors' mapping of data from GLOBCOVER 2009, ESA (2010)

Table 1. Land-use (change) in South America

	Area in 2005 (million ha)		As % of land cover		Deforestation rates (in %)
	Arable	Forest area	Arable	Forest	2005-10
Argentina	29.5	33.0	10.8	12.1	-0.80
Bolivia	3.3	58.7	3.0	54.2	-0.53
Brazil	66.6	477.7	7.9	56.5	-0.42
Chile	2.3	16.1	3.1	21.5	0.23
Colombia	3.6	60.7	3.3	54.7	-0.17
Ecuador	2.6	10.9	9.3	39.2	-1.89
French Guiana	0.0	8.1	0.2	91.5	-0.04
Guyana	0.5	15.1	2.6	76.7	0.00
Paraguay	4.3	18.5	10.8	46.5	-0.99
Peru	4.3	68.7	3.4	53.7	-0.22
Suriname	0.1	14.8	0.4	94.7	-0.02
Uruguay	1.4	1.5	8.1	8.6	2.79
Venezuela	3.5	47.7	3.9	54.1	-0.61
South America	121.9	831.5	6.9	47.3	-0.41

Source: Adapted from FAOSTAT (2011)

The latter is primarily associated, firstly, to a growing demand in the food and feed markets for agricultural production (particularly in Asia) and secondly, to an expanding demand for feedstocks for biofuel production to supply both domestic and international markets. The intersection of food and fuel markets has made these interactions relatively more complex over time. Agricultural production dynamics currently respond to changes in demand taking place in these two markets simultaneously.

The total arable land in this region is about 122 million ha, a major portion of which is located in Brazil and Argentina (Table 1). Although this figure is still a small portion of the total land area, and there is some land available for agricultural expansion (mainly grasslands), pressure on forests is also increasing in the region. This pressure on forests is due not only to the economics of agricultural expansion, but also to the agroecological conditions under which this frontier expansion has been taking place. In South America, greater pressures on forests are evident in Ecuador, Paraguay and Argentina, while annual deforestation rates in the remaining countries range between -0.4 to -0.6%. In Brazil, deforestation rates have been declining in the last two years compared to the peak observed in the mid 2000s.

While some agricultural intensification has been taking place, agricultural production has often occurred in a context of abundance of land resources which translates into a rapid expansion of the agricultural frontier onto new lands – a portion of which are forests – often under medium- and large-scale landholdings. This is mainly the case of agricultural expansion in Brazil, Argentina and Paraguay, and to a lesser extent in Bolivia (Figure 1). In South America, agricultural growth has been linked to the increase of traditional staples for domestic demand. Additional expansion of agricultural lands has primarily been driven by the growth of international demand for agricultural commodities, mainly for beef and grains.

Productive activities geared towards international and most dynamic domestic markets experienced the most significant expansion in Latin America between 1990 and 2010, among them: soya, sugarcane and oil palm. The growing expansion of biofuel production for feedstocks has also stimulated the growth of these three crops (ECLAC 2008). Much of this growth is taking place in South America. For example, Brazil is the world's largest sugarcane producer and ranks second in soybean. Argentina is the third largest soya producer worldwide. Oil palm is growing in Colombia and, to a lesser extent, in Brazil. These

Table 2. Harvested area of selected crops in South America

	Harvested areas (million ha)		Production (million TM)		Annual growth (in %)	
	1990	2010	1990	2010	Area	Production
Beans	5.4	4.2	2.9	4.0	(1.3)	1.7
Cassava	2.5	2.4	31.2	31.6	(0.3)	0.1
Maize	15.6	19.2	31.8	92.2	1.0	5.3
Oil palm	0.2	0.4	2.9	7.2	3.8	4.6
Rice	5.5	5.1	13.4	23.4	(0.4)	2.8
Soybeans	17.7	46.2	33.1	132.3	4.8	6.9
Sugarcane	5.3	10.2	335.0	811.7	3.3	4.4
Wheat	9.7	8.2	16.8	25.7	(0.9)	2.1

Source: Adapted from FAOSTAT (2011)

crops are mainly produced by a small group of farming companies through large-scale plantations that constantly incorporate new technologies and have easy access to capital.

Soybean has exhibited the most significant growth in the region over the last few decades. Between 1990 and 2010, its production increased from 33.1 million to 132.3 million tons. During this period, the harvested area expanded from 17.7 million to 46.2 million ha. This occurred mainly in areas previously dedicated to less profitable activities such as cattle ranching, also at the expense of native forests. Sugarcane tends to occupy a smaller amount of land comparatively, but its extension is still significant: it increased from 5.3 million to 10.2 million ha in the region during the same period, and with important growth in productivity. Conversely, the area dedicated to the most important staple crops in the region in terms of land use, such as wheat, rice and beans, have not registered important variations at the regional level. The only conventional crop that has expanded in the period mentioned is maize (Table 2).

It is particularly interesting to note the substantial increase in the harvested area of soybean after several countries, such as Brazil, Argentina, Paraguay and Bolivia actively began to adopt this crop in the mid-1990s through capital-intensive farming. This process has also helped to capitalise an important segment of agricultural producers linked to the agribusiness sector and contributed to significant multiplier effects in expanding local and national earnings. Transnational capital, particularly through international trading companies, has also played an important role in this process, as we will discuss further in this section. Sugarcane grew more steadily, benefitting in part from foreign investment in the ethanol industry, which largely helped to modernise what used to be a very traditional sector (Abramovay 2009). In addition, oil palm is a perennial crop; it has relatively small planted areas but has been growing very rapidly, particularly in Colombia, and industry plans to expand this crop in Brazil.

2.2 Multiple factors shaping agricultural expansion

Four factors have shaped the expansion of agricultural production in the region:

- Changes in market conditions, including the expansion of domestic demand for staples and processed agricultural products influenced by urbanisation; growing international demand for commodities and more integrated value chain development; and additional demand resulting from biofuel production, both ethanol and biodiesel.
- Growing public investments in infrastructure, as well as more private investments in production and processing with a greater role played by foreign direct investment.
- Availability of resources on the new frontiers, mainly soils, water and light, which constitute basic material conditions for the expansion of agriculture.

Table 3. Evolution of urban population in South America

	1960	1970	1980	1990	2000	2010
Population (million persons)	148	191	241	295	347	393
Urban population (in %)	NA	55.2	58.4	61.8	64.9	75.0

Source: Adapted from CEPAL, Statistical Yearbook (2009)

- Improved seeds and technological packages, often accompanied by improved mechanisation and processing.

Countries in South America are undergoing a rapid process of urbanisation that began in the 1970s and which has accelerated in the last two decades (Table 3). The urban population grew from 55% in 1970 to 75% in 2010. This factor itself has led to substantial growth in demand not only for food but also for energy, including fossil fuels (although exact figures about these interactions are still lacking in the literature). In addition, there has been an increase in per capita food consumption, particularly of beef and vegetable oils. These same two trends are present in other countries as well, particularly in China, which has become one of the world's largest consumers. Thus, rising consumption in China has driven up the demand for agricultural commodities produced in Latin America, particularly in South America.

The recent expansion of the globalisation of trade has stimulated transnational trading companies to play a more active role in production and trade (UNCTAD 2009). This is particularly evident for the production, processing and trade of grains, mainly soybeans in Latin America; Archer Daniels Midland (ADM), Louis Dreyfus, Cargill and Bunge are all involved, representing companies with the largest share in the market. Transnational companies have actively helped reorganise value chains in the agricultural market, integrating them better into global circuits, as well as improving export facilities in the main ports.

Higher exposure of the agricultural sector to global markets and investors has pros and cons. On one hand, farmers in the region are in a better position to compete with other traditional producers of grains, such as the United States, in relatively favourable conditions. On the other, countries have less of a chance to bear an influence on markets, and may become more vulnerable to external market shocks and current price volatility (UNCTAD 2009).

Another factor influencing the expansion of harvested areas in the region, mainly of soybean and sugarcane, is the rise in global demand for biofuels: these account for about 2% of total fuel consumption in the region and 7% in the transportation sector (EIA 2010). This share will continue growing over time, mainly in countries that have adopted the substitution of fossil fuels for biofuels in their energy security strategies, such as Brazil, Argentina and Colombia.

Additionally, some countries are stimulating the expansion of ethanol and biodiesel processing to reach international markets, even though they face both major tariff constraints and large subsidies applying to biofuel production in the destination markets (Gorter and Just 2008). In this regard, Brazil is keen on reducing barriers for accessing the EU and US biofuel markets. In the meantime, Brazilian producers are taking advantage of a treaty through which Caribbean Basin Initiative (CBI) countries enjoy duty-free access to US markets with a quota of 7% of US consumption. Argentina is playing an important role in biodiesel production in the region, and has surpassed Brazil in this sector.

As mentioned earlier, the available land suitable for crop production has stimulated the expansion of agriculture in these landscapes, often at the expense of forestlands. A main limitation for agricultural expansion is related to the soil condition in woodlands and tropical lands; these soils are relatively low in nutrients (Laurance *et al.* 1999). Yet technologies developed in the region, particularly those related to improved seeds and soil correction, have allowed the expansion of agricultural crops in such lands. In this regard, the development of technologies for soybean production in the *Cerrado* area in Brazil is an interesting case (Kaimowitz and Smith 2001). There are also limitations with regard to infrastructure and logistics, mainly in the Amazon, which also constitutes a constraint for agricultural expansion (Lima *et al.* 2011).

Some studies assessing how crop production can meet the rising demand for food and biofuels suggest that it may lead to an increase in crop lands. Fischer *et al.* (2009) suggest that without any use of agricultural feedstocks for biofuel production, the increase of additional land to meet growing feed and food requirements from 2000 to 2020 would be about 90 million ha (36 million ha in Latin America). They further project that additional rises in demand due to biofuel development would expand cultivated land use from about 103 to 114 million ha (10 million ha in South America). From 2000 to 2010, there was a net increment of 24 million ha in cultivated lands in South America; only soybean expanded in about 20 million ha during the same period (FAOSTAT 2011).

