Barry D. Solomon · Robert Bailis *Editors*

Sustainable Development of Biofuels in Latin America and the Caribbean

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Foreword

Presently, the production of biofuels in the Western Hemisphere—mainly the USA, Brazil, and Argentina—is based on the use of maize, sugarcane, and soybeans, which together represents a very large fraction of all the biofuels produced worldwide. Biofuels account for approximately 3 % of all the fuel used for transportation and some 20 million hectares of land, which is little more than 1 % of all land use for agricultural production worldwide. Further expansion of production will very likely take place in the countries located in the Southern Hemisphere, mainly South America and Africa where land is available, and then be exported to the industrialized countries.

Complex certifications schemes are being proposed for biofuels to regulate such exports. These schemes are mostly absent for other agricultural products or the consequence of the expansion of agricultural area, which has been growing approximately 0.3 % per year, some 4 million hectares per year in the last 40 years. Seasoned analysts of agricultural expansion are often puzzled by the controversies raised by biofuel production, which seems out of proportion with the amount of land used to grow the feedstock.

This book discusses in details how these problems are being faced in many countries in Latin America: Brazil, Argentina, Peru, Colombia, Guatemala, Mexico, and others in the Caribbean. The general conclusion one gets is that sustainability concerns in biofuel production are being addressed reasonably well, especially in Brazil and Argentina, more so than in some other agricultural activities. However, areas needing improvement are also identified.

Anyone interested in biofuels should read this book. As the volume's title, "Sustainable Development of Biofuels in Latin America and the Caribbean" implies, many issues will have to be addressed to achieve further progress. All of these challenges are well covered here, including the sustainability of the feedstock used, greenhouse gas emissions (reduction), impacts on food security, deforestation, pollution, soil erosion, abuse of land, and labor rights, among others. These challenges are also likely to be experienced in other world regions where biofuels are being developed.

June 2013

José Goldemberg
São Paulo, Brazil

Preface

This book examines recent developments in biofuel production in Latin America and the Caribbean (LAC) region. Taking “sustainable development” as a central theme, most chapters consider one country in the region and explore how biofuel production is evolving given concerns about food sovereignty, trade, other social issues, and environmental conservation as well an increasingly complex and globalized economic structure. An additional chapter addresses sustainability governance and certification schemes in the LAC region.

The countries included in the collection are diverse and include Brazil (two chapters), the region’s largest and most established biofuel producer, and Argentina, which has embraced soy-based biodiesel exports as the newest component of its well-established agro-industrial complex. Smaller “up-and-coming” biofuel producers such as Colombia, which has turned to palm oil-based biodiesel for a complex mix of reasons including an attempt to provide rural farmers in coca-growing regions with an alternative crop, are also included. We also consider Peru and Mexico, minor biofuel producers that nevertheless makes for very interesting cases for examining biofuel sustainability. Mexico, for example, was the site of the “tortilla riots” of January 2007, which was in protest of maize price spikes induced in part by US biofuel policies. Those riots proved to be the first salvo in the ongoing battle of “food vs. fuel,” an issue that stands at the heart of biofuel sustainability. Last, we address Guatemala and the Caribbean region more broadly as case studies, since many smaller nations in this region have embraced biofuel production, albeit in quite different ways. For example, Jamaica, Costa Rica, El Salvador, Trinidad and Tobago, and the US Virgin Islands all take advantage of US free trade agreements to act as conduits of Brazilian ethanol, importing it in a hydrous form and dewatering it before exporting it to the USA, tax free. However, others like Guatemala have developed their own sugarcane-based ethanol industries, primarily for export, and Guatemala is the most efficient and dominant producer in Central America. Similarly, the region hosts numerous small-scale efforts to develop oilseed-based biodiesel industries, based on soy and alternative feedstock such as Jatropha curcas, which are explored in some detail.

The contributions to this book critically explore the ways in which biofuel production in Latin America affect social, economic, and environmental systems: the so-called “three pillars of sustainability”. Numerous stakeholders, drawn from government, industry, civil society, and academia have attempted to define “Sustainable Development” in the context of biofuel production and to operationalize it through a series of principles, criteria, and highly specific indicators. Nevertheless, it remains a fluid and contested concept with deep political and social ramifications, which each chapter explores in detail.

We would like to thank the U.S. National Science Foundation for partial support in writing this book under Award Number 1105039, “OISE-PIRE Sustainability, Ecosystem Services, and Bioenergy Development Across the Americas.” In addition, several people provided valuable comments on drafts of one or more chapters of this book. We would like to especially thank Alberto Acevedo, Marcus Finco, Marcia de Moraes, Pablo Pacheco, Rodrigo Pinto, Pete Richards, Matt Rudolf, and Damiana Serafini for their helpful comments. Any remaining errors or omissions are those of the authors alone.

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Chapter 1
Introduction

Barry D. Solomon and Robert Bailis

Abstract This chapter provides a background for consideration of the sustainability of biofuels in Latin America and the Caribbean (LAC). Facing the twin problems of increasingly scarce and risky petroleum resources and global climate change, many nations are turning to biofuels for the transportation sector. For several decades, the world leaders in biofuels production and use have been, by far, Brazil and most recently the USA. These programs have been considered to be in the national interest, and have been subsidized by governments to varying degrees until more recently. However, the sustainability of biofuels production has come under serious challenge, including their effect on greenhouse gas emissions, biodiversity, deforestation, water use and pollution, food security, labor practices, among other issues. The first generation of biofuels in LAC has relied upon feedstocks that are food based, primarily sugarcane and soybeans, and conversion to non-food-based, second-generation biofuels has been extremely slow. An overview will be provided of numerous sustainability concerns, challenges, and policy responses, including nongovernmental organization governance and certification standards and schemes for biofuel and feedstock production. Given the already large export markets for US and Brazilian ethanol, and for Argentinean biodiesel, greater coordination between national biofuels sustainability programs will be essential to their successful implementation.

1.1 Introduction

The worldwide production and use of transportation biofuels, ethanol and biodiesel in particular, has greatly expanded in the last decade. The Latin American and Caribbean (LAC) region has taken a leading role in this growth, accounting for 27 % of global

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production and over half of global production outside the US (BP 2012). Between 2001 and 2011, regional biofuel production in LAC increased by a factor of two. This growth mirrors a global trend that can be attributed to a proliferation of mandates and blending targets calling for increased use of biofuels in dozens of countries around the world, as well as tax exemptions and subsidies to support the emerging industries (Sorda et al. 2010; Bailis and Baka 2011).

These policies seek to meet a range of objectives that include increased energy security by supplementing costly petroleum-based fuels, reduced emissions of greenhouse gases (GHGs) as well as other harmful pollutants, and support for rural agricultural development. As a result, biofuel feedstock producers and refiners in countries with newly minted mandates increased crop cultivation and invested in the necessary infrastructure to convert starches, sugars, and oilseeds into biofuel. Producers in other countries followed suit, sensing an opportunity to gain from an increased demand for biofuels in regions with ambitious blending targets such as the European Union (EU), which will not meet demands without relying on imported feedstock or fuel.

However, many concerns about the sustainability of biofuels have been raised (Sagar and Kartha 2007; Robertson et al. 2008; Solomon 2010a, b). These include the potential impacts on food security arising from heavy reliance on edible feedstock such as maize, soybeans, oil palm, and sugarcane as well as direct and indirect land-use change (dLUC and iLUC) associated with growing biofuel crops. LUC induced by increased demand for biofuel feedstock can place pressure on sensitive biomes including rainforests, savannas, and grasslands, and deforestation is caused by palm oil plantations and soy production (Fargione et al. 2008). Many other dimensions of sustainability have also been identified, including the effects on air and water quality, soil fertility, use of marginal lands, excessive water consumption, biodiversity, land tenure, child, labor and human rights, economic and energy efficiency, government subsidies, economic development and trade, income distribution, health and gender issues, and ethics.

Countries in the LAC region are similar to other countries that have invested heavily in biofuel production. As elsewhere, interest in biofuels emerged as a means to offset oil imports, promote sustainable development, and increase economic returns from agricultural commodities (Janssen and Rutz 2011). Many countries in the region have introduced blending mandates (see Chap. 2), and several of the larger producers have become major exporters of biofuels or biofuel feedstock, in response to demand from major markets in the EU and Asia. For example, Argentina exports biodiesel produced from soy oil, and Brazil usually exports ethanol (see Chaps. 3–5). Smaller producers, like Guatemala, have developed biofuel industries based entirely on export markets (Chap. 8). Moreover, both Argentina and Brazil also export soybeans and soy oil, some of which is used as biofuel feedstock.[1] Colombia, which has introduced mandates for both ethanol and biodiesel (see Chap. 7), does not currently export biofuels, but it is a major exporter of palm oil to neighboring countries as well as

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[1] It is difficult to know if exported oilseeds or oils from the LAC region to biofuel-producing regions such as the EU are used for biofuel production or in other sectors. Nevertheless, it is worth noting feedstock exports here because it is likely that some feedstock originating from LAC were used by EU member states to produce biofuel in recent years (MVO 2009).

several Organization for Economic Co-operation and Development (OECD) member states (FAOSTAT 2013).

In contrast, other countries in the region such as Peru struggle to meet their blending mandates and have had to import biofuels in order to make up for shortfalls in domestic supply (Chap. 6). Even Brazil, the region's biofuel powerhouse, has imported ethanol in recent years in order to avoid shortfalls, although it also remains a major exporter (UNICA 2013).

In addition, as a major trading partner and dominant political force in the broader Pan-American region, the USA has a major influence on biofuel development in LAC. Trade in fuels and feedstock passes in both directions. For example, in 2011, roughly 1.7 billion liters of ethanol passed between the USA and Brazil: 60 % flowed south from the USA to Brazil and 40 % flowed in the opposite direction (Barros 2012). US policies also link Brazil to other nations in the LAC region. For example, Brazilian ethanol faced a heavy import tariff from the USA until 2012, when the tariff was lifted. However, through the US government's Caribbean Basin Initiative (CBI), Brazil exported hydrous ethanol to several Caribbean states, where the alcohol was dewatered and shipped duty-free to the USA (Yacobucci 2008). After the tariff was removed, ethanol production in CBI members, which was already suffering from increased feedstock prices, plummeted (see Chaps. 3 and 10). Further discussion of the CBI is provided in Sect. 1.2.1.

This collection examines the sustainability of biofuel production in the LAC region. We start with an overview of biofuel production, sustainability, and governance in the region (Chap. 2) followed by eight country-specific chapters exploring biofuel production and sustainability in various national contexts (see Fig. 1.1 and Chaps. 3–10). The book will close with short conclusions (Chap. 11). The chapters examine biofuel powerhouses like Brazil and Argentina as well as smaller producers such as Guatemala, Peru, and the island nations and territories of the Caribbean. In this introductory chapter, we review biofuel production in the region and discuss how the concerns about sustainability have emerged as a major driver of policy, generating numerous efforts to govern production, with mixed results.

The objective of this chapter is to provide an overview of the other contributions. The chapter is organized as follows. We begin with a short review of the recent production patterns and trades of ethanol and biodiesel globally, with particular attention to the LAC region and the countries addressed in this volume. Next, we review the main concerns about sustainability of biofuels in the region. This is followed by a more extensive discussion of the key sustainability challenges that have been incorporated into the rather extensive criteria and standards that have developed and are in various stages of adoption in the region. Finally, we conclude the chapter and provide some additional previews of the rest of the book.

1.2 Biofuel Production in LAC and Globally

Biofuels currently produced at commercial scales include ethanol, which is blended with gasoline, and biodiesel, which is blended with diesel. Ethanol is produced mainly from starch and sugar crops, while biodiesel is produced from oilseed crops

Fig. 1.1 The LAC region and the case study countries

as well as animal fats and waste vegetable oil. Ethanol was commercialized earlier than biodiesel and it continues to be produced in much larger volumes, although in regions including the European Union (EU) as well as parts of LAC like Argentina and Colombia, biodiesel is more prevalent.

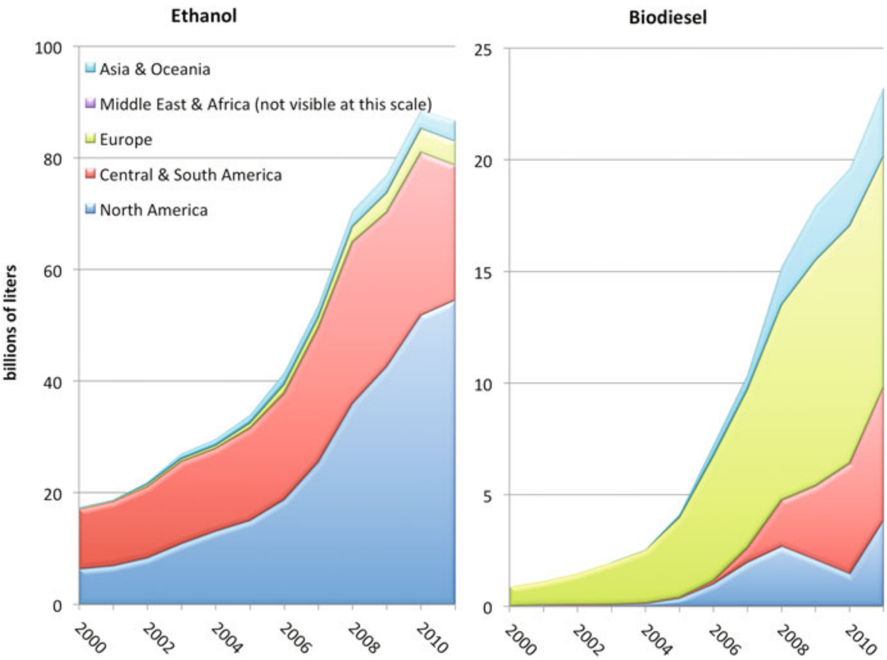

Fig. 1.2 Global biofuel production from 2000 to 2011. (Source: EIA 2012)

Since the mid-1970s, global ethanol production has been dominated by Brazil and the USA. Brazil began to develop its fuel-ethanol industry in the mid-1970s soon after the Organization of the Petroleum Exporting Countries (OPEC) oil embargo and led global production until it was overtaken by the USA in 2006 (Chap. 3). In order to allow their industries to mature, both the USA and Brazil implemented numerous policies including subsidies, tax incentives, and import tariffs (Solomon et al. 2007; Hira and de Oliveira 2009; Goldemberg et al. 2004).[2] By 2011, the USA and Brazil accounted for 89 % of global ethanol production, and around 97 % of production in the Americas, with the USA being by far the largest producer (Fig. 1.2 and Table 1.1).