2.3 Competing land-uses and deforestation trends

Three spatial patterns are recognisable with respect to where agriculture is expanding in Latin America, particularly in South America:

- Traditional crops expanded in older production zones, most notably sugarcane. This crop, which was introduced in early colonial times, is mainly located in the northeast and so-called south-central regions of Brazil (including São Paulo, Goiás, and Mato Grosso do Sul), as well as in Colombia (Cauca Valley) and Bolivia (north of Santa Cruz).
- Cattle raising has, on one hand, developed in available grasslands (the pampas in Argentina, *Cerrado* in Brazil and llanos in Colombia and Venezuela), and on the other, expanded onto forestlands converted to cultivated pasture. A major portion of beef production has traditionally been achieved through extensive land-use systems that required large amounts of land (Jarvis 1974, Hecht 1982).

Establishment of new crops, mainly oil seeds (including soybeans and oil palm) has taken place in some areas far from the urban markets since their production requires relatively large economies of scale. In more specific terms, soybean production has expanded northwards in Argentina and Paraguay, and has taken important land area in the *Cerrado* ecosystem in Brazil, from where it has advanced towards the Amazonian ecosystem (Schnepf *et al.* 2001). Since the early 1970s, the latter region has been occupied by medium- and large-scale landholdings for beef production in a process highly stimulated by land speculation (Hecht 1993). Since the late 1990s, soybean production has taken over a portion of the pasture implanted by such ranches, particularly in Mato Grosso (Schlesinger 2008). As a result, an important portion of the *Cerrado* has been converted to agriculture, which has put more pressure on Amazonian forests. In turn, agricultural production in Argentina is expanding beyond traditional farmlands of central and eastern Argentina into the arid northwest, affecting in some cases protected forests (Gasparri and Grau 2009).

Currently, land-use change transitions taking place, particularly in Brazil, do not follow a single pattern. Three main land-use trends occurring simultaneously are particularly important:

- Expansion of sugarcane taking place in southern states, particularly in Sao Paolo.
- A rapid expansion of soybean in the centre-west mainly in Mato Grosso, placing pressure on *Cerrado* lands and forests.
- The progressive expansion of planted pasture, a significant portion of which tends to take place in the Amazon region (Pacheco *et al.* 2011).

There is controversy about the interactions among these three dynamics. For Nepstad *et al.* (2006), the main issue is indirect land-use change: sugarcane expansion in the Brazilian south is driving pasture expansion in the Amazon (since sugarcane would tend to expand over lands under soybean, which in turn pushes cattle herds farther into the forests, and thus stimulates deforestation). Although it is evident that biofuel production is placing some pressure in stimulating direct and indirect land-use change and deforestation, these interactions are relatively complex and difficult to measure in practice (Gao *et al.* 2011). Some studies suggest the presence of indirect land-use change trends in the Amazon as discussed below (Lapola *et al.* 2010, Arima *et al.* 2011).

There is an intense debate about the direct and indirect influence of biofuel development in deforestation in the Brazilian Amazon. Some agree that ethanol production has a relatively small direct influence on deforestation (since most sugarcane plantations are in south-central and northeastern Brazil). More controversy exists, however, about the indirect influence of these plantations' expansion on land-use change. Some argue that sugarcane grown in the south tends to displace soybean cultivated in the centre-west, which in turn would push farther cattle herds into the Amazonian fringes. In contrast, others are skeptical about the influence of sugarcane in driving deforestation in the Amazon (Sawaya and Nappo 2009).

Sugarcane is generally established in lands already deforested, as exemplified by Sao Paulo, Brazil, which is the world's largest sugarcane production area. Meloni *et al.* (2008) evaluated the direct land-use change effects of sugarcane development in Sao Paulo using satellite images on different dates. They observed a sugarcane expansion of 1.8 million ha from 2005 to 2008. This expansion took over both pasture (53%; 960 000 ha) and agriculture (44.6%; 808 000 ha), while 0.31% (5 500 ha) took place over forest regrowth and secondary succession. Furthermore, direct land-use change has also occurred due to the accelerated expansion of soybean in Brazil (Mato Grosso) and northern Argentina (Chaco region). However, even in these cases, the expansion of soybean took place mostly as a source of food and feed for export to Asian markets rather than for producing biodiesel. This situation may change in the future since biodiesel production from soybean oil continues expanding.

Different modelling exercises have tried to determine the indirect influence of biofuel development on land-use change, and thus its implications on forest conversion. For example, Lapola *et al.* (2010), based on some simulations, state that direct land-use change will have a small impact on carbon emissions because most biofuel plantations would replace rangeland areas. However, indirect land-use changes, especially those pushing pasture areas farther into the Amazon forests, could offset carbon savings originated from biofuels production. In this regard, these authors estimate that sugarcane ethanol and soybean biodiesel will each contribute to nearly half of the projected indirect deforestation of 121 970 square km by 2020.

In summary, the main findings from both empirical work and land-use change modelling indicate that sugarcane is generally grown on lands that were cleared for agriculture in the past, and has mainly replaced other field crops. Expansion of sugar production for ethanol may cause indirect effects through displacement of crops or livestock into new areas. Nonetheless, indirect land-use dynamics may also be influenced by other factors such as rising food prices or growing demand, or specific incentives promoting food production. Soybean, specifically in Brazil and Bolivia, is generally a pioneer crop, which is often produced on areas cleared for pasture or on forestlands cleared for expanding soybean acreage. In turn, most oil palm plantations have been developed in rainforest areas specifically cleared for this purpose; however, it is currently expanding in pasture lands of low productivity, particularly in Colombia and recently also in Brazil.

3. Trends and implications of soybean production

3.1 The 'boom' of soybean expansion

As mentioned earlier, the most important agricultural dynamic in Latin America in the last two decades has been linked to the enormous expansion of soybean cultivation. This started in the Pampean region in Argentina and southern Brazil, expanding towards the north of Argentina, and the centre-west of Brazil (Schnepf *et al.* 2001). Furthermore, Brazilian investors were relatively active in expanding the soybean frontier in the Bolivian lowlands in eastern Santa Cruz, where the best agricultural lands are located (Pacheco 2006) and in the Chaco region in northern Paraguay, where most soybean expansion is taking place (Riquelme *et al.* 2006).

Between 1990 and 2010, the harvested area almost doubled in Brazil from 11.4 to 23.2 million ha. In Argentina, during the same period, it more than tripled from 4.9 to 18.1 million ha. Paraguay is the third country with a clear policy to expand the soybean frontier. Soybean is also expanding in Uruguay, driven by the comparatively larger profits from soybean cultivation (Table 4).

Soybean production takes up a significant portion of total arable land in Brazil (35%), Argentina (61%) and Paraguay (62%) (Table 5). This growth has largely been driven by the adoption of new technologies such as new seed varieties – often genetically modified – and soil-recovering systems, mainly in medium- and large-scale landholdings under capital intensive production systems. The advent of no-till or low-till farming systems, as well as the 'winter harvest', which enables farmers to increase overall profitability per hectare, is also important. Soybean production became highly profitable through economies of scale, leading to concentration of income among fewer capitalised producers (Kaimowitz and Smith 2001). Accompanying the

Table 4. Soybean: harvested areas in selected years

	Area harvested (thousand ha)			Annual growth (%)	
	1990	2000	2010	1990-2000	2000-2010
Brazil	11 487	13 640	23 293	1.7	5.4
Argentina	4 962	8 638	18 131	5.5	7.4
Paraguay	900	1 176	2 671	2.7	8.2
Bolivia	143	617	1 086	14.6	5.7
Uruguay	29	9	863	(11.6)	45.7
Others	205	76	112	(9.9)	3.8
South America	17 725	24 156	46 156	3.1	6.5

Source: Adapted from FAOSTAT (2011)

significant growth in production areas in Brazil and Argentina, productivity levels are also relatively high: roughly 2.9 tons/ha in these two countries and 2.8 tons/ha in Paraguay. The yields are relatively low in other producer countries (1.5 to 1.8 tons/ha), including Bolivia, partially due to less investment in research and extension systems.

Several factors have contributed to the expansion of soybean in the region. Seed technology, including a short cycle and Roundup Ready varieties genetically modified to resist gliphosate herbicides, is one of the main reasons for soybean's success. Higher profitability over other crops is another reason. Other factors include double cropping (where soy is planted in the same year on fields previously sown with wheat or other crops such as sorghum and corn) and intercropping (where soy is planted within maize rows). The no-tillage sowing system has reduced costs and increased efficiency in the crop's soil water-use, allowing for cultivation in areas previously deemed unsuitable for grain production in northern and northwestern Argentina. No-tillage has been adopted rapidly and is currently applied in an important portion of soybean-planted areas.

Figure 2 shows the most suitable areas estimated for soybean expansion in Latin America (Fischer *et al.* 2002). Lands with medium- to high-suitability for soybean are primarily located in the northeast of Argentina and in eastern Bolivia, as well as in northeastern Brazil. Figure 3 shows that a major portion of these lands is already under cultivation, likely with soybean, and another portion of them (mainly in Argentina and Bolivia) is still under forest cover. Significant pressure from soybean expansion on deforestation takes place in these lands (Pacheco 2006, Gasparri and Grau 2009).

Main markets for soybean and its derivatives

Soybean grown in South America is used to produce soybean oil and cake for feed markets, among other products. The domestic market for soybean and derivatives is relatively important in the region, but increasingly, a significant portion of production is devoted to meet a growing international demand, mainly in Asia.

Table 6 shows exports of soybean and derivatives in 2000 and 2009 based on data from FAOSTAT (2011). This data suggests that Brazil is one of the main suppliers of soybean grain, and to a lesser extent cake and oil; Argentina's oil industry processes a comparatively higher portion of soybean into soybean cake and oil. These data suggest that important expansion of planted areas of soybean in Brazil has not necessarily been accompanied by the development of the processing industry. In 2009, for the region as a whole, about 36 million tons were exported as grain – with more than half originating in Brazil – and 36 million tons as cake; soybean oil accounts for about 6.5 million tons – about one third of which originates in Argentina. Paraguay and Bolivia are two countries that play only a minor role in the soybean market. Bolivia, for example, exports mostly to Venezuela, Colombia and Peru since it benefits from preferential tariffs in the Andean market.