While ethanol fuel production elsewhere in LAC pales in comparison to Brazil (Fig. 1.3), a growing interest is evident in other states of the region. Small producers of note include Guatemala (Chap. 8), Paraguay, Argentina (Chap. 5), Peru (Chap. 6), and Jamaica (Chap. 10); Jamaica's output was much higher in 2006–2009, as was the case with El Salvador, Costa Rica, and Trinidad and Tobago (Table 1.1). Other countries in LAC such as Mexico have introduced biofuel policies, but have failed to commercialize the sector thus far (Chap. 9). Regionally, ethanol production increased by an average of 13 % per year between 2000 and 2008, but declined by 3 % between 2008

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[2] Brazil ended its direct subsidies in 1999 and, more recently, the USA removed its import tariff on Brazilian ethanol.

Table 1.1 Biofuel production in Pan-America, 2006–2011 (million liters per year). (Source: EIA 2012)

Fuel	2005	2006	2007	2008	2009	2010	2011
Ethanol							
USA	14,780	18,489	24,685	35,141	41,404	50,338	52,727
Brazil	16,040	17,764	22,557	27,059	26,103	28,203	22,748
Canada	255	255	801	870	1,161	1,393	1,741
Colombia	29	267	273	255	325	279	348
Guatemala	0	75	168	168	174	174	232
Paraguay	35	46	58	87	122	128	128
Argentina	0	6	18	12	24	122	174
Jamaica	128	302	282	373	400	116	174
Peru	0	0	29	29	58	99	122
Costa Rica	120	122	168	139	70	29	23
Cuba	46	29	23	17	17	17	29
Mexico	0	0	0	0	0.2	17	17
El Salvador	89	335	275	264	125	0	0.2
Trinidad & Tobago	33	103	184	247	162	0	128
US Virgin Islands	0	0	10	187	14	0	0
Biodiesel							
USA	344	948	1,854	2,560	1,953	1,300	3,662
Brazil	1	69	404	1,164	1,608	2,386	2,673
Argentina	12	35	209	807	1,341	2,089	2,747
Colombia	0	0	6	81	331	418	522
Canada	12	46	93	99	122	139	157
Peru	17	23	23	12	12	29	35
Uruguay	2	2	3	3	6	12	12
Mexico	0	0	6	6	6	6	6

and 2009, and another 17 % between 2010 and 2011. Declining production is largely attributable to increasing sugar prices, which favor sugar production over ethanol.[3]

Biodiesel production in the LAC region emerged more recently than fuel ethanol and is less concentrated (Figs. 1.2 and 1.3). The region accounts for roughly one-quarter of global production. Brazil (Chap. 4) and Argentina (Chap. 5) are the largest producers, with each supplying ~ 45 % of the regional output, having lagged behind US production by a couple of years. Colombia (Chap. 7) contributes the bulk of the region's remaining supply, while others, like Peru (Chap. 6) produce small quantities for niche markets.

The balance of global biodiesel production is divided between the EU, the USA, and Asia. The EU collectively accounted for 44 % of global production in 2011. In the USA, biodiesel production grew dramatically from 2005 to 2008, but has been somewhat volatile in the years since, dropping in 2009–2010 and then rebounding in 2011. Though the EU dominates global production, the popularity of diesel-powered passenger cars and the region's renewable energy policies, discussed in more detail in Chap. 2, make it impossible for the EU to meet its demand for biodiesel. Thus,

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[3] Between January and December 2009, Brazilian sugar prices, which serve as a benchmark for the world market, doubled. Prices declined by mid-2010, but they underwent a similar increase by the end of the year and remained high through the first quarter of 2011 (CEPEA 2012).

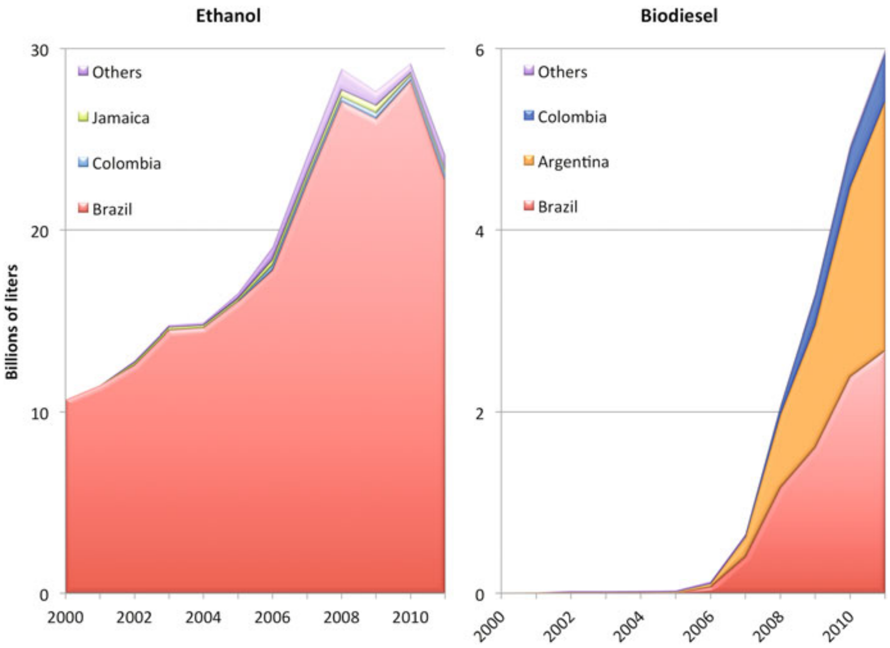

Fig. 1.3 Biofuel production in the LCA region from 2000 to 2011. (Source: EIA 2012)

the EU is an attractive market for countries developing export-oriented biodiesel industries like Argentina, as well as the region's major oilseed producers, which include Argentina, Brazil, and Paraguay (sources of soybeans and soy oil), as well as Colombia (palm oil).

1.2.1 Regional Cooperation and Trade

While Brazil and the USA have dominated biofuel markets for several decades, in recent years many other countries in LAC have developed ethanol and biodiesel industries. Brazil and the USA have promoted these industries as a means to increase energy security, reduce greenhouse gas emissions, and promote economic development. For most of this time, Brazil has been the world's leading exporter of ethanol (esp. to North America and Europe), and in the last decade Argentina the leading exporter of biodiesel (the USA is not a major exporter). With a few common feedstocks dominating biofuel production and growing global interest in sustainable development, the establishment of regional cooperation on sustainable biofuels could facilitate common political, socioeconomic, and environmental interests. Not doing so may reinforce patterns of behavior that contribute to environmental harm (Dauvergne and Neville 2009). Several regional economic and political forums could be used to promote common practices and standards on sustainable biofuels. For example, an Inter-American Commission on Ethanol was established in 2006 to promote ethanol in the region, including the elimination of the US import tariff. Founding members included the IADB, Brazil, and the Governor of Florida (Carolan 2009).

Soon after, a memorandum of understanding (MOU) between the USA and Brazil to advance cooperation on biofuels, and the CBI (Meyer 2010; Yacobucci 2008) was signed in March 2007 to promote scientific cooperation, development and use of biofuels, including third country production for domestic consumption as well as international harmonization of standards. The MOU was expanded in November 2008 through a collaborative effort with the Inter-American Development Bank (IADB), the Organization of American States (OAS), and the United Nations Foundation. The expanded effort named the Dominican Republic, El Salvador, Haiti, and St Kitts and Nevis as initial target beneficiaries of feasibility studies and USA–Brazil biofuels cooperation. This agreement also introduces technology sharing between the USA and Brazil and further efforts to advance biofuels industries in the Western Hemisphere.

The Brazil–USA MOU includes technology sharing on cellulosic ethanol. However, there has been little focus on sustainability. Indeed, the MOU was established in part for political reasons, including the removal of the US import tariff of $0.14 per liter on imported ethanol from Brazil, which was allowed to expire at the end of 2011 (Cowie 2011).

The CBI was established in 1983 and amended in 1989 to promote a stable political and economic climate in the region (Yacobucci 2008). The CBI is the common name of the Caribbean Basin Economic Recovery Act of 1983, which was amended in 1990. There are 18 countries and territories in the Caribbean and Central America that have benefited from it. If fuel ethanol is grown from 50 % local feedstocks in the region, it may be imported duty-free, as tariffs were effectively eliminated. This economic advantage initially did not apply to ethanol imported to the USA from Brazil, unless hydrous ethanol was first sent to dehydration plants in the Caribbean or Central America (Farinelli et al. 2009). At the time, there was a US$ 0.14-per -liter tariff on non-CBI country imports that targeted Brazil. Thus, the Caribbean became a hub to transfer significant quantities of lower-cost Brazilian hydrous alcohol into the USA via dehydration into anhydrous ethanol in the Caribbean. Jamaica and Trinidad and Tobago benefitted the most from this arrangement (see Chap. 10). The advantage of this program for CBI countries ended with the elimination of the US$ 0.14–per-liter tariff in December 2011, given the lower cost of Brazilian ethanol production. The US Congress allowed the volumetric excise tax credit for domestic biofuel production to expire at the same time, after being in effect in various forms since 1979 (Solomon et al. 2007). However, as noted in Chap. 3, Brazilian ethanol production fell in 2011–2012 due to a decline in yields and higher sugar prices. As a result, since 2011, Brazil has been a significant importer of US ethanol (Barros 2012).

1.3 Biofuel Sustainability Concerns and Policy Responses

Worldwide biofuel production increased fivefold between 2000 and 2011; production within LAC increased threefold in the same time period. This rapid growth has raised many concerns about potential consequences. While biofuels are theoretically renewable, unsustainable production practices can alter landscapes and stress social–ecological relationships in multiple ways (e.g. Patzek 2004; Pimentel and Patzek 2005; Fargione et al. 2008; Robertson et al. 2008; Solomon 2010a, b). Indeed, between 2005 and 2008, as blending mandates were implemented in the USA and EU and similar policies were introduced in dozens of other countries (including many in LAC as is discussed in Chap. 2), world food markets experienced the largest price shock in 30 years (FAPRI 2009), setting off riots in dozens of cities worldwide (Vidal 2007; Martin 2008). Since that time, other impacts have come to light linking biofuels to biodiversity loss and deforestation (Fitzherbert et al. 2008; Gao et al. 2011), land grabs (ActionAid 2008; Zoomers 2010), and forced labor (Welch 2006; Dos Santos 2007).

These concerns are global in nature, but several impacts have materialized specifically in the LAC region. For example, increased maize and sugar prices in LAC associated with public demonstrations and potential food insecurity have been traced to biofuel policies (Keleman and Raño 2011; Babcock 2012; Rosenthal 2013). Soy, the region's main feedstock for biodiesel, has been linked to deforestation in the Brazilian Amazon (Nepstad et al. 2006; see also Chap. 4) as well as Argentina's scant forest areas (Delvenne et al. 2013). Expanding soybean cultivation has also been tied to conflict over land (Gomes et al. 2009; Tomei and Upham 2009). In Colombia, oil palm has been linked to land grabs (Maughan 2011) and sugarcane has been associated with conflict over water access and pollution (Chap. 7 of this collection). In addition, multiple analyses have demonstrated that the expansion of biofuel feedstock can lead to iLUC within the region (CARB 2009; Lapola et al. 2010; Arima et al. 2011).

Perennial crops that can grow on marginal lands, like *Jatropha curcas*, were introduced to address some of these concerns. The crop experienced a brief boom and subsequent bust due to global financial trouble and poor crop performance. Despite these troubles, dozens of *Jatropha* projects persist across the LAC region, but output is far too low to make a meaningful contribution to the region's biodiesel industry at this time (Wahl et al. 2012).

Both in anticipation of, and in response to these impacts, governance mechanisms have been introduced by a wide range of actors including national and subnational governments, private corporations, and non- or intergovernmental organizations in order to govern biofuel feedstock production, refining, and trade. These mechanisms include mandatory regulations as well as voluntary certification schemes, sustainability standards, meta-standards, and codes of conduct (Bailis and Baka 2011, and Chap. 2 in this collection). Some of these efforts focus on a single issue such as GHG emissions, e.g., the US EPA's Renewable Fuel Standard 2 (RFS2) and California's Low Carbon Fuel Standard (LCFS) (CARB 2009; EPA 2010). Other mechanisms are more comprehensive in scope. For example, several individual EU member states as well as the region as a whole have introduced governance schemes that seek to address a range of environmental and/or social impacts, although they do not define quantitative limits to these impacts like they do GHG emissions (Van Dam et al. 2010; Bailis and Baka 2011).

Within the LAC region, several national policies also attempt to address multiple impacts (see Chap. 2 for an in-depth review). Also applicable to the LAC region, the Inter-American Development Bank developed the Biofuels Scorecard, which is designed for use at the project level to catalog social, environmental, and economic issues linked to biofuel production (Janssen and Rutz 2011). Similarly, Germany and Brazil are working with the International Standardization Organization (ISO) to develop voluntary sustainability criteria for bioenergy (see Chap. 2 for further discussion).

Additionally, several sustainability "roundtables" have been organized by various non-state actors. These multi-stakeholder initiatives (MSIs) include the Roundtable on Sustainable Biomaterials (RSB 2012a) and International Sustainability & Carbon Certification (ISCC 2012), as well as several crop-specific "roundtables" that have been developed for common biofuel feedstocks: the Roundtable on Sustainable Palm Oil (RSPO), Bonsucro for sugarcane, and the Round Table on Responsible Soy (RTRS). The crop-specific schemes were not originally developed for biofuel certification, but have been adapted to make them more congruent with other biofuel efforts, particularly the European Union Renewable Energy Directive (EU RED; see Chap. 2 for a more detailed discussion of each scheme and Chap. 7 for an exploration of Colombia's experience with Bonsucro). Each initiative has developed voluntary certification schemes with specific criteria and indicators that are meant to demonstrate compliance with certain sustainability principles.

While adopting similar approaches, the schemes differ widely in their specific design. Some concern themselves primarily with avoiding negative consequences. Others go further by encouraging, or even requiring, biofuel production to result in improvements, at least in some circumstances. For example, the RSB requires that biofuel operations located in regions of poverty "contribute to the social and economic development of local, rural and indigenous people and communities" and "improve food security in food insecure regions" (RSB 2010, p. 15 and 17).

Several schemes require environmental/social impact assessments (ESIAs) to be conducted, at least under some circumstances. For example, Bonsucro requires an ESIA for "greenfield" development (plantations initiated on uncultivated land after January, 2008). RSB requires all projects to conduct a "screening exercise," and proceed with a full ESIA if the screening process indicates that the project exceeds certain risk thresholds (RSB 2012b).

1.4 Key Sustainability Challenges

There are numerous dimensions to biofuel sustainability, which can be complex and contested. These include emissions of GHGs and other pollutants, impacts on soil, water, and air quality, energy security and economic efficiency, food security, human rights, and other social issues like labor conditions, poverty alleviation, and gender equity. In this section, we review these key themes and discuss the ways in which they are addressed by various governance mechanisms.

1.4.1 GHG Emissions

While several factors will determine the sustainability of biofuels production and use, especially important considerations will be the feedstock used, production technology, and GHG emissions. Interestingly, while many biofuel policies mention GHG emission reductions as an explicit objective, none of the policies defines a firm reduction target. In contrast, the policies introduced in the USA and EU, which are potential sources of demand for the LAC region's biofuels, have defined specific targets, as have the majority of the voluntary non-state sustainability schemes (see Chap. 2 for a full discussion).

Two feedstocks dominate biofuel production in the LAC region: sugarcane for ethanol and soy oil for biodiesel. Palm oil for biodiesel plays a role in Colombia and Peru. Numerous life-cycle assessments (LCAs) have been carried out to estimate the GHG emissions of biofuels relative to gasoline or diesel fuel (Hoefnagels et al. 2010; Yacobucci and Bracmort 2010). Results of LCAs vary widely because of different assumptions and methodologies. Figure 1.4 shows a range of estimates of GHG emissions from biofuel production for some common ethanol and biodiesel feedstocks without accounting for LUC. The large range of estimates for some fuels is the result of different allocation methodologies (Hoefnagels et al. 2010; Bailis and Baka 2010). Conventional gasoline and diesel are included for comparison, as are maize ethanol and soy-biodiesel produced in the USA. Using different assumptions and allocation methods, GHG emission reductions range from 80 to 90 % for sugarcane ethanol and 35–90 % for palm-based biodiesel (Borjesson 2009; Sousa et al. 2010; Hoefnagels et al. 2010). *Jatropha* achieves 30–60 % reductions.[4] Soy can achieve 50 % reductions under some assessment methods, but other methods yield much less favorable results, with few or no reductions relative to conventional diesel.

Both dLUC and iLUC can have large impacts on GHG emissions from biofuel production, which can negate the emission reductions shown in Fig. 1.4. dLUC's impact results from feedstock cultivation that displaces natural vegetation. iLUC comes into play if the use of biofuel feedstock affects existing commodity markets in ways that induce LUC elsewhere. One assessment of dLUC focused on the LAC region showed that biofuel crops planted in the Brazilian Amazon or Cerrado zone can lead to dLUC that releases many times the carbon dioxide (CO_2) saved by replacing fossil fuels, leading to a large "carbon debt" that must be "paid off" before any benefits of biofuels can be realized (Fargione et al. 2008). However, dLUC can work in both directions. For example, if perennial biofuel crops like *Jatropha* or oil palm are planted on degraded pasturelands that have been previously depleted of carbon, carbon may accumulate in the landscape and increase the GHG reductions achieved by displacing fossil fuels (Bailis and Baka 2010). The EU RED implicitly acknowledges this by awarding a "bonus" to biofuel feedstock cultivated on "severely

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[4] Data for Jatropha are for bio-kerosene production, but we include them here because the emissions are similar and this is the only peer-reviewed LCA study of Jatropha biofuel produced in the LAC region.

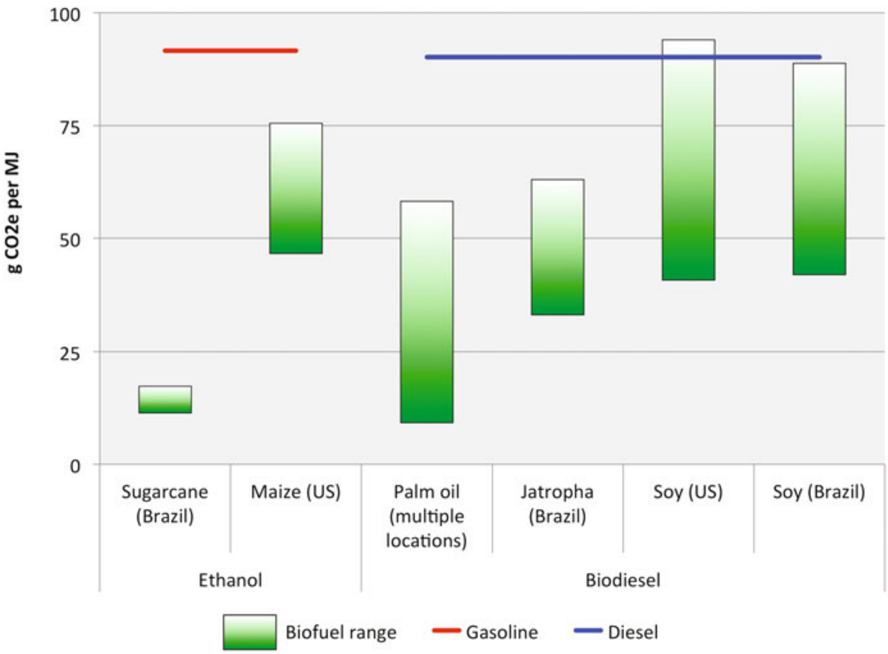

Fig. 1.4 LCA-based estimates of GHG emissions from common biofuels without considering d/iLUC. (Sources: Hoefnagels et al. 2010; Chum et al. 2011; Bailis and Baka 2010; Souza et al. 2010; Skone and Gerdes 2008)

degraded" land (European Union 2009, p. 54). Thus, dLUC does not always lead to increased emissions; it must be considered in its specific geographic context.

In contrast to the location-specific nature of dLUC, iLUC occurs as a result of the aggregate impact of increased demand for biofuel feedstock and the ways in which feedstock growers around the world subsequently respond. Using global trade models that account for interactions (elasticities) between commodity prices, yields, cultivated areas, and land transformation (CARB 2009), it is possible to forecast the location and quantity of additional land that will be brought into cultivation in response to increased biofuel production. Many analyses have been conducted to estimate the GHG emissions due to biofuel-induced land transformation, providing estimates of emissions per unit of biofuel produced. Estimates of iLUC-induced GHG emissions for common biofuel crops are shown in Fig. 1.5. *Jatropha* is not included because no credible accounts of iLUC from *Jatropha* have been published. The magnitude of iLUC emissions is similar to emissions from feedstock production, transport, and processing shown in Fig. 1.4. In addition, the range of estimates is large, reflecting the uncertainty in iLUC methodologies, which rely upon projections of market responses to future biofuel supply.

iLUC is addressed in some sustainability schemes, but not others. For example, the RTRS does not mention iLUC at all (RTRS 2010). The RSPO acknowledges iLUC and stresses that oil palm "plantation development should not put indirect pressure on

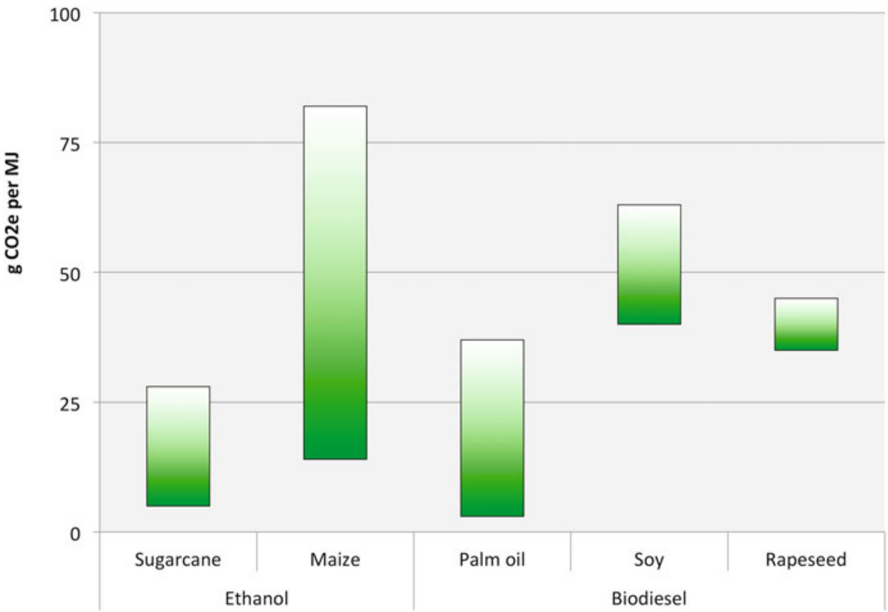

Fig. 1.5 Range of GHG emissions from indirect land use change (iLUC). (Source: Chum et al. 2011; Wicke et al. 2012)

forests," but they have not articulated any prescriptive set of measures (RSPO 2013, p. 51). RSB and Bonsucro take a similar approach (RSB 2010; Bonsucro 2011).

The EU RED mentions iLUC several times, but is ambiguous regarding measures to avoid or reduce it. Only the US. RFS2 and California's LCFS have taken steps to quantitatively incorporate iLUC explicitly into their regulations. Both have used global trade models to estimate iLUC-induced GHG emissions, which they add to emissions from other stages of the life cycle (CARB 2009; EPA 2010).

1.4.2 Biodiversity and Other Ecosystem Services

In addition to GHG emissions, both dLUC and iLUC can lead to loss of biodiversity and other ecosystem services. This has been most thoroughly documented in Brazil, where the soy complex is linked tightly to the expansion of cattle in the Amazon region (Chap. 4). However, it is potentially problematic throughout the entire LAC region because the region's biodiesel industry is based on a mix of soybeans and oil palm, both of which have a history of displacing natural forest elsewhere in the region (Tomei and Upham 2009; Maughan 2011; Gutiérrez-Vélez et al. 2011).

Moreover, although sugarcane does not generally encroach upon moist forest regions like the Amazon biome, it has been implicated indirectly by some analyses, as discussed earlier. This has also been documented anecdotally in Guatemala (Chap. 7).

Regardless of the feedstock, the conversion of natural vegetation to industrial mono-cropping systems can degrade ecosystem functions like biodiversity as well as erosion control, soil quality, and hydrologic processes. The RSB and the feedstock-specific sustainability standards attempt to address these impacts by singling out and placing limits on the use of "high conservation value" land for feedstock production (RSB 2010; RTRS 2010; Bonsucro 2011; RSPO 2013). The RSB goes further by stipulating that ecosystem functions and services affected by biofuel production be maintained or even enhanced and that buffer zones and ecological corridors be either protected, restored, or created (RSB 2010).

1.4.3 Water Accessibility and Quality

Large-scale commercial agricultural operations can have substantial impacts on water and air quality. Water impacts may occur as a result of water demand in feedstock production and processing as well as potential impacts on water quality as a result of agricultural runoff or pollution from the refining facility (National Research Council 2008). Water demand from feedstock includes both evapotranspiration and irrigation. Not all biofuel feedstocks are irrigated, but in cases where irrigation is applied, it can lead to unsustainable practices if withdrawals exceed recharge rates. Indeed, this may be occurring in Colombia, as is discussed in Chap. 7. In addition, biofuel refining requires water. Refineries consume far less water than crop production, but if they are situated in water-scarce regions, localized shortages can negatively affect nearby communities (National Research Council 2008).

Biofuel production can impact water quality as a result of agricultural runoff from feedstock cultivation as well as pollution from the refining facility. Each of the biofuel feedstocks commonly used in the LAC region receives applications of several hundred kilograms of fertilizers every year, as well as 1–2 kg of insecticides and herbicides. Figure 1.6 shows average nutrient and agrochemical inputs applied to soybeans and sugarcane, with maize and *Jatropha* included for comparison. While crops need nutrients, excessive nutrient applications are harmful to water quality. Herbicides and insecticides can also have detrimental impacts (Fig. 1.6).