While in the past, most of the region's soybean exports targeted the European market, the Chinese market has been fundamental in driving up demand,

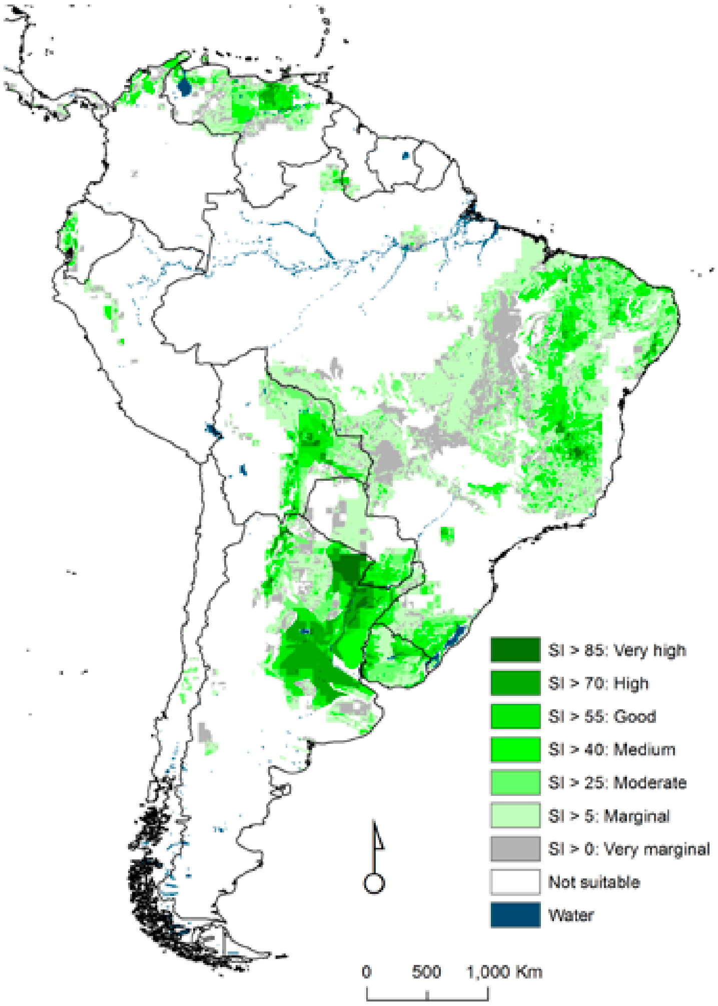

Figure 2. Suitability of soybean production in Latin America

Source: Author's mapping of data from IIASA (2002)

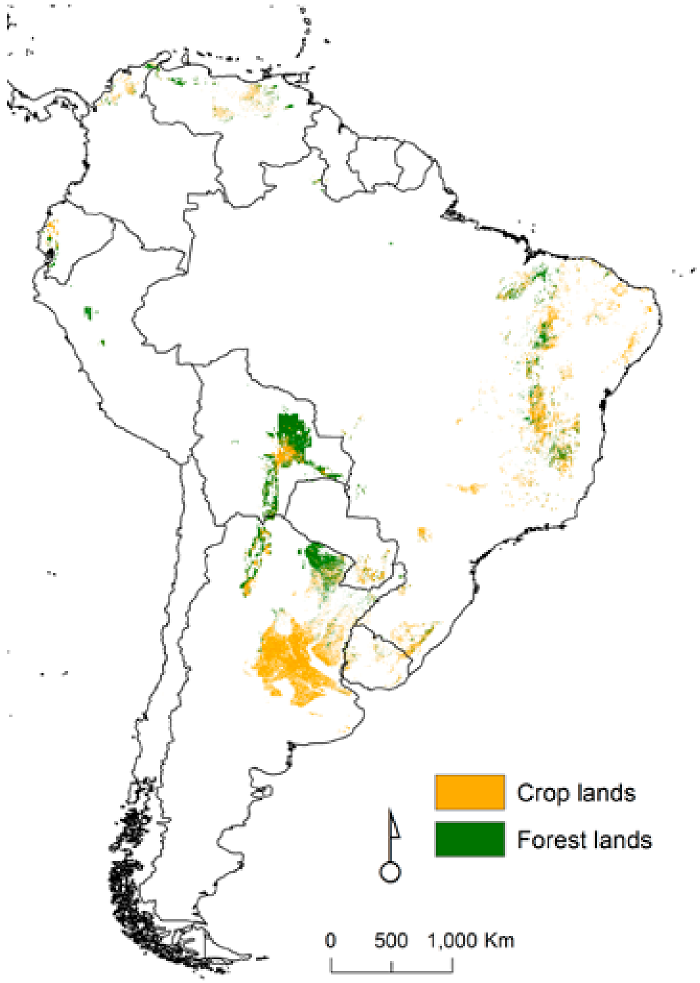

Figure 3. Suitable soybean area overlapping with crop and forest lands

Source: Author elaboration based on data from IIASA (2002) and Globcover (2009)

Table 5. Soybean: harvested areas, production and yields in 2008

	Soybean in 2010			% of total cultivated land
	Harvested (thousand ha)	Production (thousand tons)	Yield (tons/ha)	
Brazil	23 293	68 519	2.9	35.0
Argentina	18 131	52 677	2.9	61.5
Paraguay	2 671	7 460	2.8	62.1
Bolivia	1 086	1 637	1.5	33.4
Uruguay	863	1 817	2.1	61.1
Others	112	199	1.8	0.8
South America	46 156	132 309	2.9	38.8

Source: Adapted from FAOSTAT (2011)

Table 6. Exports of soybean and derivatives in selected years (in thousand tons)

	2000			2009		
	Soybean	Cake soybean	Soybean oil	Soybean	Cake soybean	Soybean oil
Argentina	4 123	12 931	2 980	4 292	21 600	4 439
Brazil	11 517	9 389	1 073	28 563	12 253	1 594
Bolivia	216	629	155	126	961	205
Chile	1	0	0	13	0	0
Colombia	0	32	9	0	0	5
Paraguay	1 796	411	98	2 129	1 036	254
Venezuela	0	4	12	0	0	0
Others	28	0	6	1 090	0	19
South America	17 680	23 395	4 332	36 212	35 851	6 517

Source: Adapted from FAOSTAT (2011)

Table 7. Soybean exports from Latin America by destination in 2010 (thousand USD)

	Soybean	Cake soybean	Soybean Oil	Total	In %
China	13 730	-	946	14 676	37.0
Netherlands	918	1 757	1	2 676	6.7
Germany	1 076	947	0	2 023	5.1
Spain	934	858	116	1 908	4.8
Thailand	657	868	-	1 525	3.8
France	128	1 107	134	1 369	3.5
Italy	453	717	100	1 270	3.2
United Kingdom	284	685	4	973	2.5
Indonesia	-	870	-	870	2.2
India	-	-	727	727	1.8
Republic of Korea	-	450	237	687	1.7
Denmark	9	575	-	584	1.5
Poland	0	572	1	573	1.4
Russian Federation	425	130	0	555	1.4
Malaysia	52	418	45	515	1.3
Chinese Taipei	454	-	-	454	1.1
Others	2 346	4 110	1 832	8 288	20.9
Total	**21 466**	**14 065**	**4 143**	**39 674**	**100.0**

Source: Adapted from COMTRADE (2011)

particularly for soybean in grain and oil. Table 7 provides information on the main destination markets for the soybean exports from Latin America. In 2010, the Chinese market accounted for more than one-third (37%) of the total value of exported soybean and derivatives from Latin America, mainly Argentina and Brazil. Although some European countries are still important in total demand (e.g. Netherlands, Germany, Spain, France, Italy), their participation has gradually shrunk over time. Furthermore, some other Asian countries such as Thailand, Indonesia, India and Korea are also demanding some soybean and derivatives originating from South America.

Soybean oil for biodiesel production

Soybean is the main feedstock for biodiesel production in Brazil. In 2008, the total biodiesel production in the country was about 1 200 million litres; 80% was made out of soybean oil. In 2011, production increased to about 2 600 million litres; 75% was made out soybean oil (Barros 2010, ANP 2012,). According to our estimates, the most important portion of soybean oil production in Brazil targets the conventional food and feed markets (84%); a minor portion fulfills the growing demand for biodiesel (16%). A target blending of 5% in biodiesel would save US$ 1.4 billion/year (CLAES 2010). The soybean sector is in better position to capture opportunities from a growing biodiesel demand due to its highly developed links across the soy value chain. The biodiesel plants, most of which use soybean oil as raw material, are scattered across the countryside. There are also a few in the Amazon biome, a larger portion of which is placed in Mato Grosso (see Brazilian case study in the next section).

Argentina is now one of the five largest biodiesel producers and exporters in the world. Biodiesel exports in Argentina equalled 160 000 tons in 2007, most of which were sold in the international market. In 2008, due to additional investments in expanding the biodiesel industry, it was operating at half of its installed capacity. In addition, the country is a net importer of diesel, and annually spends hundreds of millions of dollars on imports (CAER 2009). In the last two years, for example, Argentina spent almost US$1 billion importing fossil fuel diesel.

Since October 2008 and during part of 2009, the Argentine biodiesel industry suffered some decline in demand, coupled with softening prices that largely followed the price of fossil fuels (CAER 2009). The biodiesel industry recovered in 2010, in part due to growing exports of biodiesel from the European markets, and as well as to a B5 blending mandate that began to apply in the domestic market in February. CAER (2009) estimated that biodiesel exports will reach about 1.5 million tons in 2010, representing an increment of 50% with respect to 2009. Additionally the domestic market of biodiesel will absorb about 800 000 tons per year. The blending mandate will increase to 20% in the next four years, thus putting pressure on the current installed capacity.

3.2 Brazil: Production and market trends

Production and processing dynamics

Figure 4 provides the location of the suitable areas for soybean production in Brazil as estimated by IIASA. The southern portion and the centre-east are the most suitable production areas in Brazil. Nonetheless, as mentioned before, soybean expanded in the south and centre-west of the country. This occurred thanks to favourable technological, institutional and economic conditions explained in more detail below.

From 1990 to 2010, the soybean cultivated area increased from 11.5 to 23.3 million ha with an annual rate of 3.5%. In turn, soybean production in the centre-west region of Brazil, where the state of Mato Grosso is located, has expanded from 3.9 to 10.4 million ha (4.9% per year); it is the region with the largest area of soybean plantations (Table 8).