In addition, biofuel refineries produce numerous waste streams that can negatively affect water quality (Table 1.2). For example, in ethanol plants, salts build up in cooling towers and boilers, which must be discharged. Different condensing stages produce high-temperature effluents that must be cooled before release. Moreover, sugarcane-based ethanol generates waste streams called stillage or vinasse with high levels of potassium and organic matter. During the early stages of Brazil's ethanol program, vinasse was released directly into waterways, seriously degrading water quality. In the late 1970s, the industry introduced a "ferti-irrigation" process, in which vinasse is applied to cane fields as a source of water and nutrients. This has reduced the impact on water quality, although some problems remain in parts of the North and Northeast (BNDES 2008; also see Chap. 3). "Ferti-irrigation" requires significant investment in storage tanks and distribution channels and other cane-ethanol-producing

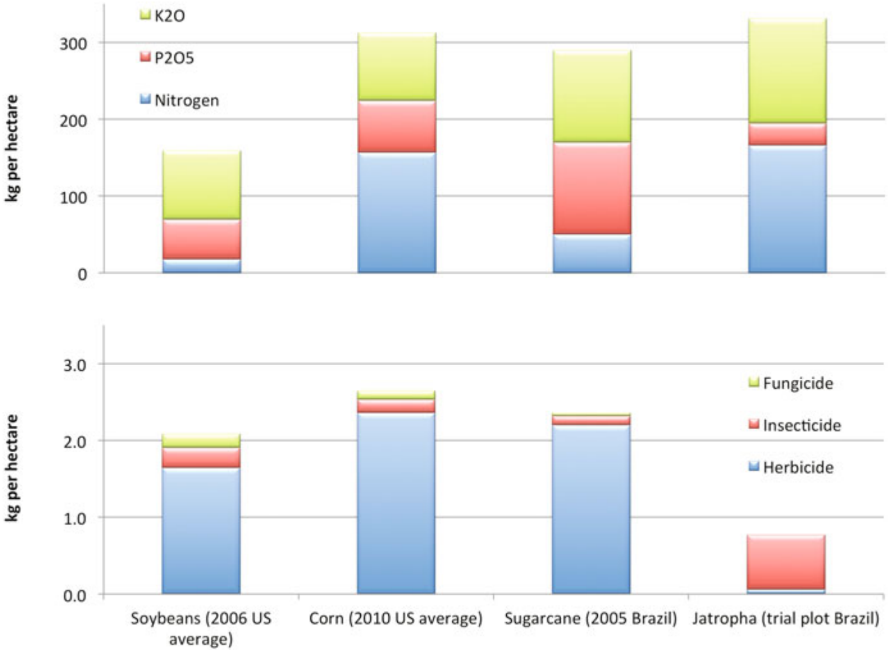

Fig. 1.6 Use of fertilizers (*top*) and pesticides (*bottom*) in common biofuel crops. (Source: BNDES 2008; USDA 2013a; Bailis and Kavlak 2013)

Table 1.2 Effluents and treatments from Brazilian ethanol. (Source: BNDES 2008, citing Elia Neto 2005)

Source of effluent	Characteristics	Treatment
Sugarcane washing	Average polluting potential and high solid content	Decantation and stabilization pools in the case of disposal into bodies of water. When reused, treatment consists of decantation and pH correction
Multi-jets and barometric condensers	Low-pollution potential and high temperature (~ 50 °C)	Spray tanks with cooling towers, with recirculation or release
Cooling vents and alcohol condensers	High temperature (~50 °C)	Cooling towers or spray tanks for reuse or release
Stillage (vinasse) and residual water	High volume (~11 l per liter of ethanol) and organic load	Applied during cane farming along with residual water

countries in the LAC region do not utilize vinasse to the same extent as Brazil. In those cases, discharge into waterways can be problematic (see Chaps. 7 and 8).

Sustainability schemes attempt to avoid negative impacts on water accessibility and quality by respecting existing water rights, encouraging biofuel feedstock producers and refiners to develop water management plans that promote efficient water use and ensure that water resources are not depleted beyond natural replenishment capacities (RSB 2010).

1.4.4 Air Quality

Air pollution is also a concern associated with biofuel production, both in fuel production refineries and on feedstock plantations. These problems have been most apparent on sugarcane farms, where historically it has been common practice to burn the fields both before and after harvest. Fires are set before harvesting to burn off dried leaves and stalk tops, and to evaporate water in the stems. These fires increase the efficiency and yields of cane removal and lower production costs by decreasing the volume of material to be processed. Fires can also help rid the fields of poisonous spiders and snakes. These types of practices, as well as the use of open air burning to clear land, have been targeted for control by various governance mechanisms because of the adverse health effects, both chronic and acute, which can be linked to these fires (see Chap. 3 and RSB 2010). Many types of air pollution are of concern, but particulate matter can be especially hazardous to human health (Kampa and Castanas 2008).

In Brazil, efforts have been under way to phase out open burning of sugarcane starting in Sao Paulo and spreading to other states (see Chap. 3). This change has been facilitated by the mechanization of cane harvesting, which was introduced as a labor-saving practice. There are also energy benefits to mechanization, because the additional tops and leaves may be used for electricity generation, underscoring the trade-offs between environmental, energy, and social effects of biofuel production.

There is also concern about emissions from biofuel refineries. As long as fossil fuels or biomass is used at these facilities, some emissions of conventional air pollution are inevitable. Emissions occur not only from plant operations themselves, but also along haul roads, from storage piles, and even evaporative losses from tanks. Particulate matter, volatile organic compound, nitrogen oxides, and carbon monoxide emissions are most troublesome, and fuel processors or refinery operators need to develop control plans to meet regulatory standards and prevent pollution wherever possible.

1.4.5 Soil Quality

Soil quality is an essential element of agricultural sustainability. Negative impacts on soil include erosion, loss of nutrients, and decreased soil fertility. In response, farmers may increase agrochemical inputs, which increases the environmental burdens of crop production and negates some of the benefits of fossil fuel substitution. If conditions worsen, farmers may abandon land altogether, leading to negative social impacts and potentially contributing to d/iLUC as new land is cultivated.

In addition, practices like conventional tillage can lead to reductions in soil carbon, particularly for annual crops. Losses of soil carbon are especially high if land is converted from undisturbed natural vegetation to cropland. These losses also reduce the benefits of fossil fuel substitution.

Most biofuel sustainability standards and regulation devote effort to avoiding negative impacts on soils. However, the emphasis varies. For example, the US RFS and California LCFS, which are primarily concerned about the global warming impacts of biofuels, limit their discussion stocks of carbon in the soil (CARB 2009; EPA 2010). The EU RED is also concerned about soil carbon, but also acknowledges the importance of maintaining soil quality for its own sake (European Union 2009). MSI standards have each defined principles to maintain soil quality. For example, the RSB requires feedstock producers to "implement practices to maintain or enhance soil physical, chemical, and biological conditions" specifically by minimizing erosion, maintaining organic matter, and, under some conditions, developing a management plan informed by direct monitoring of soil conditions via periodic sampling (RSB 2010, p. 21). Other standards are more specific. For instance, to control soil erosion and maintain soil organic matter in sugarcane production, Bonsucro, which has received a lot of interest from producers in Latin America (see Chaps. 2 and 7), requires producers to mechanically till less than 20 % of their cultivated area and to leave at least 20 % of tops and leaves in the field after cane is harvested (Bonsucro 2011).

1.4.6 Human and Labor Rights

Support for human and labor rights is by no means unique to biofuels as these are transcendent human aspirations, as reflected by statements of the United Nations, International Labour Organization (ILO), and many other groups. These include the creation and enforcement of assurances against child, slave, and forced labor; the lack of restrictions on the hiring and treatment, and compensation and benefits granted to workers based on gender, race, national origin, etc.; protection of the rights to organize and collective bargaining; and assurance of safe working conditions. While these goals are not endorsed by all countries and in all circumstances, many of these conditions have been reflected in biofuel governance schemes (Chap. 2).

All biofuel producers have environmental, health, and safety standards at biofuel production facilities though the standards are not always enforced. Thus, third-party verification under a governance scheme can play an important role in this aspect of sustainability. The situation on biofuel crop plantations is more vexing given the much larger geographic extent and limited enforcement resources. As a result, there are some concerns about labor standards on these farms. For example, in Brazil there have been some reported violations of labor legislation in the northern and northeast sugar-producing regions as well as several soybean regions (Welch 2006; Gomes et al. 2009). A National Pact for the Eradication of Slave Labor was launched in 2005 and a follow-up Plan adopted by the Federal Government in 2008 (Chap. 3).

1.4.7 Rural and Social Development

In addition to achieving environmental goals and improving energy security, many biofuel blending mandates include social objectives. This is true in the USA, where biofuel policies were explicitly meant to boost markets for domestic agriculture

(Solomon et al. 2007), as well as the LAC region. In Chap. 2, the authors review biofuel policies in 14 countries of the LAC region and find that a majority of them seek to meet socioeconomic goals: for example, 8 out of 14 mention general rural and socioeconomic development; 9 out of 14 mention employment; and 7 out of 14 mention poverty reduction or "social inclusion." The notion of "social inclusion" was used liberally in formulating Brazil's biodiesel program, which is responsible for over 40 % of the region's output. The Brazilian program was founded with the intention that a large fraction of feedstock would originate from small-scale family farmers. Unfortunately, this has not occurred to the extent that was originally envisioned (Chap. 4).

Several chapters in this collection demonstrate the difficulty of achieving social goals, particularly rural development, with biofuel policies. Indeed, there are real concerns that biofuel policies can actually leave rural communities worse off. Negative social impacts include infringements of human rights or labor rights, which we discussed above, as well as threats to food or land tenure security, which are both explored below. Most MSIs focus on avoiding these negative consequences. Others go further by encouraging biofuel operators to contribute to socioeconomic development. For example, the ISCC requires biofuel producers to create incentives among employees and their communities including "bonus payment, support of professional development, family friendliness, medical care/health provisions, [and] improvement of social surroundings" (ISCC 2012, p. 25). However, this is a minor provision, which may be omitted provided that 60 % of other minor requirements are satisfied.

The RSB goes further in this regard, by requiring that feedstock producers, processors, and refiners operating in "regions of poverty" improve social conditions by introducing a range of measures such as:

- Optimize job creation and promote permanent jobs among local workers rather than seasonal and/or migrant laborers
- Provide training and retaining as many workers as possible if introducing mechanization
- Encourage women, youth, indigenous communities, and other vulnerable groups to seek employment or otherwise participate in operations; and
- Implement at least one of the following: create year-round and/or long-term jobs; establish cooperatives or micro-credit schemes empowering small-scale farmers; use locally produced bioenergy to provide modern energy to local communities; introduce shareholding options, local ownership, joint ventures, or other types of partnerships; or provide other benefits such as health clinics, housing, hospitals, or schools

1.4.8 Food Security

The food security challenge in biofuel development is a direct result of the dramatic growth in maize use for ethanol in North America, primarily the USA (Solomon et al. 2007). Through indirect impacts on global markets, this increased the price of maize around the world, leading to concerns that biofuels production may be starving the poor (Runge and Senauer 2007). Overall, the US National Academy of Sciences and other researchers have found that global biofuels expansion accounted for 20–40 % of the food price increase experienced in 2007–2008, when the price of many food items doubled (ActionAid 2012).

Several dimensions of food security and prices need to be considered. Firstly, as maize use for ethanol has grown over time, so has overall maize production. Secondly, while maize use for ethanol is substantial, accounting for around 40 % of the total US maize output in the last few years, its use for human food production is actually much smaller than its use for both ethanol and feed grain.[5] Around 20 % of US maize production is exported. The USA is the largest maize exporter in the world, followed by Brazil and Argentina. Mexico and Colombia are typically among the largest importers (USDA 2013b). Thirdly, while growth in biofuel production can lead to increased food prices, the price of other staple foods that are not used for biofuel such as rice have often risen during the same period. This underscores the fact that multiple factors are at work, including rising energy costs, increased demand, market speculation, and adverse weather (Gorter et al. 2013). Finally, food prices can sometimes increase in one world region while falling in others (World Bank 2013).

The largest effects in LAC of the diversion of maize into ethanol production in the USA was felt in Mexico, especially during the tortilla crisis of 2007 (Keleman and Raño 2011). These concerns subsided somewhat as food prices fell during the Great Recession and into 2010, but have risen again since then. As a result, Mexico has added a specific provision in its biofuel law banning or restricting the use of maize for ethanol production (see Chap. 9). This concern is reflected in most of the MSIs (Chap. 2). Only a few other countries in LAC have used maize for biofuels, on a limited basis, such as Paraguay and Argentina (Chap. 5).

As noted earlier, the main feedstocks for biofuels in LAC are sugarcane and soy oil. While both sugar and soybeans have experienced some price increases, neither one can be considered a staple food source. In some areas, soy oil is an important source of fat, but in the LAC region, soybeans are primarily grown for soymeal, the supply of which is not affected by the use of soy oil for biodiesel production. Moreover, there are many substitutes for soy oil (corn, cottonseed, sunflower, canola, palm, coconut, safflower, olive, and peanut) (Rosillo-Calle et al. 2009). Similarly, though sugar is consumed in large quantities, it is not a staple source itself. As a consequence, much less concern has been focused on the restriction of sugarcane and soy oil for biofuel production than is the case with maize. However, concerns have been raised because expanding sugarcane or soybean cultivation may displace land that is used for important food crops (Bailis and Baka 2011).

1.4.9 Land Rights

Biofuel production is a land-intensive activity. Since the introduction of large-scale biofuel blending mandates, there have been numerous concerns expressed about the

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[5] The use of maize as livestock feed, indirectly human food, accounts for either the first or second largest share of the market, depending on the year (Solomon et al. 2007).

threat that biofuels can pose to land rights worldwide (Peskett et al. 2008; Cotula et al. 2008; Von Braun and Meinzen-Dick 2009). This is particularly relevant in Latin America, where generations of inequitable land distribution have contributed to some of the highest wealth disparities in the world (Ferranti 2004; Alesina and Rodrik 1994).

Industrial biofuel production is thought to benefit from economies of scale, which supports the development of large monoculture plantations. This trend has raised concerns about land concentration and potential rights violations, particularly among vulnerable populations including poor rural communities and indigenous groups. For example, in Brazil, 70 % of the land under sugarcane cultivation is held by just 340 large-scale industrial mills with average holdings of 30,000 ha; the remaining land is divided among 60,000 small-scale landholders, with farm sizes averaging less than 30 ha (Cotula et al. 2008). Soybean farming, which is the mainstay of Brazil's biodiesel industry, also favors very large landholdings. The rapid expansion of that crop into Brazil's agricultural frontier has been associated with intimidation and violence (van Gelder and Dros 2006; also see Chap. 4).