Table 8. Cultivated area with soybean in selected years,1990-2010 (in thousand ha)

	1990	1995	2000	2005	2010	Growth in % (1990 – 2010)
North	35	25	73	514	563	13.9
Northeast	377	571	847	1 441	1 857	8.0
Southeast	1 120	1,134	1 135	1 900	1 517	1.5
South	6 159	5 419	6 101	8 689	8 942	1.9
Centre-west	3 894	4 554	5 538	10 883	10 461	4.9
Total	**11 585**	**11 703**	**13 694**	**23 427**	**23 339**	**3.5**

Source: Based on IBGE (2011)

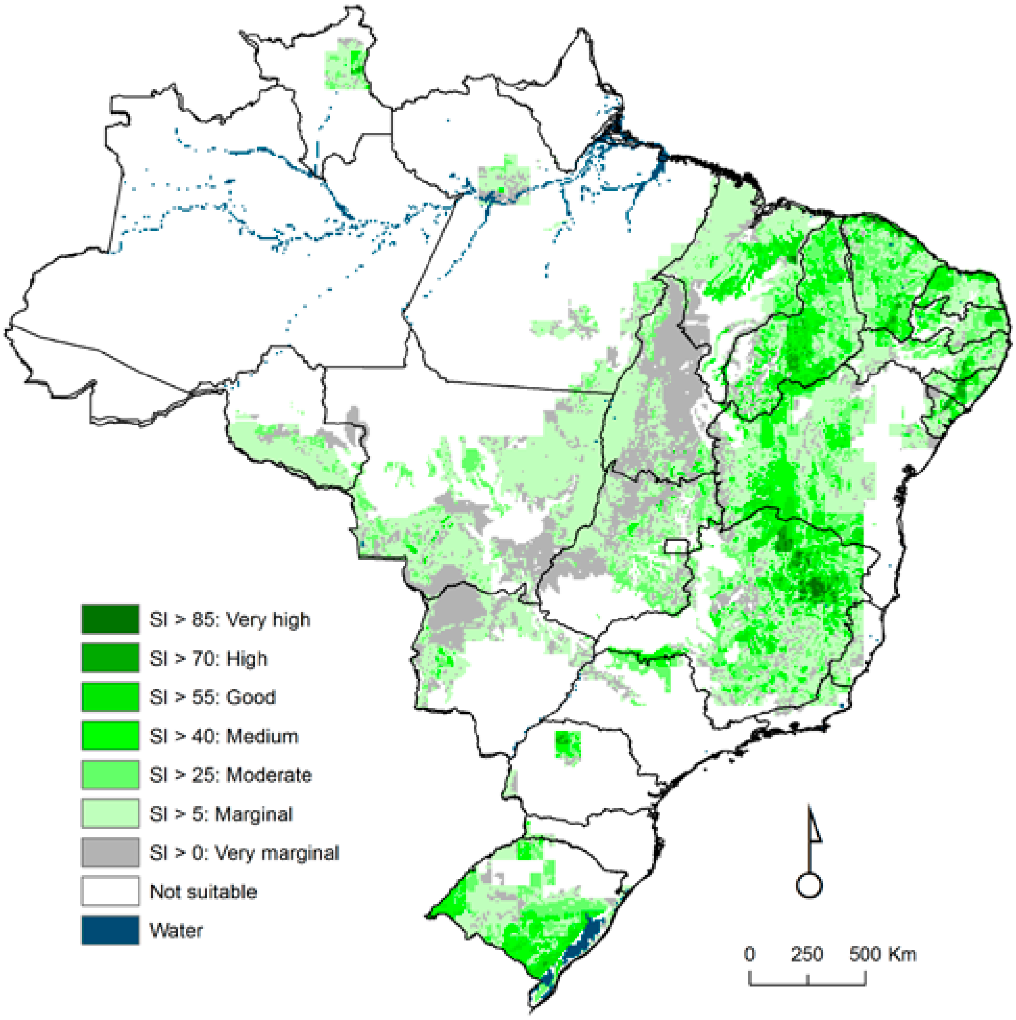

Figure 4. Suitability for rain-fed soybean and high level of inputs

Source: Author's mapping of data from IIASA (2002)

Table 9. Soybean production and yields in Mato Grosso and Brazil, 1990–2010

	1990	1995	2000	2005	2010	Growth in % (1990-2000)
Mato Grosso (million tons)	3.1	5.5	8.8	17.8	18.8	9.1
Brazil (million tons)	19.9	25.7	32.8	51.2	68.8	6.2
Mato Grosso (tons/ha)	2.0	2.3	3.0	2.9	3.0	2.1
Brazil (tons/ha)	1.7	2.2	2.4	2.2	2.9	2.7

Source: Based on IBGE (2011)

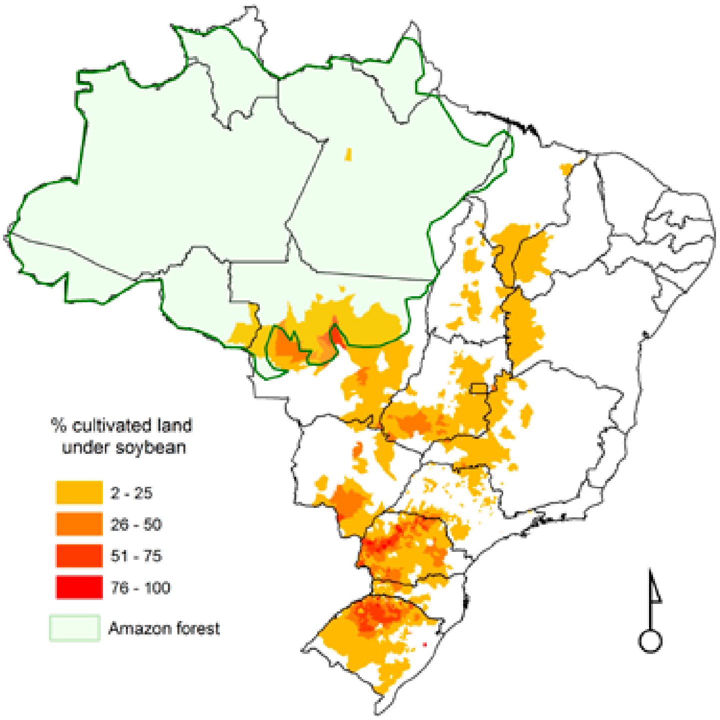

Figure 5. Location of soybean production

Source: Adapted by author based on IBGE (2011)

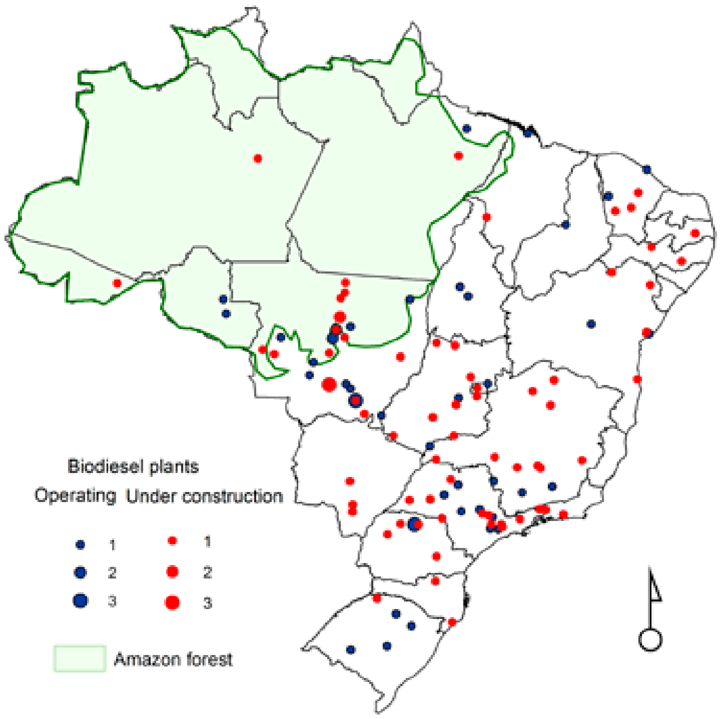

Figure 6. Location of biodiesel plants

Source: Based on Menani (2008)

Soybean has been expanding significantly in the state of Mato Grosso in the southern portion of the Brazilian Amazon since the mid-1980s (Figure 5). This growth has been mainly driven by the availability of cheap land, much of which is forested; increasing public investment in roads to connect the region to main markets and exports and access to technology that allows soy to grow particularly in the *Cerrado* through varieties adapted to the region's highly acidic soils. These conditions have favoured investments by some of the largest grain trading companies in both processing and transportation, making it possible to integrate the agricultural frontier into major international markets. Although meal and cake are the main soybean products (due to greater interest from food and feed markets), oil production has become relevant with expanding internal demand for biofuel production. Thus, capital has been invested to grow biodiesel processing capacity, creating an additional incentive for expanding the agribusiness sector (BWC 2009).

Table 9 shows soybean production trends in the last recent years. While total soybean production has increased steadily in the country, it reached its peak in Mato Grosso in 2005 with almost 18 million tons. Pressure from environmental groups led to measures that halted the expansion of cultivated areas over forestlands. A 'soy moratorium' was agreed on 2006, prohibiting companies from purchasing soybeans cultivated on lands deforested after July of 2006. Initially designed for a two-year period, the moratorium was extended for an additional year to mid-2009, and more recently to July 2010 (ABIOVE 2010). Consequently, stagnation will likely continue.

The Brazilian Ministry of Agriculture forecasts a total harvest of soybean for the whole country equivalent to 75.3 million tons by 2017/18 from 25.6 million ha with an average yield of 2.9 tons per ha (MAPA 2008). This same source estimates an area expansion factor of 1.16 (adding 3.6 million ha) and a production increase factor of 1.44 (adding 23.1 million tons). This plan will lead to expand the production of soybean in Mato Grosso as well, leading to further pressures on forests, especially given the relative scarcity of pasture lands available for plantations – lands where mechanised agriculture could likely expand.

Companies involved and business models

Although soybeans have traditionally been planted by medium- and large-scale Brazilian producers, the influence of transnational companies has significantly increased over time in the downstream processes of transportation, processing and marketing. Schlessinger (2008) estimates that, in Mato Grosso, more than 77% of soybean is produced by farms with an area larger than 1 000 hectares. In this state, a relatively large corporate group has been established around soy production (Grupo Maggi). Furthermore, large food production and trade corporations such as Archer Daniels Midland (ADM), Louis Dreyfus, Cargill and Bunge have established their operations in Brazil, and they control an important share of the market (Baker 2004).

Large-scale corporations have the main role of organising the collection of the soy harvest and exporting derived soy-products to overseas markets. Some also intervene in the processing of soybean and the production of biodiesel. The arrival of these transnational companies has had an important role in expanding and consolidating the soybean complex (GRAIN 2007). ADM is the world leader in processing agricultural goods and fermentation technology. It is one of the world's two major processors of soybean, maize, wheat and cacao. ADM started to produce biodiesel from soybean at the end of 2007 and now produces 565 000 litres of biodiesel per day. Grupo Maggi is the world's largest individual soybean producer, accounting for more than 17% of soybean grown in Mato Grosso (Gao *et al.* 2010).

This agro-industrial production model requires large amounts of chemical fertilisers and pesticides to raise productivity, and only a few skilled labourers. Farmers start the soybean chain in Mato Grosso. After the harvest, most of the soybeans are bought, collected and transported to crushing plants or exported by the global soybean traders (i.e. ADM, Bunge and Cargill) or the Grupo Maggi. These companies finance about 60 to 65% of the soybean area cultivated in Mato Grosso. Soybean growers often make forward-sales (at planting time) to these trading companies in return for seed, fertiliser and chemicals (Gasques 2003, Cadier 2004). This model gives the companies indirect control over large amounts of land and production without having to internalise long-term environmental costs.

Markets for food, feed and biodiesel

Soybean is used to produce soybean oil and cake, though the most important product is cake for animal-feed markets. The domestic market for soybean and derivatives is relatively important, although a significant portion of the production is increasingly exported. About 70% of the soybean grain is crashed and processed in the country, and the rest is exported. In the case of soybean cake, 47% is consumed inside Brazil, compared to 60% of the soybean oil. The total biodiesel production in the country is about 1 200 million litres, and 80% of this production is made out of soybean oil. As mentioned earlier, the most important portion of soybean oil production in Brazil targets the conventional food and feed markets (84%) and the rest fulfills the growing demand for biodiesel. A target blending

Table 10. Brazil: indicators of soybean and biodiesel production

Production (2008)	Soybean	59 million tons[a]	
	Soybean oil	6 million tons[c]	
	Biodiesel	1 200 million litres[b]	
	% feedstock	82% of soybean oil[b]	
Distribution		**Domestic market**	**Foreign market**
	Soybean grain[c]	70%	30%
	Soybean cake[c]	47%	53%
	Soybean oil[c]	60%	40%
	Biodiesel[b]	100%	
No. plants (b)	Brazil	Amazon	
	62	15	

a Based on IBGE (2011),
b ANP (2009),
c ABIOVE (2010)

of 5% in biodiesel would save US$ 1.4 billion/year (CLAES 2010). Marson and Miccolis (2011) assess the legal and institutional framework for biodiesel development in Brazil elsewhere.

Soybean is the main feedstock for biodiesel production in Brazil. This suggests that the Brazilian government's attempts to promote biofuel development from a diversity of feedstocks have not been entirely successful. Further, it suggests that the government has also struggled to include smallholders in the value chain, particularly in the northeast, making visible problems surrounding the Social Fuel Stamp (Selo de Combustível Social) programme (Box 1). In 2011, about 75% of biodiesel was produced from soybean (ANP 2012) due to the poor performance of smallholder agriculture to produce biofuel feedstocks. Other contributing factors included difficulties of southeast companies to bring smallholders into the production chain, mainly due to logistical issues. Nevertheless, in 2007, about 36 000 smallholders supplied oilseeds to the biodiesel industry, representing about 18% of the total biodiesel production (de Campos and Carmelio 2009).

In addition, the soybean sector is in better shape to benefit from opportunities created for the growing biodiesel demand due to three factors: its highly developed links across the soy value chain; available technology for production; and existing logistics for storage and transportation. The 62 biodiesel plants,

Box 1. Social Fuel Stamp program in Brazil

The Social Fuel Stamp was created by the Biodiesel Law (Lei do Biodiesel), sanctioned in 2005 (Law No. 11097/05), as part of a broader programme in Brazil to introduce biodiesel into the energy mix. This law also created a specific permit for biodiesel producers and importers, and provided fiscal incentives for biodiesel sales. Based on this law, the National Fuel Agency (Agencia Nacional do Petroleo, ANP) took on the role of regulating and overseeing activities related to biodiesel production, quality control, distribution and sales, as well as the diesel–biodiesel blend. In January 2008, the biodiesel policy instituted the mandatory blend of 2% for biodiesel. In July of that same year, this percentage rose to 3%. It has risen to 5% since January 2010.

The Social Fuel Stamp was established to facilitate the inclusion of smallholders in the value chain of biodiesel. The stamp is issued to biodiesel producers who purchase a minimum percentage of feedstock from family farmers, depending on the region, viz. 30% in the northeast, southeast and south; 10% in the north and mid-west up until the 2009/10 harvest; and 15% as of the 2010/11 harvest. These biodiesel producers have to sign contracts duly negotiated with family farmers with clauses including purchase prices, conditions for delivering feedstock, technical assistance and training for the family farmers, among others. The public auctions for selling biodiesel set aside 80% of lots exclusively for producers who hold the stamp. The stamp also entitles producers to lower tax rates, and gives them more favourable financing conditions at the Brazilian National Development Bank (BNDES) and its accredited financial institutions.

Until the beginning of 2009, the 30 companies that earned the Social Fuel Stamp accounted for more than 90% of the volume purchased through the ANP bidding process (Marson and Miccolis 2011). This scheme has been questioned because it has not met initial targets aimed at supporting smallholders in the poorest regions (north and northeast). Initially, the scheme focused on castor beans and jatropha as promising feedstocks that could grow on family farms under harsh conditions. Yet, technical constraints were faced to produce biodiesel from castor oil and introduce jatropha.

The latter was aggravated by the high profits of castor bean oil on the international market for other uses; the challenge of the technical obstacles of growing jatropha by smallholders unused to cultivating it; low average income-generation/ha; and low value-addition by family farmers who generally only supply unprocessed seeds (Marson and Miccolis 2011). Partially as result of this, the incentives provided by the Social Fuel Stamp went to benefit the biodiesel industries purchasing soybean from farmers in the mid-west, technically classified as family farmers (IPEA 2010, Marson and Miccolis 2011).

Source: Based on Marson and Miccolis (2011) most of which use soybean oil as the main raw material, are scattered around the countryside; there are 15 plants in the Amazon biome, mostly in Mato Grosso. According to Marson and Miccolis (2010), very few large-scale producers are headquartered in the Amazon region; most of these producers rely heavily on soybeans, although some use beef tallow and palm oil. The authors suggest that the vast majority of these plants are producing far below their capacity, and that the oil extracted in half of all plants currently in production is not produced by the same company (which suggests the high rate of integration agreements with producers of raw materials, mainly soybeans).

Hall *et al.* (2009) estimate that 21% of the soy oil produced in Brazil would have been needed to meet national targets for the fuel mix (3%) in 2008. The target mix increased to 5% in 2010; applying the same method would mean that 35% of the soy oil would be needed. This is an overestimate since Hall *et al.* (2009) assumed that only soybean would be used to produce biodiesel; in fact, 82% of total biodiesel production was from soybean oil in 2008. As noted earlier, this amount was reduced to 75% in 2012, although the total volume of biodiesel production is also growing over time. It is noteworthy that the main derivative of soybean is the cake mainly used for cattle feed, and that oil represents only 18% by weight of the soybean.

Implications for land-use change

Soybean production has expanded over both the *Cerrado* and tropical forests in Mato Grosso, yet there are some uncertainties regarding the contribution of soybean expansion to deforestation. In Brazil, while a portion of soybean expansion leads to direct deforestation, another portion occurs in lands already deforested, often under degraded pasture. Morton *et al.* (2006) indicate that the area of tropical forest converted directly to large-scale crop production between 2001 and 2004 in Mato Grosso ranged from 785 to 2 150 square km/yr. It peaked at 23% of 2003 annual deforestation in large clearings of more than 25 ha. The fact that a major portion of soybean expansion took place on pasture areas led to a rapid displacement of cattle ranching activities into forestlands, which tend to create indirect pressures on deforestation (Lapola *et al.* 2010, Arima *et al.* 2011). Lima *et al.* (2011), based on a review of literature, argue at least 80% of the direct deforestation is due to clearance for cattle rearing in Mato Grosso. They further suggest that 13–18% of deforestation is due to soy expansion, although less than 6% can be attributed to biodiesel since most soy is used for other products.

3.3 Multiplier effects from soybean production

The effects of soybean production are manifold and sometimes contradictory. On one hand, soybean sector growth has reportedly been generating direct and indirect jobs and income; some urban centres in municipalities that grow soybean have shown important development. However, soybean production creates relatively few direct jobs because it involves large-scale and capital-intensive activities. While job creation numbers are likely higher than in cattle ranching, fewer jobs can be expected where soybean displaces traditional cultivation activities that employ more labour (BWC 2009, Lima *et al.* 2011). Since soybean is often grown in medium- and large-scale landholdings, it tends to concentrate income in a small group of larger enterprises. In addition, soybean contributes to expanded earnings for the state and municipalities, as well as helping to create employment at the regional level. Thus, it has a significant impact on economic growth. In this regard, with respect to soybean cultivation, there is a trade-off between the concentrations of benefits and spill-over effects in the regional economy at large.

In Mato Grosso, benefits from expanded soybean production include increased export earnings and productivity (GDP per capita) since soybean constitutes a highly profitable crop. Social costs include land concentration, illegal land acquisition and income concentration in a few medium- and large-scale landholders (Fearnside 2007). In some cases, local populations and smallholders have been displaced (van Gelder and Dros 2005), although the magnitude of the latter's impacts is still under debate (Lima *et al.* 2011).

The most important environmental cost of soybean expansion in Mato Grosso is the conversion of Amazon forest and *Cerrado* savannah, with associated effects on biodiversity loss and carbon emissions (Galford *et al.* 2010). Soybean production leads to deforestation through two different ways. First, soybean cultivation expands onto productive lands previously cleared for pasture, which forces cattle production deeper into the forest. Second, market conditions may encourage soybean production to 'leap-frog' into areas of primary forest ahead of ranching.