Land rights are also a concern in other LAC countries. For example, Colombia, like Brazil, suffers from very high economic disparities. There, sugarcane is being cultivated on large plantations in regions with historically entrenched land inequality (see Chap. 7). Similar conditions prevail in Guatemala, where a brutal civil war was fought, in part, as a result of inequitable land distribution (see Chap. 8).

Sustainability standards include provisions for the protection of land rights, but these provisions rely largely on existing legal institutions within the host country and international treaties protecting indigenous land rights (Bonsucro 2011; ISCC 2012).[6] The RSPO requires that operators demonstrate they have obtained the legal right to use the land and that the plantations are not "legitimately contested by local people who can demonstrate that they have legal, customary or use rights" (RSPO 2013, p. 11). However, the deep history of institutionalized inequality in the LAC region is an indication that existing laws are probably not sufficient to safeguard land rights in the face of political and economic pressure to expand biofuel production.

As with rural and social development, the RSB goes somewhat further than the other MSIs in ensuring land rights by requiring all projects to undergo a screening exercise to establish formal and informal land-use rights. This is particularly relevant because informal rights may not be well defined within the existing legal mechanisms on which the other MSIs rely. If the screening exercise reveals any negative impacts, then a full "land rights assessment" is required (RSB 2012c) and biofuel production cannot proceed without evidence that any disputes were settled "through Free, Prior and Informed Consent and negotiated agreements with affected land users" (RSB 2010, p. 29). Future analysis will be needed to determine whether the RSB's additional criteria lead to fewer infringements of land rights than other sustainability schemes.

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[6] These include the ILO Convention on Indigenous and Tribal Peoples and the UN Declaration on the Rights of Indigenous Peoples.

1.5 Conclusions

The USA and Brazil dominate the Western Hemisphere's ethanol industry. Together with Argentina, they also lead biodiesel production. However, many other countries in the region are rapidly expanding these sectors. This growth has raised concerns about sustainability. There is no generally accepted methodology to assess the sustainability of biofuels in different countries. However, the preceding discussion examined a number of factors that have been raised by multiple initiatives originating from individual nation-states, intergovernmental collaborations, and several MSIs. These include the choice of feedstock and associated cultivation practices, GHG emission reductions, deforestation, soil erosion, abuse of land and labor rights, decreased food security, poverty alleviation, and rural development.

Two biofuel feedstocks are most common in LAC—sugarcane and soybeans. There is broad agreement that sugarcane results in greater GHG reductions than maize-based ethanol produced in North America. Emission reductions from soy-based biodiesel are less certain, particularly when accounting for d/iLUC. Similarly, other dimensions of sustainability are questionable. For example, in the case of Brazil and Argentina, soybean expansion has been linked to deforestation, soil erosion, and a loss of biodiversity (Chaps. 4 and 5).

The chapters in this collection reveal other concerns about the potential sustainability of the region's biofuel industry. These include air pollution from sugarcane burning and water pollution from vinasse (Brazil—Chap. 3); violation of indigenous land rights in Colombia (Chap. 7); isolated cases of poor labor conditions and use of child labor in Brazil (Chaps. 3 and 4); and limited institutional and enforcement capacity in Guatemala (Chap. 8), among others.

Thus, based on the sustainability principles explored above, each of the national biofuels programs examined in this collection are associated with major concerns. Despite this, over 100 individual biofuel feedstock cultivators and refiners have been certified as sustainable biofuel operations (discussed in detail in Chap. 2). However, the implications of this trend remain unclear. On the one hand, these certifications could be seen as a promising development, indicating that despite sustainability concerns at a national level, individual businesses can rise to the challenge and conduct operations in a sustainable manner. On the other hand, the trend may simply reflect market-savvy businesses interested in glossing their operations with an environmentally and socially acceptable sheen in order to access export markets in the USA and EU.

Of course, it is too early to judge whether the biofuel certification schemes and other governance mechanisms that are gaining traction, particularly ISCC, RTRS, and Bonsucro, which represent over three-quarters of certified operations in the LAC region at the time of writing, are sufficiently strong to safeguard against the grave environmental and social impacts which have been raised as concerns.

In addition, regardless of their rigor, certification schemes may not be sufficient to build a culture of sustainability through the region's various national programs. To achieve sustainability at a regional scale, additional governance mechanisms beyond voluntary MSIs will likely be required. One possible approach is that taken by the EU, which has made a number of MSI-based schemes eligible as “qualifying standards” for their own RED program. This creates a strong incentive for biofuel producers to use those standards in order to gain access to the EU market.

Within LAC, national programs that appear to have the greatest potential are the sugarcane-based ethanol programs in Brazil, Colombia, and Guatemala. Sugarcane ethanol is among the most technically efficient feedstocks. Provided LUC is avoided, sugarcane-based ethanol can readily meet GHG emission targets. Careful management can also minimize other environmental impacts, but incentives have to be in place. The same holds true for social objectives. Numerous soy-based biodiesel operations in Argentina and Brazil have also been certified as sustainable, but there are several issues with these crops that raise doubts about whether a broader culture of sustainability can be operationalized in that industry (see Chaps. 4 and 5). For soy-based biodiesel, additional measures should be taken to ensure that the use of crops for biofuels does not result in land-use change, which has been observed in both Brazil and Argentina. Avoiding iLUC in particular is difficult. It is unlikely that the MSI-based sustainability schemes will be effective because of their focus on specific operations. Minimizing iLUC requires broader policy measures to promote cross-sectoral land-use planning and limit deforestation.

Given the continuing debates about biofuel policies, improved estimation of environmental and socioeconomic impacts is essential, along with strong monitoring and verification of performance. Most of the biofuels governance systems require such certification. These requirements are in their early stages, and third-party certification and transparency will be important parts of the process of demonstrating the sustainability of biofuels programs in LAC.

Since most of the biofuels programs in LAC are experiencing similar challenges and share common interests in sustainability, greater regional cooperation is essential. Preexisting regional fora could be used for addressing these issues, such as the Memorandum of Understanding between the USA and Brazil to Advance Cooperation on Biofuels, and the CBI. Once the biofuels certification programs and other governance mechanisms gain experience, additional coordination and technical assistance across the region will be valuable as well.

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Chapter 2
International Sustainability Standards and Certification

Christine Moser, Tina Hildebrandt and Robert Bailis

Abstract Standards have evolved as the major mode of governance for biofuels. In particular, the European Union (EU) policy approach actively employs a variety of voluntary certification standards under its meta-standard in order to safeguard sustainability of its mandated biofuel demand. Advantages and disadvantages of this novel, hybrid governance arrangement have been widely discussed. In order to fully understand the implications of this international governance arrangement, we argue that more research is required to determine the dynamics that evolve in specific contexts as to whether standards come to matter and which. In this chapter, we highlight two macro-level factors of such dynamics—markets and policy—for the geographic focus of this volume: Latin America and the Caribbean (LAC). The current adoption of standards reflects the production and trade patterns of the region. EU sustainability criteria are most relevant for the biodiesel exporting industry in Argentina, while the US standard for greenhouse gas (GHG) savings influences Brazilian ethanol producers. Showing a tendency to minimal compliance, the current standard adoption in Argentina points at problematic dynamics within the EU Renewable Energy Directive (RED) governance arrangement. Weak regulatory and policy frameworks may pose barriers to the uptake of certification standards. Especially in LAC, where biofuel production often developed from already existing flex crop industries, biofuel policy is embedded in multiple sectoral policy areas and historical agrarian structures. The EU's 100 % captive market for certified biofuels is likely to help overcoming this barrier. However, further research is urgently needed as to whether certification in weak policy contexts has complementarity or cosmetic effects.

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2.1 Introduction

Despite their promotion as an environmentally friendly alternative to fossil fuels, the rapid expansion of biofuels from crops set into motion over the past decade has raised numerous concerns about detrimental effects on ecosystems and communities living in and around biofuel production sites (see Chap. 1; German et al. 2011; Lüdeke-Freund et al. 2012). In anticipation of and in response to these effects, public and private actors on different scales have developed regulations, standards, and codes of conduct to mitigate or minimize the negative impacts of biofuels and their production processes (Bailis and Baka 2011). These initiatives reflect a shift from government to governance, which is a phenomenon seen in other primary commodity sectors (Biermann and Pattberg 2012). In this shift non-state actors, for example, standard-setting organizations and auditing firms, assume some responsibility for governing the behavior of producers and/or consumers. However, in contrast to other sectors, in which "non-state market-driven" rulemaking through standards may be explained by a lack of state interest or ability to govern (Cashore 2002), biofuel governance is better characterized as a *hybrid mode of governance*, in which the state remains a central figure, but a greater role exists for private actors and vocal civil-society groups (Swyngedouw 2005; Bailis and Baka 2011).

As a main advantage, certification standards are acknowledged for their potential to transcend nation-state boundaries and thus influence international supply chains to adhere to principles of sustainability, and thus function "as a mechanism in countries with poor abilities to enforce policy" (Diaz-Chavez 2011, p. 5768; cf. Lewandowski and Faaij 2006; Verdonk et al. 2007; Mol 2010; Janssen and Rutz 2011; Scarlat and Dallemand 2011). At the same time, however, there is a necessity to include stakeholders at points of productions in standard-setting processes (Lewandowski and Faaji 2006; Verdonk et al. 2007), to consider their capabilities and interests (Lee et al. 2011; Edwards and Laurance 2012; Romijn et al. 2013), and to account for local practices and physical environments (Khatiwada et al. 2012; Efroymson et al. 2013). While most certification standards relevant to biofuels are "second-generation standards" that have adopted participatory practices in standard-governance and auditing (Ponte and Riisgaard 2011, p. 259), some are not. In addition, the European Union's (EU's) hybrid arrangement includes standards that differ greatly in scope with some representing the minimum set of environmental criteria stipulated by the EU and others addressing a wide range of environmental and social issues.

Given the transnational sphere of influence of these arrangements (Barry et al. 2012, p. 2), sustainability standards set elsewhere are potentially relevant to biofuel production in Latin America and the Caribbean (LAC). The questions we ask in this chapter are thus: What is the relevance of international standards and certification for sustainable biofuel production in the LAC region? In which countries will certification standards help to bridge a 'governance gap'? Which standards might circumvent local stakeholders' interests and needs and where? In fact, little has been said as to whether and how competing standards and certification schemes (come to) matter at all at points of production. In order to understand the efficacy of governance interventions, we need to consider specific contexts. As Pawson frames it, context operates by “constraining the choices of stakeholders” and creating “different pregiven characteristics that leave some well-disposed and some badly-disposed” to benefit from a particular set of institutional arrangements (Pawson 2006, p. 25). Thus, we should ask, “What works for whom in what circumstances?”

This book is focused on the LAC region, where contextually, biofuel development can be viewed as an outgrowth of preexisting agro-industries. Governing for sustainability across the LAC region encompasses a complex array of land use policies, labor laws, and environmental regulations. The political landscape is also populated by peasant movements, labor unions, trade associations, and environmental watchdogs. In some countries, like Peru and Colombia, where drug trafficking remains a source of instability, biofuel crops have even been promoted as alternatives to coca cultivation. Clearly, circumstances vary around the region and local context is an essential factor affecting the viability of governance efforts.

In addition, while this collection includes a chapter on biofuel production in Caribbean states, little information exists about governance in the island nations. This is not surprising, given the relatively small role that Caribbean nations play in the region’s biofuel production. Most of the production that does occur consists of dewatering hydrous ethanol imported from Brazil. As previously mentioned, biofuel industries around the world are highly dependent on preexisting agro-industries to supply feedstock. In the Caribbean region, sugarcane, which is the most likely candidate for biofuel feedstock (see Chap. 10), has been declining for decades. Current production is just one-third of what it had been in the 1980s (FAOSTAT 2013). Thus, our discussion focuses on governance efforts in countries of Central and South America.

This chapter takes a macro-perspective to consider contextual factors that shape the international governance for sustainable biofuels. We frame our discussion in the literature on global environmental governance and draw on research from other areas of social and environmental standards. The latter informs our focus on the two macro-level institutional factors that guide our assessment—markets and regulatory frameworks. Our goal is not to provide a comprehensive review, but rather to highlight some key macro-level contextual determinants that influence whether and how sustainability standards (might) come to matter in LAC.

The chapter begins by introducing the demand side for certification—the transnational, hybrid governance arrangements shaped by EU and US policies as well as multilateral organizations, and the standards and certification systems adopted to safeguard sustainability of biofuels. We argue that *if* international standards and certification matter (i.e., whether they are taken up), will largely depend on the specific biofuel sector characteristics in the countries of the region. We will thus shed light on biofuel industry developments throughout LAC and important characteristics of the region in Sect. 2.3 and contrast these developments with current certification patterns. While Sect. 2.4 then addresses the standards’ approaches to critical sustainability issues of biofuel in LAC, Sect. 2.5 will elaborate on intersections between countries’ legal and policy frameworks and international sustainability standards. The conclusion will summarize and point to further research needs, including more theory building and linkage to results from existing certification research.

2.2 International Approaches to Sustainable Biofuels: Governance through Standards

In this section, we review the various approaches of governance toward sustainable biofuels through standards. Compared to traditional regulation enforced by the state, governance implies the steering of behavior and conduct of others by means of networks consisting of non-state and state actors (Ponte et al. 2011). In the last two decades, standards have come to function as a key tool in governing conduct in more and more areas. Standards can be defined as sets of “specifications and/or criteria for the manufacture, use, and/or attributes of a product, process, or service” (Matus 2009, p. 1). They represent norms by which “people, objects and actions can be judged and compared, and which provide a common language to evaluators, the evaluated and their audiences” (Ponte et al. 2011, p. 1).

Standard setting can be driven by different groups of actors such as governments, civil society, industry, or a variety of these actors together in multi-stakeholder initiatives. Typically, literature distinguishes between standards set by public authority and hence embedded in regulation, and voluntary standards that are often referred to as ‘private’ because they are not rooted in state authority (Ponte et al. 2011). Private actors are perceived to outweigh public actors in determining and monitoring sustainability standards due to a ‘global governance gap’ as state-based and multilateral efforts fail to address environmental and labor issues (Overdevest 2010). In response to this ‘gap’, standards have emerged as critical modes of governance for biofuel production, albeit with substantial overlap between private and public rulemaking: “we witness the emergence of private market environmental authorities, moral environmental authorities and all kinds of hybrid authorities in biofuel regulation” (Mol 2010, p. 61).