4. Trends and implications of oil palm expansion

4.1 The steady growth of oil palm production

Oil palm cultivation is becoming increasingly attractive in South American countries for two reasons: it constitutes an important raw material for edible oil production and it's the most productive feedstock for biodiesel production. Its cultivation has increased in the region since the 1980s, although it has become more significant in the two subsequent decades. Its annual rate of growth was equivalent to 4.9% in the 1990s and to 3.6% from 2000 to 2010 (Table 11). According to FAOSTAT (2011) main countries producing oil palm are Colombia (165 000 ha), Ecuador (135 000 ha) and Brazil (91 000 ha). Plantations have developed in Central America (Honduras, Costa Rica and Guatemala), but are smaller in scope. Oil palm plantation developed at higher annual rates of growth in Colombia and Ecuador during the last decade. In the 2000s, oil palm plantations have been growing, in relative terms, more rapidly in Brazil. This is largely due to new plantation development in the Brazilian north, driven mainly by government incentives. It's noteworthy that the harvested areas of oil palm in South America are still relatively small when compared to those in Malaysia and Indonesia.

In Colombia, where more experimentation on varieties and plantation systems has taken place, oil palm fruit-yields are relatively high (19.4 tons/ha in 2010). Peru has slightly lower productivity (18.9 tons/ha), followed by Ecuador (15.6 tons/ha) (Table 12). Yields in the region are relatively lower than in Malaysia (21.2 tons/ha), but relatively similar to yields in Indonesia (17 tons/ha). The main factors affecting yields are poor plantation management in the region and inadequate adaptation of varieties to specific agroecological conditions.

Areas considered suitable for production in Latin America are primarily located in the northwestern portion of South America (Figure 7). Fischer *et al.* (2002) identified areas as medium to highly suitable for oil palm plantations, but which have competing uses, such as forests, or are already used for agriculture. It is worth noting that a major portion of the land suitable for oil palm is still under forest cover (Figure 8).

Most oil palm production began in Latin America during the late 1970s and early 1980s. There has been a steady growth of oil palm cultivation in Colombia followed respectively by Ecuador and Brazil. Much of this growth has not necessarily been linked to clear agricultural policies, but rather to private groups attempting to develop the oil industry, primarily for domestic food markets, and lately for export as well. This production has been fostered by a few economic groups that have been expanding their production areas, such as in Brazil. In Colombia, conversely, a few large-scale companies have expanded their plantations, but

Table 11. Oil palm: harvested areas in selected years

	Area harvested (thousand ha)			Annual growth (%)	
	1990	2000	2010	1990-2000	2000-2010
Brazil	33	45	91	3.1	7.0
Colombia	90	135	165	4.1	2.0
Ecuador	59	114	135	6.6	1.7
Paraguay	18	13	16	(3.0)	2.1
Peru	4	10	14	8.8	3.4
Venezuela	3	25	27	22.9	0.8
Suriname	5	1	1	(22.9)	0.9
South America	211	342	448	4.8	2.7

Source: Adapted from FAOSTAT (2011)

Table 12. Oil palm: harvested areas, production and yields in 2010

	Oil palm in 2010			% of total cultivated land
	Harvested (thousand ha)	Production (thousand tons)	Yields of oil palm fruit (tons/ha)	
Brazil	91	1 122	12.3	0.1
Colombia	165	3 200	19.4	4.6
Ecuador	135	2 100	15.6	5.3
Paraguay	16	152	9.5	0.4
Peru	14	265	18.9	0.3
Venezuela	27	328	12.3	0.8
Suriname	1	1	2.0	0.9
South America	448	7 169	16.0	0.5

Source: Adapted from FAOSTAT (2011)

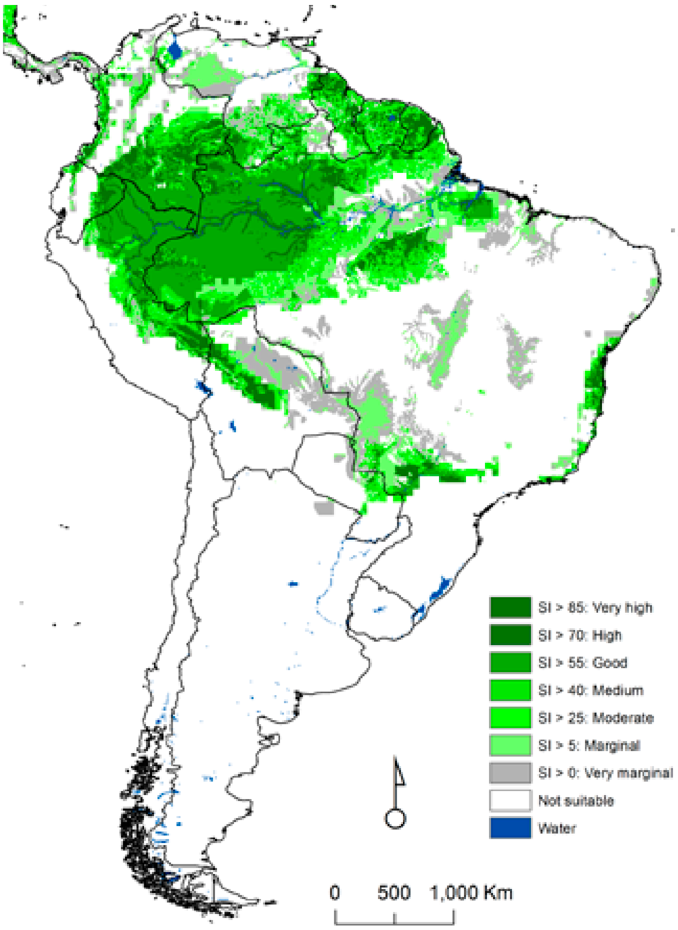

Figure 7. Suitability of oil palm production in Latin America

Source: Author's mapping of data from IIASA (2002)

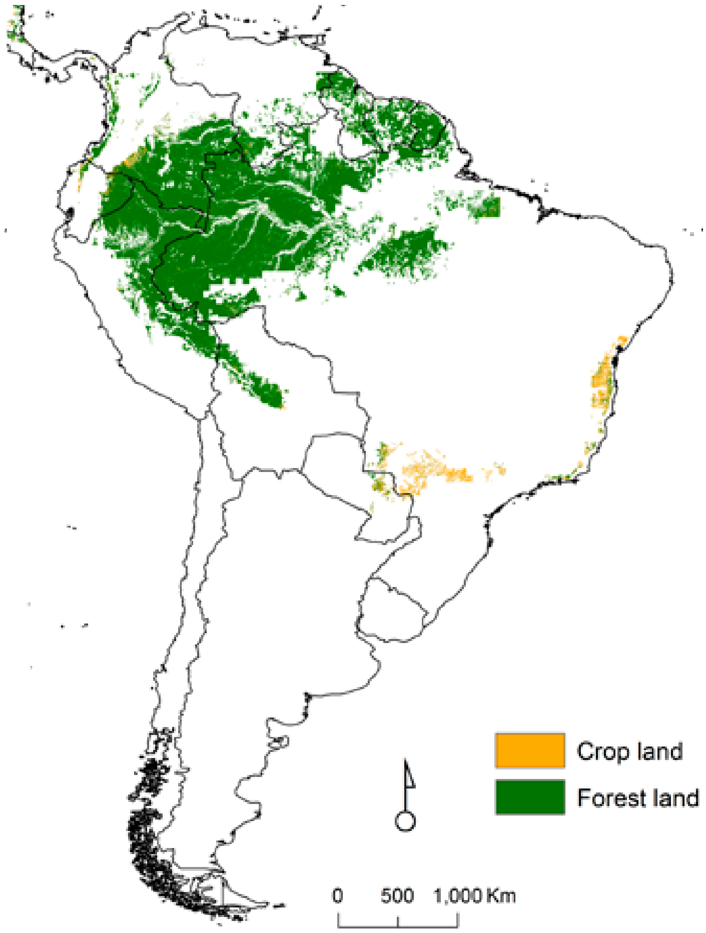

Figure 8. Suitable oil palm area overlapping with crop and forest lands

Source: Author elaboration based on data from IIASA (2002) and Globcover (2009) some 5 400 smallholders are also involved in oil palm production (Mesa-Dishington 2008). In the Brazilian Amazon, concerns exist that expansion of large-scale plantations could threaten conservation efforts (Butler and Laurance 2009, Marson and Miccolis 2010).

According to IIASA estimates, large areas are suitable for expansion of oil palm plantations in Brazil; this area would be relatively smaller in Peru, Colombia and Ecuador. Oil palm is more suitable in low-elevation regions in the humid tropics and can even tolerate the highly acidic soils that are widespread in Amazonia (Butler and Laurance 2009). In Brazil, an estimated 29.6 million ha are suitable for oil palm production excluding forestlands, which represents about 6% of total deforested area in 2010 (EMBRAPA 2010). In Colombia, the Plan for Biodiesel Development (CONPES 3510) has defined a goal of 2 million ha planted with oil palm (DNP 2008).

Markets for palm oil production

The oil palm producing countries dedicate an important portion of production to their domestic market for food oil, while still paying some attention to the foreign market. Domestic production of palm oil will likely increase to the extent that different countries in the region can establish or revise their blending targets, which may put additional pressure on supply. FAOSTAT (2011) suggests that Colombia and Ecuador are the two net exporters of crude palm oil (CPO). Between 2000 and 2009, exports of palm oil from these two countries increased from 149 000 tons to 424 000 tons (Table 13). This trend speaks to the important development of plantations and processing capacity in the region.

Main export markets for palm oil are Mexico, United Kingdom, El Salvador and Germany, followed by a larger number of countries that import smaller amounts of this product (Table 14). It is interesting to note that while Colombia primarily targets Brazil, Venezuela and European markets (Germany, United Kingdom and Netherlands), Ecuador sells to Venezuela, Peru and Mexico. In turn, Mexico constitutes the main market for Central American countries. Specifically, Guatemala sells its production to Mexico and El Salvador; Honduras exports to Mexico; and Costa Rica sells to Mexico and Nicaragua. Nothing suggests these market trends will change in the near future. Between 2000 and 2010, exports from Latin America decreased slightly; this is related to expanding domestic demand likely from biofuels production.

4.2 Colombia: Production and market trends

Production and processing dynamics

Oil palm was introduced in Colombia around the 1970s in relatively small areas, and initially supplied oil to the domestic market. The planted areas grew rapidly in the 2000s, mainly in response to government incentives for increasing palm oil for exports, as well as meeting blending targets for biodiesel production (5% in 2008). In 2000, the total area under oil palm was equivalent to 156 070 ha in production out of which 28 693 ha

Table 13. Palm oil trade in selected years (in thousand tons)

	2000			2009		
	Imports	Exports	Balance	Imports	Exports	Balance
Brazil	21	31	11	128	25	(104)
Colombia	4	97	93	62	214	152
Ecuador	2	13	11	0	186	185
Peru	1	8	7	35	0	(35)
Venezuela	6	0	(6)	44	-	(44)
Others	0	0	(0)	14	0	(14)
South America	34	149	115	283	424	142

Source: Adapted from FAOSTAT (2011)

Table 14. Palm oil exports from Latin America by destination in 2010 (thousand USD)

	2006	2007	2008	2009	2010	Average 2006-2010 (in %)
Mexico	164	218	346	260	268	36.4
United Kingdom	46	64	127	60	34	9.6
El Salvador	37	64	77	58	76	9.0
Germany	2	53	130	78	13	8.0
Venezuela	30	-	71	44	76	6.4
Colombia	5	9	27	50	78	4.9
Nicaragua	2	29	40	36	32	4.1
Netherlands	4	33	65	26	2	3.8
Peru	6	17	41	24	13	2.9
Spain	21	52	11	2	4	2.6
Others	40	76	143	67	93	12.2
Total	**358**	**615**	**1,079**	**705**	**688**	**100.0**

Source: Adapted from COMTRADE (2011)

were in development. In 2010, 249 694 ha were in production and 152 318 ha in development for a total of 402 012 ha (SISPA 2011). It is noteworthy that the planted area reported by the Colombian Federation of Oil Palm Growers (FEDEPALMA) is higher than the one from the Food and Agriculture Organization (FAO). Currently, Colombia is the country with the largest area of oil palm plantations in South America, and these plantations are likely to continue growing in the future.

In Colombia, oil palm is expanding in four different regions. SISPA (2011) notes the largest production area in 2010 is in the eastern zone (158 404 ha) followed by the northern zone (114 986 ha) the central zone (112 986 ha) and finally the western zone (15 636 ha). The largest expansion is occurring in the eastern zone where more land is available, followed by the northern zone (Figure 9). In the last two years, more than 16 700 ha have been lost in the western zone to bud rot disease. In this same period, the presence of low-yield palm (including both young and very old palms) in the production area has increased significantly in the northern and eastern zones. The average fruit yield/ha was 17.9 tons in 2007 and 16.8 tons in 2009 (FEDEPALMA 2009). Bud rot disease has led to a relative stagnation in the total area under cultivation during the last two years.

In spite of this disease, there are plans for significantly expanding the area covered by oil palms. This will be mainly to supply the biodiesel market, although both the global economic crisis and bud rot have affected investment plans for expansion of oil processing capacity. In recent years, oil palm expansion has been largely an outcome of state incentives, which have led some investors to acquire less productive land (mainly in pasture use) to expand oil palm plantations. The main incentives have been tax holidays (Law No. 788/2002 and Law No. 939/2004), implementation of free tax zones (DS. No. 383/2007), tax reductions from investments in productive assets (Law 111/2006) and credit incentives from implantation and maintenance of plantations (*Programa Agro Ingreso Seguro*). The latter include special credit lines and the Incentive of Rural Capitalisation (Incentivo a la Capitalización Rural - ICR); through ICR, the government reimburses a percentage of the agricultural credit that a producer has acquired from a bank to invest in certain agricultural activities such as planting and maintaining several late-maturing perennial crops (e.g. oil palm, cocoa, rubber).

According to DNP (2008), biofuel production (including both bioethanol and biodiesel) benefitted from at least US$410 million from mainly tax holidays and subsidised credit. The most significant policy decision to support biodiesel expansion was a 5% blending target by 2008 for the whole country, which has created a niche market for biofuel production supplied by the largest biodiesel

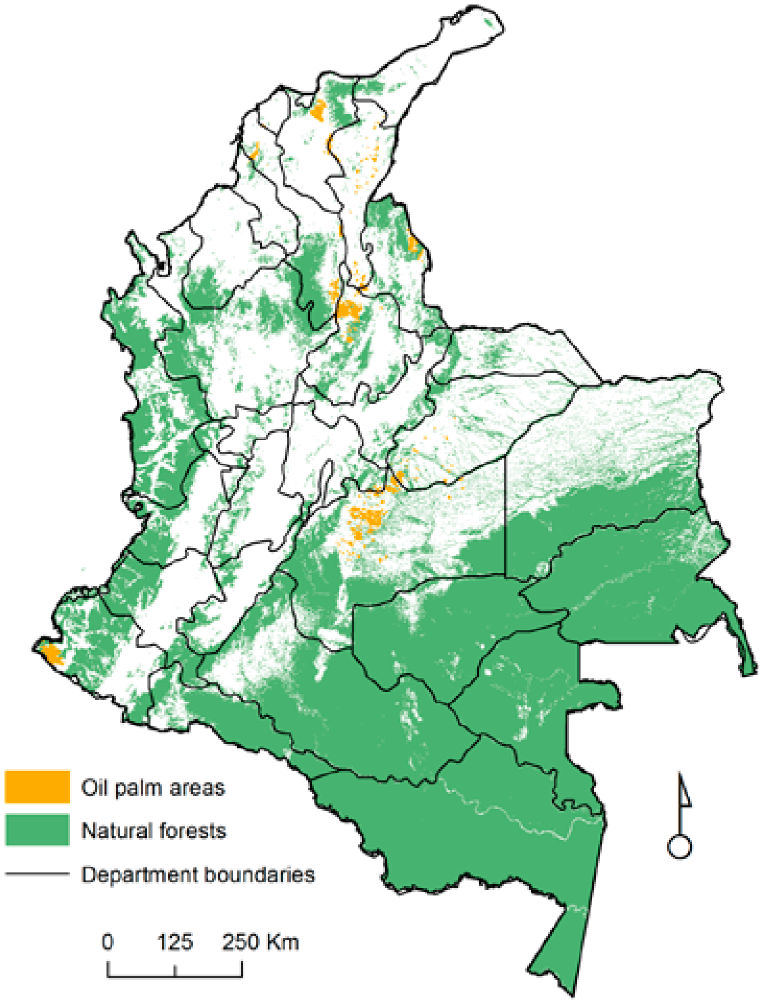

Figure 9. Location of palm oil production zones in Colombia

Source: FEDEPALMA (2009)

companies. In 2010, Colombia increased the biodiesel blend to B7 in the Atlantic region, while other regional mixes reached B5 and B7. The government target for B20 is 2015. Furthermore, in Colombia, the state controls biodiesel prices; these are determined as the maximum value between estimated production costs and consider some efficiency standards and the price of imported diesel plus the cost of converting palm oil into biodiesel (DNP 2008).

Companies involved and business models

In 2008, 55 mills were operating in Colombia, out of which 28 are relatively small (less than 15 tons fresh fruit bunches (FFB)/hour), 15 are medium-size (from 15–25 FFB/hour), and 13 have a capacity larger than 25 FFB/hour. Among the latter, only 2 plants have a capacity equivalent to 60 tons FFB/hour: one in Villanueva, Casanare (owned by Palmar del Oriente SA and Extractora del Sur de Casanare) and another in San Alberto, César (owned by Indupalma SA). Most plantations are in the hands of vertically integrated private companies.

About one-third of plantations correspond to landholdings with areas greater than 1 000 ha, while another third are between 200 and 1 000 ha. The contribution of smallholders – less than 20 ha – along with 'alliances' equate to 19% of total production in 2010 (SISPA 2011) (Table 15). The alliances constitute production partnerships between companies and smallholders associated in cooperatives with about 1 to 4 ha each with planted oil palm. There have been 109 alliances established as of 2008, comprising a total of 5 391 smallholders (FEDEPALMA 2011). Unfortunately, no information is available about the benefits of these alliances to smallholders. Furthermore, the oil palm sector employs many small-scale cooperatives that provide numerous services to large-scale plantations (i.e. planting, weeding, harvesting and transportation).

Biodiesel production started in 2008 and has experienced rapid growth. There are currently seven plants in production which use palm oil as feedstock, and there is one project under construction that was expected to enter into production in 2012 (Pinzon 2011).These plants are producing biodiesel with an installed capacity of 536 000 tons/year and a production of 350 000 tons (FEDEPALMA 2011).

Markets for food and biodiesel

In 2008, 775 thousand tons of palm oil and 178 thousand tons of palm kernel oil were produced. Domestic palm oil sales represented 445 thousand tons; 323 thousand tons were exported. Domestic sales increased by 19 thousand tons in 2008 due to the new market for biodiesel production, which absorbed 39 thousand tons, or 5% of oil produced (FEDEPALMA 2009). In 2009, the palm oils represented 66% of the total domestic market of oils and fats. From 2008 to 2010, CPO produced in Colombia increasingly supplied the biodiesel market, which effectively reduced exports. Yet, since most of CPO consumption is taking place in the main country's capital cities, there is still some geographical imbalance between supply and demand of CPO. Currently, Colombia neither imports nor exports biofuels; exports are unlikely in the short term given the local industry's commitment to supply local demand and the government's flexibility to reach the blend as new facilities enter into production. However, in the medium term, Colombia may become an exporter of biodiesel from palm oil (Pinzon 2011).

Implications for land-use change

With the exception of some areas in the western and northern zones, where oil palm expansion has led to some forest conversion, anecdotal evidence suggests that most expansion is taking place on grasslands and planted pasture. The expansion would therefore have fewer impacts on direct deforestation. Additional research, however, is required about the land-use trajectories associated with oil palm expansion.

Table 15. Oil palm planted areas by landholding size in selected years

Size range in ha	Planted area (in ha)		Percent of total	
	1999	2010	1999	2000
Alliances	645	64 023	0.4	15.9
Less than 20	4 908	11 319	3.3	2.8
20 to 200	19 366	52 089	12.9	13.0
200 to 1 000	57 454	132 029	38.4	32.8
More than 1 000	67 391	142 553	45.0	35.5
Total	**149 764**	**402 013**	**100.0**	**100.0**

Source: Adapted from SISPA (2011)

Table 16. Colombia: main destination markets of CPO (thousand tons)

	2007	2008	2009	2010	2011
Domestic market	425.9	444.7	508.5	520.1	506.3
Biodiesel production	0	6.7	67.2	144.5	204.0
Palm oil exports	303.6	323.2	216.0	87.4	162.8
Total	**729.5**	**774.6**	**791.7**	**751.9**	**873.1**

Source: Adapted from SISPA (2011)

The main expansion zones are the grasslands located in the *Orinoquia*, in the eastern zone. Therefore, pasture expansion rather than oil palm plantations are still driving most forest-clearing in Colombia (Etter *et al.* 2006). Although some pasture lands are being converted to oil palm, there is no clear process of indirect land-use change. This is due to two factors: the relatively low productivity of converted pastures and cattle ranching intensification across the country. Additional research is required to determine land-use change impacts.