2.2.1 Governmental (Meta-) Standards

As major sources of biofuel demand, including exports from the LAC region, the US and EU’s biofuel policies are important frameworks affecting regional biofuel governance. In the USA, the Energy Policy Act of 2005 introduced the Renewable Fuel Standard (RFS), which created biofuel-blending mandates for transport fuels (US Congress 2005, p. 551). The 2007 Energy Independence and Security Act (EISA) raised the annual renewable fuel targets to 136 billion liters by 2022 (57 billion liters of ethanol and 21 billion liters of advanced biofuels by 2015; 79 billion liters of advanced biofuels by 2022; Scarlat and Dallemand 2011). Since 2010, the revised RFS program (or RFS2) requires greenhouse gas (GHG) emission reductions of 20 % for conventional, 50 % for advanced, and 60 % for cellulosic biofuels. RFS2 defines a methodology to assess life-cycle GHG emissions from each fuel pathway, including emissions from indirect land use change (iLUC, see Chap. 1). The US Environmental Protection Agency (EPA) is tasked to implement, monitor, and report all activities related to the program. To this end, the EPA assesses and stipulates feedstock options.

Relevant to LAC producers, ethanol made from sugarcane and biodiesel from soybean oil are considered advanced biofuels. In contrast, palm oil is ruled out as a biodiesel pathway under RFS2 (EPA 2011). EPA assigns renewable identification numbers (RINs) to obligated parties that satisfy their volume obligations for each category of biofuel. RINs provide a proof for compliance and a system of tracking biofuels from production to consumption. Biofuels that do not comply with GHG requirements are not excluded from use, but do not count toward blenders' obligations (Scarlat and Dallemand 2011).[1]

In 2009, the EU adopted the *Renewable Energy Directive 2009/28/EC* (RED) and amended the complementary *Fuel Quality Directive 98/70/EC* through *Directive 2009/30/EC*. The legislation stipulates that by 2020, the share of energy from renewable sources in transport shall reach a share of at least 10 %. For biofuels and other liquid bioenergy carriers, the EU RED provides mandatory sustainability criteria (EU 2009): In order to be counted toward the 10 % target and to be eligible for funding schemes, biofuels were required to prove reduced life-cycle GHG emission reduction of 35 % (increasing to 50 % in 2017 and to 60 % after 2018 for new plants).[2] Unlike RFS, the EU RED does not assess and stipulate eligible feedstock pathways but focuses on production criteria: Fuels produced on land with recognized high biodiversity and carbon stocks and on peatland cannot be counted under the RED. Like the RFS2, the RED does not include social or socioeconomic criteria. The European Commission (EC), however, monitors the origin of biofuels in order to assess production effects in the EU and third countries as well as impacts on LUC, commodity prices, and food security (Scarlat and Dallemand 2011). Reacting to persistent concern about food security, the EC in late 2012 suggested amending the RED such that only 5 % of the 10 % of renewable fuels used in European transport are derived from food crops (conventional or first-generation biofuels). Further, GHG emission reduction requirements shall be increased for new biofuel providers with effect from mid-2014 (EU 2012).[3] Compliance with the RED mandatory sustainability criteria can be demonstrated in three ways: voluntary certification within several qualifying standards, Member State competent authority criteria, or bilateral agreements between the EU and third countries. Member States are to accept standards accepted by the EC.[4] Thirteen such standards, of which we introduce some in the next section, had been accredited at the end of 2012 (EC 2013a).[5]

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[1] The *Low Carbon Fuel Standard* (LCFS): the US state of California takes a different approach, obliging all transport fuel providers to reduce the carbon intensity of transport fuels by 10 % by 2020. To this end, a cap-and-trade system based on reporting has been imposed (Scarlat and Dallemand 2011). The LCFS defines its own GHG calculation methodology based on a life-cycle approach that includes both direct and indirect land use change impacts.

[2] Advanced biofuels made from residues, nonfood cellulosic material, and lignocellulosic material are double-counted, i.e., their contribution against the 10 % target can be considered twice that made by other biofuels.

[3] The suggested amendment is expected to pass through the legislative procedure by the end of 2013 (European Parliament 2013).

[4] In some Member States, sustainability policies and standards were already in place when the RED was finalized (Scarlat and Dallemand 2011).

[5] The 13 schemes are Bonsucro, Ensus, Greenergy, ISCC, NTA 8080, Abengoa RSBA, Red Cert, Red Tractor, RTRS EU RED, RSB EU RED, RSPO EU RED, 2BSvs, and SQC.

The EC itself refers to RED as “the most comprehensive and advanced binding sustainability scheme of its kind anywhere in the world” (EC 2010, p. 1). This regulation can indeed be considered significant as the RED pathway explicitly functions as a meta-standard, recognizing certification schemes as “quasi-implementing agencies” (Biermann and Pattberg 2012). In this way, the EU RED exemplifies hybrid governance by actively blending state authority and private (non-state) actors (Mol 2010; Bailis and Baka 2011). Here, non-state certification standards, which we discuss in the next section, provide assurance that production of biofuels meets environmental requirements by means of assessment, evaluation, and certification through third parties—the certification bodies (Hatanaka et al. 2005).

2.2.2 Voluntary Standards

Voluntary standards have evolved in parallel to standards set by national governments. In this discussion, we differentiate between sustainability standards that require third-party verification (certification standards) and standards provided as guidance norms in multilateral arrangements, but lack any oversight.

Biofuel sustainability standards generated by private actors differ in many aspects, including the actor groups involved in initiating and determining standard setting, focus on certain feedstock vis-à-vis biomass in general, and geographical scope (Table 2.1). In terms of geographic scope, nine of the 13 certification standards recognized under the EU RED are applicable to biofuel production in LAC—the remainder are limited to EU Member States.[6] Critics have noted that the proliferation of standards schemes can be problematic, particularly for the EU’s governance arrangement (van Dam et al. 2010; Scarlat and Dallemand 2011; Soliman and Roggeveen 2012; IEA Bioenergy 2012b). With a lack of harmonization, definitions of key terms (such as forestland or high conservation value) and methodological approaches vary. For producers especially, proliferation imposes complexity and may lead to increased costs in order to demonstrate compliance across inconsistent criteria (Scarlat and Dallemand 2011; Soliman and Roggeveen 2012).

Certification standards also differ in that some focus on specific crops, while others cover bioenergy or biomaterials more generally. Crop-specific schemes for palm oil (Roundtable on Sustainable Palm Oil, RSPO), soy (Round Table on Responsible Soy, RTRS), and sugarcane (Bonsucro) were originally developed for specific markets. As is discussed in Chap. 1, they cover a variety of social and environmental issues. Initially they omitted criteria on GHG emissions, but they have added them in order to gain recognition under the EU RED (Table 2.5).

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[6] Abengoa Bioenergia and Greenergy developed certification standards applicable only for their own supply chains (the RED Bioenergy Sustainability Assurance (RBSA) and the Greenergy schemes) and are not included in this discussion.

Table 2.1 Characteristics of critical voluntary certification standards

	Initiators	Stakeholders/members involved	Scope and status	Adoption worldwide[a]
Round Table on Responsible Soy (RTRS)[b]	WWF, Maggi Group, Unilever, Cordaid, Coop, Fetraf-Sul	150 members: NGO's (11 %); producers (19 %); industry, finance and trade (49 %); observers (21 %)	Global; operational in 2011	31 certificates
Roundtable on Sustainable Palm Oil (RSPO)[c]	WWF, Migros, Unilever, Malaysian Palm Oil Association, Aarhus United UK Ltd	816 members in seven categories: processors and traders (38 %), consumer goods manufacturers (37 %), growers (16 %), retailers (6 %), social NGOs (1 %), environmental NGOs (2 %); banks and investors (1 %)	Global; operational in 2008	871 certificates
Bonsucro (former Better Sugarcane Initiative, BSI)[d]	WWF and IFC (World Bank)	Representatives of 74 members (one representative from each of the five categories): industrial (millers) (39 %), intermediary (supply chain) (34 %), end-users (12 %), civil society/NGOs (10 %); farmers (5 %)	Global; operational in 2010	43 certificates
International Sustainability and Carbon Certification (ISCC)[e]	Initiated and facilitated by Meo Carbon Solutions consulting and funded by the German Federal Ministry of Agriculture (BMELV)	65 full members today: biomass producers and processors; trade, logistics, and user; NGOs, social sector, science and research, public sector	Global; operational in 2010	1489 certificates
Roundtable on Sustainable Biomaterials (RSB)[f]	Swiss EPFL (École Polytechnique Fédérale de Lausanne) Energy Center	98 members organized in three different chambers and seven categories: farmers and growers (15 %), producers (21 %), retailers; transportation industry and banks (10 %), rights-based NGOs (4 %), rural development organizations (7 %), environmental organizations (16 %); IGOs and governments (26 %)	Global; operational in 2011	7 certificates

Table 2.1 (continued)

	Initiators	Stakeholders/members involved	Scope and status	Adoption worldwide[a]
The Netherlands Technical Agreement—NTA 8080/81[g]	The Netherlands Standards Institute (NEN) (based on Cramer Criteria)	22 members: NGO (14 %), government (9 %), power companies (18 %), universities (5 %), produce (5 %), industry (50 %)	Global; operational in 2011	26 certificates
Biomass Biofuels voluntary scheme (2BSvs)[h]	Associations representing the French biofuel industry (crop producers and downstream clients) and auditing firm Bureau Veritas as technical advisor	Seven French consortium members—large French corporations and agricultural cooperatives	Global imports; operational in 2011	625 certificates

Where information from websites was incomplete further information was obtained by addressing standard organizations directly

[a] In certificates issued as of July 2013

[b] www.responsiblesoy.org/

[c] www.rspo.org/

[d] www.bonsucro.com/

[e] www.iscc-system.org/

[f] http://rsb.org/

[g] www.sustainable-biomass.org/

[h] http://en.2bsvs.org/

Among the actors engaged in drawing up bioenergy standards are governmental organizations (e.g., in the case of NTA 8080 and International Sustainability and Carbon Certification, ISCC), industry associations (e.g., in the case of 2BSvs), single companies (e.g., Greenergy and Abengoa Bioenergia), and multi-stakeholder roundtable initiatives (e.g., Roundtable on Sustainable Biomaterials (RSB), RSPO, Bonsurco, and RTRS). Although initiated by governmental agencies in Germany and the Netherlands, ISCC and NTA 8080 have both consulted stakeholders in determining sustainability criteria and indicators.

Standard organizations have held stakeholder meetings in the LAC region to include regional perspectives (e.g., RSB 2013b). To account for the contingencies raised by local context, the RTRS and RSPO provide for "national interpretations" of their standards based on the inputs from civil society and commercial groups who convene to agree on country-specific criteria and indicators (Johnson 2012). The RTRS has been interpreted on a national level in Argentina, Brazil, and Uruguay; Bolivian and Paraguayan interpretations are yet to be completed (RTRS 2013c). Colombia has concluded such a national interpretation of the RSPO, while Ecuador is in the early stages of the process. Aside from the integration in national contexts, the RSPO also created the "local interpretation" mechanism which can be applied by single companies to interpret and adopt—in consultation with local stakeholders—RSPO criteria and indicators. One Guatemalan, one Brazilian, and one Colombian company have seized this opportunity so far (RSPO 2013b). Sustainability standards arising from multi-stakeholder initiatives indeed have been recognized for increasing legitimacy and potential democratic credentials based on such instruments of consensus (Pattberg 2012; Mol 2010). Yet, exactly these deliberative structures have been criticized because they may enable certain stakeholders to gain disproportionate influence and focus attention on certain topics, leaving other issues unaddressed (Chap. 7; Elgert 2013; Johnson 2012; Schouten et al. 2012).

Another approach, led by Germany and Brazil, is where the International Standardization Organization (ISO) is currently developing ISO 13065 for sustainable bioenergy. Involving 35 observing and participating countries, the ISO aims to "create globally harmonized sustainability criteria" and to provide "a level playing field for all countries and stakeholders" (ISO 2011). Results of the process in the form of a draft standard are expected in 2014 (Dale et al. 2013).

Many multilateral agencies have also weighed in on biofuel sustainability. As a result, a multitude of frameworks, guidelines, and toolkits to safeguard or assess sustainability in biofuel production have been developed, but are not intended to provide certification. On an international level, the *Global Bioenergy Partnership* (GBEP) coordinated agreement on a list of 24 sustainability indicators to guide national efforts in bioenergy sector development (Scarlat and Dallemand 2011). Endorsed in November 2011, this list could also serve as a base for voluntary implementation. In LAC, Colombia has pilot-tested the GBEP criteria (see Chap. 7).[7] Similarly, the "Bioenergy and Food Security Criteria and Indicators" (BEFSCI) was developed by the United

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[7] Argentina, Brazil, Colombia, Mexico, and Paraguay have GBEP member status, while Chile, El Salvador, and Peru are participating as observers (GBEP 2011).

Nations Food and Agriculture Organization (UN FAO) to inform national bioenergy frameworks on how to prevent threats to food security. FAO also joined forces with UNEP to establish the "Bioenergy Decision Support Tool" (Fritsche 2012).

Specifically targeting the LAC region, the Inter-American Development Bank (IADB) developed the *Biofuels Sustainability Scorecard*. Launched in 2008 and revised in 2009, the Scorecard is based on sustainability criteria of the RSB and provides a tool to understand, oversee, and possibly track the range of complex issues associated with biofuel production and use. The Scorecard is designed for use at the project level, and addresses social, environmental, and economic issues of sustainability as well as crosscutting governance aspects (Janssen and Rutz 2011).