4.3 Impacts associated with oil palm development

The economic and social implications of oil palm development are under debate in Latin America, using the expansion taking place in Colombia as a showcase. There are some important lessons to be learnt from oil palm expansion in Southeast Asia, mainly Malaysia and Indonesia, where it has grown more vigorously. In the latter country, the economic profitability of oil palm development is significant. Yet it has also had important environmental impacts, mainly due to the conversion of natural forests and peat swamp forest areas into plantations. This has contributed to a significant increase in greenhouse gas (GHG) emissions with implications for climate change (Lamade and Bouillet 2005, Koh and Wilcove 2008).

In Indonesia, oil palm offers a very profitable opportunity on ecologically suitable lands. It has thus contributed to important increases in national and regional revenues in most production areas, in spite of price volatility and crisis in international markets (Levang *et al.* 2008, McCarthy and Cramb 2009, Caliman 2011). In this same country, social conflicts related to oil palm development are abundant, involving conflicts between local communities against private companies ortransmigrants (Potter and Lee 1998, Colchester *et al.* 2006, Casson 1999). Furthermore, there is much room for improving benefit sharing between stakeholders (Koh 2008, Therville *et al.* 2011). While many smallholders are adopting oil palm as a key source of income, high profitability is not enough to secure livelihoods. Moreover, specialisation involves risks since farmers will depend on a cash crop with fluctuating price in international markets (Feintrenie *et al.* 2010).

While the economic implications of oil palm development are not under question (due to the comparatively higher benefits from oil palm as compared to other crops), the social implications of oil palm plantation development are highly controversial (due to the likely association between crop expansion and people's displacement, though this varies between or within countries).

In Colombia, for example, two perspectives on social conflicts have emerged. On one hand, oil palm expanding along the Pacific coast tends to threaten land rights of Afro-Colombian communities. In other cases, oil palm plantations are linked to forced displacement due to the encroachment on community lands by local armed movements – or paramilitary groups linked to the long history of violence in Colombia. The lands have been converted to oil palm as a way to legitimise property rights that are further usufruct by private companies (Escobar 2004).

Some studies suggest that palm oil does not produce forced displacement by itself, though the process of production might generate incentives leading to that (Ocampo 2009). The latter is due to unclear local tenure rights and lack of working institutions to formalise such rights. The significance of oil palm plantations in displacing people is unclear: coca plantations also play a significant role in land displacement, and in some areas the two crops coexist (Rangel *et al.* 2009). Furthermore, anecdotal evidence indicates that most oil palm expansion is likely taking place in the western portion of the country under degraded pastures; therefore, this expansion creates little pressure to displace local people and also has little influence on deforestation since it expands on grasslands.

5. Discussion and conclusions

Most of the changes in agriculture in South America in recent years have been associated with soybean, sugarcane and oil palm expansion. This expansion has prompted significant agricultural development, along with important trends of modernisation of production. This, in turn, has brought significant earnings for rural producers and several other groups associated with the respective value chains, stimulating local development where these crops are grown.

Soybean growth has been driven by increasing demand, which has benefitted from important technological change linked to the use of improved seeds and adoption of capital-intensive mechanised agriculture, often in medium- and large-scale landholdings. Oil palm growth, on a commercial scale, is also driven by demand expansion, along with organised efforts of the industrial sector to take advantage of government incentives. Other factors promoting this expansion are availability of capital originating from banks and corporate traders, as well as access to relatively cheap land in frontier areas. The ambition to develop the biodiesel sector through blending targets and specific support-incentives has, to a lesser extent, also helped stimulate this expansion.

Numerous domestic investors have been engaged in the cultivation of these crops, largely stimulated by profits from soybean and oil palm production; these producers are now integrated into more developed markets. In the case of soybean in Brazil, the arrival of transnational corporations for processing and trade has greatly contributed to link production zones with global markets through more articulated and vertically integrated value chains. In so doing, they have taken advantage of expanding demand of feed markets in Europe and Asia, notably in China. In the case of oil palm in Colombia, however, companies from the edible oil industry expanded their operations into the oil palm sector to supply a growing domestic and international food market, as well as increased domestic demand of the biodiesel sector. The latter has created demand that complements an already vigorous market for food and feed, and is expected to grow in the future.

The economic benefits that agricultural expansion has brought are unquestionable, with an important role played by both state and private investments. National governments in Brazil and Colombia, for example, have provided significant financial resources in public goods or fiscal incentives to promote the expansion of commercial agriculture; this has helped increase private investments not only in expansion of production acreage, but also in storage and processing facilities. In many cases, however, a few corporations control all production; this is due to their power in the market as both a supplier of financial capital and inputs and as a buyer of final products from landholders. Its role as a buyer tends to benefit actors that have higher control down the value chain. Among crops, soybean and oil palm most probably reap the largest profits for landholders.

The business model for soybean production depends primarily on large-scale capital-intensive and mechanised agriculture linked to a processing industry, which in some cases, may adopt vertically integrated production systems. While this model may lead to increased productivities, and larger economies of scale in commercialisation, it tends to employ limited labour/ha (and mostly skilled workers). In turn, oil palm production tends to employ more labour for planting and harvesting, but also requires important amounts of capital for plantation development.

These models have tended to exclude smallholders who are not able to access land and capital; when they do manage to introduce crops, it tends to happen through highly specialised systems that increase their vulnerability to price fluctuations. Due to the combination of these factors, these business models have tended to favour medium- and large-scale landholders, industry and trade companies. This has concentrated economic benefits in a few hands, although with multiplier effects in the broader economy, primarily from earnings obtained by exporting to overseas markets.

The most serious criticisms of agricultural development have focused on negative environmental outcomes. Production systems are blamed for driving forest conversion, leading to loss of biodiversity and contributing to climate change through increased GHG emissions. Yet controversy persists with regard to the magnitude of these impacts, and the extent to which they are being driven by conventional food and feed markets as opposed to emerging biodiesel markets. In this regard, it is known that the largest conversion of forests to other land uses in South America is not necessarily being driven by mechanised agriculture or expansion of tree crops such as oil palm. Rather, it is driven by pasture, itself spurred by specific drivers whose analysis is beyond the scope of this paper.

Agricultural expansion contributes to direct deforestation, but its impacts on forest conversion are largely indirect (though difficult to discern with respect to pasture expansion). Several other studies, as discussed in previous sections, have addressed this issue. Biofuel development has increased demand for crops that feed biofuel production, thus expanding the incentive for triggering direct and indirect land-use change with potential effects on forest conversion. This may change in the future if greater expansion of mechanised agriculture takes place on degraded pasture lands.

There are also negative social impacts of agricultural development. Medium- and large-scale plantations may stimulate land concentration, which may displace local people and take away their livelihoods. This often happens with commercial crop expansion in many agricultural frontiers in Latin America. In Brazil, for example, soybean expansion has often expanded on public lands through illegal encroachments, as well as through market transactions. In some cases, this has also affected local populations In Colombia, oil palm expansion has put pressure on local populations, leading to displacement. In other countries, expansion has been an easy way to justify possessing lands where paramilitary groups had previously displaced local people. Lastly, in some cases, oil palm has stimulated cattle ranchers to sell their land to oil palm growers through formal markets. Therefore, many social impacts stemming from the expansion of plantations are related to the local political economy where these developments occur, as well as on existing power relationships that affect land ownerships and conditions to secure tenure rights, among others.

This brings up an important question: what are the main ways to enhance governance of investments related to soybean and oil palm expansion, including enforcement and compliance of environmental regulations? The main responses to this question must arise not only through state policies, but also from private actors and civil society at the global and local levels.

It is well known that, despite important national land and environmental laws to regulate agricultural expansion and deter pressures on forest conversion, regulations are weakly enforced. Engaging the private sector, therefore, is fundamental to enhance land and forest governance, and thus plantation development. To that end, different institutional arrangements are emerging that could help enhance the sustainability of plantation development, along with putting in place more inclusive business models. These arrangements include the adoption of sustainability standards, the establishment of roundtables linked to certification mechanisms (e.g. roundtables on soybean and oil palm) and industry commitments to not purchase goods produced in forestlands converted to agriculture without complying with national laws (e.g. soybean moratorium).

Additional research is required in several areas: the effectiveness of these different governance mechanisms; the required private and public arrangements to enhance governance outcomes; and other opportunities for solutions with better environmental and social outcomes. South America may offer important lessons on how policy and civil society can respond to enhance governance of agricultural development in order to reduce negative environmental impacts, particularly deforestation. Nonetheless, much has to be done to build more inclusive models for smallholders based on the agricultural potential of soybean and oil palm, most likely in combination with other crops. In this regard, it is important to explore ways to build the capacities of smallholders since there is a multitude of small-scale resource management systems able to reconcile social, economic and environmental goals. Therefore, enhancing governance of investments in agricultural development and supporting the potential of smallholders stand are two policy agendas to be pursued hand in hand.

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This paper examines trends associated with commercial agriculture expansion in South America. It emphasises soybean and oil palm expansion associated with food, feed and biofuel markets, paying particular attention to their economic, social and environmental implications.

The paper assesses two cases in detail: expansion of soybean production in Brazil (with its epicentre in Mato Grosso) and oil palm expansion in Colombia. These crops generate economic benefits and multiplier effects for the broader economies in the two countries. Multiple factors drive the expansion of soybean and oil palm and their socio-economic and environmental effects, including policy incentives, market conditions, improved technologies, expansion of roads and changes in tenure. Together, these factors have led to a vigorous expansion of the agribusiness in South America under different business models, which present some interesting differences in these two cases.

The outcomes of this expansion are still under debate. In some cases, it has contributed to increase economic incomes in production zones, and generated additional earnings for local and national economies through the development processing industries down the value chain. In other cases, it has contributed to land concentration and favoured traders and industry owners at the expense of smallholders. In addition, land conversion has created more homogeneous landscapes linked to adoption of large-scale mechanised and capital-intensive agriculture. Nonetheless, it is difficult to argue that economic gains have outweighed environmental and social costs. A more nuanced analysis is required to devise development pathways that can improve distribution of social and economic benefits while at the same time reducing carbon emissions.

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