These multiple efforts have led to a fragmented network of actors and a multitude of partly independent, partly interconnected standards. At one level, there is an incentive for each group of stakeholders to work with meta-standards like the EU RED because participation will likely increase adoption rates of their standard. The RED has also forced some convergence between schemes and EU Member States' approaches. For example, crop-based standards like RTRS and RSPO defer to the EU's requirements of 35 % GHG emission reductions. The RED also works as a binding force between the standards as the regulation encourages mutual recognition among the standards. Subsequently, for example, the ISCC under its EU standard recognizes all other RED-accepted standards. Mutual recognition among standards is not limited to biofuels, indirectly linking additional standards into a broader network. For example, the RED-accepted RSB recognizes agricultural and forestry standard schemes like SAN/RA and FSC (SAN 2012), which are not qualifying RED standards. Similarly, the ISCC accepts FSC and PEFC certificates as proof of sustainable wood production (IEA Bioenergy 2012b). Further mimetic effects can be observed among voluntary standards; for example, the IADB adopted RSB criteria for its scorecard.

Whether international approaches to sustainable biofuels will be applied in the LAC region will largely depend on the specific biofuel industry characteristics such as the feedstock processed, the industry size, and its export orientation. The following section focuses on production and trade in the region and assesses which sustainability schemes have yet been adopted in LAC countries.

2.3 Biofuel Production, Trade, and Certification in LAC

Biofuel and bioenergy support policies in the EU and the USA indubitably had a tremendous effect on the global production and trade of biofuel within the last decade (Lamers et al. 2011). Thus, biofuel markets worldwide are expected to also be increasingly impacted by the sustainability criteria embedded in the US and European policies (OECD/FAO 2012). However, the reach and impact of the sustainability issues that are addressed in biofuel governance and certification in regions like LAC remain unclear. Research on environmental and social standard setting in other sectors finds that uptake depends on macroeconomic factors such as high export rates (to Europe and the USA), foreign direct investments, and per capita income, as well as trade (Guler et al. 2002; Delmas 2002; Neymayer and Perkins 2004; van Kooten et al. 2005; Potoski and Prakash 2004; Durst et al. 2006). As shown in the previous section, the EU established a regulatory regime of adopting a "governance through standards" (Ponte et al. 2011) approach. Certification thus becomes a trade-related pressure for feedstock and biofuel producers targeting the EU's "100 % captive markets for sustainable biofuels" (Ponte 2012), taking on the role of global quasi-implementing agents of an EU policy (Levidow 2013).[8] A similar, albeit narrower, picture is drawn for imports to the USA. GHG emission reductions achieved by a given fuel pathway are set by the EPA. These rulings define the feedstocks and fuels that reach US markets from biofuel producers in LAC (OECD/FAO 2012).

Assuming that trade drives certification in the international biofuel industry, the following section focuses on the economic parameters of the biofuel and feedstock development in the LAC region. Production- and trade-related data help us to understand where biofuel standards and certification may be of particular relevance. The discussion is enriched through an assessment of the current status of standard uptake in the region.

2.3.1 Characteristics and Current Developments of Biofuel Production and Trade in LAC

In the last decade, Latin American countries, in particular, witnessed large investments and numerous governmental plans to enhance biofuel production (Rutz et al. 2008; van Gelder et al. 2012). The demand for biofuels is largely a result of blending targets or mandates implemented in recent years by national governments around the world including many countries in the LAC region itself (Table 2.2). Most countries have established blending mandates or targets for both ethanol and biodiesel. In the majority of cases, however, the biofuel production remains below the target (Diop et al. 2013; OECD/FAO 2012).

The major biofuel feedstock in LAC are the so-called "flex crops," which are agricultural commodities that have multiple or flexible uses in diverse industries, including food, feed, and industrial applications as well as fuel (Borras et al. 2012). Soy, sugarcane, oil palm, and maize are the most prominent examples of flex crops used in LAC to produce biofuel, all fit this description to some degree. As this collection of chapters shows, the region's biofuel industries are outgrowths of preexisting agro-industries. Sugarcane, soybean, and oil palm complexes each have diverse historical trajectories. Sugarcane cultivation, for example, dates to the early colonization of the region by the Portuguese and Spanish (Abbot 2009). Soybeans, grown primarily in Brazil and Argentina, are intimately linked to the regions' enormous cattle complex, as well as rapidly growing demand for high-protein animal feeds in the EU and China. These links can explain both the rapid expansion of biofuel investment

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[8] Given existing rulings under the World Trade Organization (WTO; Bernstein and Hannah 2008; Ackrill and Kay 2011), it is noteworthy that sustainability criteria addressing biofuel production (and not biofuel as a product) have not been challenged. However, Argentina, Brazil, and Colombia have warned the EU that they may file a complaint (Janssen and Rutz 2011).

Table 2.2 Biofuel targets and mandates in the LAC region

Country	Mandate
Argentina[b,c]	E5 and B7 mandates are in place. The B7 mandate increased from B5 in 2010. There was an intention to reach B10 blending by October 2012, but it was postponed. The new goal is to reach 10 % by July through a gradual increase (e.g., see Chap. 5)
Bolivia[b]	B2.5 and E10 mandate in place
Brazil[b]	Mandates a minimum ethanol content of 18–20 %. This was reduced from 25 % in 2011 when ethanol supplies tightened due to rising global sugar prices. Currently there is a B5 mandate (e.g., see Chap. 4) but the industry is overcapitalized, with 60 % of the installed capacity currently idled. The industry is calling for an increase to B7 in 2013, building to B10 in 2014 to utilize this excess capacity. Longer-term objectives are B20 by 2020
Chile[a]	Voluntary E5 ethanol and B5 biodiesel targets in place, but not mandatory
Colombia[b]	E8-10 ethanol mandate in place since 2008, with discussions underway to increase the mandate, biodiesel mandate in place B10 (e.g., see Chap. 7)
Costa Rica[b,c]	E7 and B20 mandates in place
Dom Rep[b]	E15 and B2 mandate in place
Ecuador[b]	Targets of B2 by 2014 and B17 by 2024; E5 pilot programs implemented in several provinces
Guatemala[b,c]	E5 mandate introduced (e.g., see Chap. 8)
Jamaica[a,b,c]	E10 mandate (e.g., see Chap. 10)
Mexico[b]	E2 "soft" ethanol mandate in place in the state of Guadalajara, which was to be expanded to Mexico City and Monterrey in 2012, though program has stalled (e.g., see Chap. 9)
Panama[b]	Preparing to introduce an E2 mandate in April 2013, rising to E5 in 2014, E7 in 2015 and E10 by April 2016
Paraguay[b,c]	E24 and B1 mandates in place
Peru[b,c]	Mandates of E7.8 and B5 in place. Expected to move toward B5 (e.g., see Chap. 6)
Uruguay[b,c]	B5 mandate in place

[a] Adapted from Lane 2012
[b] Adapted from REN21 2013a
[c] Adapted from REN21 2013b

in LAC as well as the slow pace with which some of the blending mandates have been met. The latter is the result of high feedstock prices on global markets that have hampered the development of a biofuel industry in some countries of the region in the last few years (OECD/FAO 2012). Linkages between intermediate- and end-use sectors and varying degrees of complementarity and substitutability between each feedstock increase consumer vulnerability to price fluctuations (Diop et al. 2013).

Moreover, independently of the further use of the crop, both soy and sugarcane have been implicated in LUCs and problematic land appropriation in Brazil and Argentina (Borras et al. 2012). Despite the potential negative impacts of increased reliance on flex crops, these crops also have certain advantages. For example, they increase flexibility and allow producers to adjust to potentially volatile market conditions (Borras et al. 2012; Diop et al. 2013). Thus, it is no surprise that a significant amount of investments in Latin America is found in the flex crop production (van Gelder et al. 2012).

Table 2.3 Biofuel production and trade in Argentina and Brazil (in million liters). (Sources: Currently, data on the adequate amount of biofuel production and trade statistics in developing countries are lacking (Diop et al. 2013; Lamers et al. 2011), numbers fluctuate regarding the source used. This table is based on data from USDA (Barros 2012; Joseph 2012a) and updated with data published by the INDEC (National Statistics and Census Institute Argentina))

		Ethanol[a]				Biodiesel			
		2010	2011	2012	2013[b]	2010	2011	2012	2013[b]
Brazil	Production	24,516	20,212	19,970	22,500	2,386	2,673	2,700	2,760
	Consumption	22,167	19,290	20,000	21,700	2,462	2,613	2,691	2,772
	Export	562	1,083	1,000	1,000	8	6	0	0
Argentina	Production	122	170	251	400	2,050	2,742	2,774	2,800
	Consumption	118	166	237	390	573	848	987	1,300
	Export	0	0	0	0	1,535	1,900	1,759	1,500

[a] Numbers are exclusively for fuel usage, ethanol production and consumption for all uses are around 10–13 % higher

[b] Estimated

As outlined in Chap. 1, there are significant differences in the way biofuel production and consumption have developed in the region. Overall, Argentina and Brazil present the only established fairly export-oriented biofuel industries in South America (OECD/FAO 2012). Brazil dominates global fuel ethanol production together with the USA (Lamers et al. 2011) producing most of its ethanol for domestic markets (Barros 2012). Compared to local consumption, only relatively small amounts of ethanol are exported (Table 2.3). In 2012, most ethanol exports arrived in the USA, and smaller amounts went to other countries such as Japan, South Korea, Jamaica, and the Netherlands (Barros 2012). Hence, the US EPA's provision regarding GHG emissions appears to be more relevant to Brazilian ethanol production than European sustainability criteria at the moment.

Brazil is also the second largest producer of soybeans, after the USA (FAOSTAT 2013); the major flex crop used for biodiesel production accounts for 77 % of all biodiesel in Brazil (Zimmerman 2013). Given that soy is also a fundamental staple food item in the Brazilian diet, the soybean and oil production are observed by the government: The biodiesel blending target of 5 % will only be increased if the soybean production can supply both, the food and industrial sectors to prevent inflationary pressures (Zimmermann 2013). This might be one of the reasons why the biodiesel production remains far below the ethanol production (2,700 million liters in 2012, see Table 2.4). Currently, Brazil's biodiesel production only covers the domestic demand and is not exported (Barros 2012).

This is different for soy as raw material: Soybeans are mostly exported to China (over 70 % of all exports) and around 16 % to the EU. Thus, Brazilian soybean exporters (also) targeting European biofuel suppliers might need to prove compliance with the RED criteria. Soybean oil is mainly exported to China and India (Zimmermann 2013).

Even though Argentina has also built an ethanol industry (Table 2.3), compared to Brazil the Argentine ethanol sector is much smaller but still growing (Joseph 2012a). Argentina's ethanol industry so far relies on sugarcane exclusively, but corn is on the rise here (also in Brazil, Babcock and Carriquiry 2012). In 2013, roughly 30 % of the total ethanol volumes are expected to be corn-based. Ethanol is not expected to be exported in the near future, because domestic demand is given priority (Joseph 2012a).

While Brazil dominates the ethanol industry, Argentina leads the biodiesel exports. Being among the largest biodiesel producers worldwide, the country relies mainly on soybean oil; 40 % of all soybean oil produced is processed to biodiesel. Besides implementing a B7 mandate (Table 2.2), the government incentivizes the biodiesel industry through reduced taxation of biodiesel exports compared to exports of soybean oil (Joseph 2012a). Exporting 60 % of its biodiesel (1.7 billion liters in 2012), Argentina used to mainly target the EU, specifically Spain.[9] Evidently thus, EU-RED sustainability criteria and certification would be relevant to soy and biodiesel producers in Argentina. In mid-2012, however, Spain closed its market, prohibiting imports of biodiesel from outside the EU. Further, the EU recently imposed temporary antidumping taxes of between 6 and 10 % on biodiesel imports from Indonesia and Argentina (EC 2013b), which is being opposed by Argentina (Chap. 5). The dispute is ongoing and Argentina recently lodged a complaint with the World Trade Organization against the EU. As it is currently not profitable for Argentina, exports to Europe have halted. Against this background, forecasts predict a drop of Argentina's exports from 3000 million liters to 2800 million liters by the National Statistics and Census Institute Argentina (INDEC, Joseph 2012a). Meanwhile the country is in search of new markets such as Peru and the USA.

In order to avoid restrictions on their strong export industry, both Argentina and Brazil closely monitor other countries' trade-related import policies, including sustainability criteria. Because EU markets are important for biodiesel producers in Argentina, the RED ruling is particularly relevant to soy production. In 2012/2013, Argentina has challenged the RED quasi-mandatory restrictions by providing evidence regarding the minimum GHG emission savings of its soybean oil in a study prepared by its Agricultural Research Institute (INTA). According to the study results, widespread no-tilling practices and short distance from farms to processing facilities imply that Argentine biodiesel meets the EU's GHG emission threshold (Joseph 2012a). In addition, the Argentine Chamber of Biodiesel established the voluntary CARBIO Sustainability Certification Scheme (CSCS). So far, neither of the two measures has been officially recognized by the EU. In the USA, Argentina's soy-based biodiesel is currently assessed for an EPA approval to be awarded Renewable Identification Number (RIN) alternative fuel credits, which prove that US importers and refiners are meeting the biofuel standards for biodiesel blending (Biofuel Industry News 2013). Initially, Brazilian sugarcane ethanol was penalized by the US RFS for exceeding iLUC thresholds although it was recognized under its "conventional biofuel" category (Bailis and Baka 2011). Finally, due to significant industry pressure, Brazilian cane-ethanol even qualified as "advanced biofuel" as reanalyzes of iLUC associated led to downward corrections of values by 93 %. Further pressure is raised on Brazil and Argentina by proposals in the USA and the EU in 2012 to put a cap on food-based biofuels in their biofuel policies. This insecurity might intensify the already declining EU investment projects due to today's high

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[9] Spain imported around 1 billion liters in 2011 (Joseph 2012a).

grain and oilseed prices and the lack of success to date with *Jatropha* (Babcock and Carriquiry 2012; Wahl et al. 2012).

Colombia does not quite reach Argentina's and Brazil's production quantities, but the country has reached ground building a biofuel industry since 2002. Due to granted tax incentives by different states when buying less productive land (Pacheco 2012; Pinzon 2012), some of the largest palm oil plantations in Latin America are nowadays based in Colombia, which has led to palm oil exports. Colombia produced around 537 million liters of biodiesel from palm oil in 2011, which the country does not export yet. In addition, local sugarcane production is fairly high. Being among the largest ethanol producers worldwide, the country produced around 351 million liters of ethanol and is predicted to produce 410 million liters in 2013. Colombia is close to reach its mandated B10 and E8-10 levels (Table 2.2) and has set its biodiesel blending target for 2015 even higher, to 20 %. Due to the strong buildup efforts of the biofuel industry, Colombia is expected to become a biofuel exporter in the medium term (Pinzon 2012).

Some of the remaining countries in the region show nascent developments or at least potential to develop a biofuel industry. Potential is seen in these countries due to their profitable feedstock industry, policy attempts such as strong governmental subsidies, or because they have taken first steps toward a biofuel industry by building biofuel plants. Ethanol industries emerge, for example, in Peru where 220 million liters of ethanol made from sugarcane were produced in 2012 (Janssen and Rutz 2011; Nolte 2012). In 2013, Peru is predicted to export around 129 million liters of ethanol. Lately, Peru exported mainly to the Netherlands. An ethanol industry based primarily on corn developed in Paraguay, with 180 million liters of ethanol production being expected in 2013 (Joseph 2012b). In addition, Guatemala currently exports small amounts of ethanol from sugarcane, mostly to Europe (Tay 2012). Through the Caribbean Basin Initiative (CBI) development program, initially launched in 1983, Caribbean nations have a duty-free access to the US market (see Chap. 1). This has led to reprocessing of Brazilian fuel in the Caribbean, especially in Jamaica, to benefit from tax-free imports. Besides Jamaica, also the Dominican Republic has a large ethanol plant. In addition, El Salvador, Costa Rica, Trinidad and Tobago, and the US Virgin Islands have exported smaller amounts of ethanol under the CBI. Lately, the Bahamas replaced Jamaica in ethanol exports to the USA (Ribando et al. 2010).

For biodiesel, several Central and South American countries have begun to rely on African oil palm. Guatemala and Honduras have favorable conditions and high yields of palm oil cultivation to potentially build a biodiesel industry in the near future (Janssen and Rutz 2011; Tay 2012). Honduras owns several extraction plants appropriate for biodiesel production and the topographic conditions are well suited to grow African oil palm. Up until now, Honduras rather exports palm oil to food markets because of the high prices achieved on international market (Gomez 2012). Peru established a small palm oil-based biodiesel industry, but most biodiesel is imported for domestic consumption (Chap. 6 and Nolte 2012). In the past, palm oil has also been the basis in sporadic and small exports of biodiesel from Ecuador (Vega 2012; Pacheco 2012) and could become relevant in Panama (Guardia 2013). With the aim of substituting refined soybean oil in the food industry in order to allocate more soybean oil for biodiesel, significant investments in oil palm as a third flex crop have occurred in Brazil lately (Barros 2012).

Table 2.4 Voluntary certification standards adoption in LAC countries

	No. of certified entities						
	RSB[a]	ISCC[b]	2BSvs[c]	RSPO[d]	RTRS[e]	Bonsucro[f]	Total
Argentina	–	19 (17 RED)	58 RED	–	12 (5 RED)	–	89 (80 RED)
Brazil	–	9 (7 RED)	2 RED	4	9 (1 RED)	36 (27 RED)	60 (37 RED)
Chile	–	1 RED	–	–	–	–	1 RED
Colombia	–	–	–	2	–	–	2
Costa Rica	–	3 RED	–	–	–	–	3 RED
Guatemala	–	6 RED	–	–	–	–	6 RED
Panama	–	1 RED	–	–	–	–	1 RED
Paraguay	–	3 (2 RED)	2 RED	–	1	–	6 (4 RED)
Peru	1 RED	1 RED	–	–	–	–	2 RED
El Salvador	–	–	–	–	–	–	–
Mexico	1 RED	–	–	1	–	–	2 (1 RED)
Nicaragua	–	3 RED	–	–	–		3 RED
Uruguay	–	1 RED	–	–	1	–	2 (1 RED)
Total	2 RED	47 (42 RED)	62 RED	7	23 (6 RED)	36 (27 RED)	177 (139 RED)

The abbreviation RED marks certificates that qualify under the EU-RED meta-standard. Numbers include single operators certified (usually feedstock producers or mills/first gathering points) as well as chain of custody certifications which include several operators in a production chain

[a] RSB 2013d

[b] ISCC 2013a

[c] 2BSvs 2013

[d] RSPO 2013a

[e] RTRS 2013a, b

[f] Bonsucro 2013

Against this backdrop, it is reasonable to assume that adoption of international biofuel standards and certification—to the extent that it is driven by trade—at the moment is likely to occur mostly in export-oriented countries such as Brazil (ethanol), Argentina (biodiesel), and to a lesser extent in Guatemala and Peru (ethanol). However, to the extent that feedstock producers interact flexibly with international food, feed, and fuel markets, certification could also become relevant to feedstock-exporting countries such as Argentina and Brazil (soybeans, soybean oil, and sugar), Colombia and Honduras (palm oil), and many others (Zezza 2013). In addition, intraregional expansion of flex crop cultivation and biofuel production chains—for example, Brazilian producers expanding to Paraguay and Bolivia (Borras et al. 2012)—may make international standards relevant in these countries, too.

2.3.2 *Current Status of Standard Adoption in LAC*

In this section, we now examine the degree to which sustainability standards have made inroads in the LAC region. To this end, we have collected data of standard adoption, i.e., the numbers of certificates issued in LAC countries in February and July 2013. Table 2.4 presents the adoption of certification standards across the LAC region at the time of writing (July 2013).[10] We identify those certificates that qualify under the EU-RED meta-standard specifically. While we cannot relate these data to figures of total production volumes, they are helpful for depicting trends, especially in comparison to each other.

Unsurprisingly, by far the majority of certification activities are found in Argentina (89 in total, 80 of which are EU-RED compatible), followed by Brazil (57 in total, 41 EU-RED compatible). Among the schemes, 2BSvs (62 certificates) and ISCC (47 certificates, of which 42 apply to biofuel chains) are the most prevalent ones. RTRS, with 12 certificates, nine of which are linked to biofuel production, is the third most popular in Argentina. In Brazil, the sugarcane-specific Bonsucro standard is the most relevant at the moment with 36 certificates (27 RED compatible). RTRS and ISCC follow with nine certificates issued by each; however, only one RTRS certificate and seven ISCC certificates apply to biofuel chains. In her assessment of biofuel certification in Brazil, Zezza (2013) finds that certification demand there stems mostly from sugar-sourcing food industries as well as emerging bio-plastics markets.

The patterns of adoption reflect the distribution of biofuel (feedstock) production and trade in the LAC region also: For Paraguay and Guatemala, we count six certificates each. In Guatemala, all six are ISCC-certified ethanol producers. In Paraguay, three ISCC and two 2BSvs certificates have been issued to US-based agribusiness giants ADM and Cargill (ADM holds certificates of compliance with both standards), and one domestic soy producer holds an RTRS certificate (nonbiofuel). Nicaragua and Costa Rica follow with three ISCC certificates, each for sugarcane production. With two RSPO certificates that are not compatible with the EU's RED standard, Colombian adoption may still confirm palm oil trade as a driver. Despite its large volumes of biofuel production, biofuel chain certification may lag because Colombian flex crop and biofuel productions do not (yet) cater to foreign markets. Peru (for sugarcane and ethanol), Uruguay (for soy), and Mexico (for *Jatropha* and palm oil) each holds two certificates. Finally, Chile holds an ISCC certificate for biofuels from waste.

While the 2BSvs thus has the highest level of engagement, the ISCC standard is more widespread in the LAC region. Awareness of the RSB is high among practitioners as well as researchers (e.g., International Energy Agency (IEA) Bioenergy 2013; Fortin 2011), but the number of operators seeking certification under the RSB is strikingly low. Most ISCC-certified entities operate in either the soy and to a lesser extent in sugarcane chains (others include, e.g., canola, cassava, and corn). 2BSvs-certified entities are mainly involved with soy, sunflower, and corn producers, but also include wheat, sorghum, and sugarcane producers.

Among the crop-specific schemes, Bonsucro and RTRS are the most prevalent in the region, and the levels of engagement with these schemes are the third and fourth highest in the region (23 and 36). Reflecting their leadership in soybean and sugar production, Argentina hosts the largest number of RTRS certifications and Brazil leads in Bonsucro certifications. In a related point, the RSPO standard appears to

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[10] As the NTA 8080 scheme has not seen any entities certified in the LAC region at all so far, it has been excluded from this table.

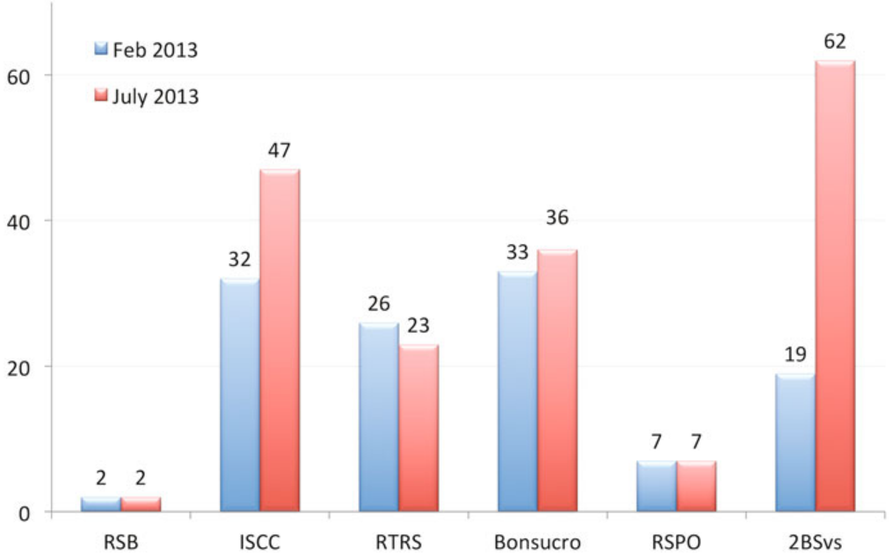

Fig. 2.1 Comparison of certification standard adoption in LAC in February and July 2013. (Sources: RSB 2013d; ISCC 2013a; 2BSvs 2013; RSPO 2013a; RTRS 2013a, b; Bonsucro 2013)

have attracted much less interest than other crop-specific schemes despite constituting the main biodiesel feedstock in Colombia as well as Peru (Chap. 6). This may be due to several factors including the larger role of soy and sugarcane in the region's biofuel industries. In addition, the RSPO was included relatively recently as a RED qualifying standard (in late 2012); currently, the standard does not certify production that was started after January 2008 compliant with the RED.

Interestingly, the region had witnessed great dynamics in standard adoption during the time of our investigation (see Fig. 2.1). In February 2013, Bonsucro (33), ISCC (32), and RTRS (26) had the leads in terms of numbers of certificates issued, followed by the 2BSvs (26). Overall certification adoption figures were similar in Argentina (48) and Brazil (45). Meanwhile, the 2BSvs has more than tripled its presence in the region, especially in Argentina, while other schemes grew more slowly or not at all (RSPO and RSB; although the RTRS even shows slightly lower presence, fluctuations may be because of outstanding website updates).

This development is likely to be linked to two factors: The first refers to the way standard organizations strategically interplay with industry characteristics. At the beginning, only crop-specific schemes catered to the increasingly important role of sugarcane and soy as flex crops in the regional "food–feed–fuel complex" (Borras et al. 2012; Bailis and Baka 2011).[11] Primarily addressing food sectors, RTRS and

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[11] For example, Borras et al. (2012) attribute the rapid expansion of these "flex crops" in such diverse countries as Argentina, Bolivia, Brazil, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Guatemala to "recent changes in the global food-energy regime" (p. 17).

Bonsucro were initiated before the EU-RED mandate was finalized. The RTRS, Bonsucro, and RSPO count national industry and trade associations among its founding members. Having become RED-qualifying schemes, they serve dual purposes. This flexibility may make schemes more attractive for producers and investors (Borras et al. 2012). Meanwhile, the ISCC expanded its certification scheme to include food, feed, technical, and chemical sectors as well as bioenergy under the ISCC Plus standard (ISCC 2013b), which may allow them to better meet demand for certification among the many entities in the LAC region participating in flex crop production. The RSB took a similar step in early 2013, changing the name of their program from the *Roundtable on Sustainable Biofuels* to the *Roundtable on Sustainable Biomaterials* and opening their certification scheme to biochemicals, textiles, and food additives.

It can be assumed that the rapid growth and overtaking of 2BSvs are due to a second factor that concerns the relationship between standard content, standard governance, and competition (Ponte and Riisgaard 2011). Our examination suggests that in the biofuel production industry-driven standards (ISCC and 2BSvs) are more successful than more inclusive roundtable initiatives. In fact, the standard considered most inclusive and comprehensive, the RSB, is the least successful, while the purely industry-led 2BSvs, which also covers only the EU-RED minimum criteria, is the most successful (see Table 2.5). On the other hand, ISCC and RSB cover a similarly wider range of criteria. The major difference between these two schemes lies in the extent of participatory inclusion of stakeholders in standard setting and governance. In this regard, the ISCC might be perceived as more efficient and thus more appealing to producers (Ponte and Riisgaard 2011). In line with institutionalist rationale (Cashore 2002), German and Schoneveld (2011) assume that the RSB will be used mostly by entities that are aligned with the norms espoused by the principles. Similarly, Upham and colleagues argue that the types of stakeholders involved in RSB and ISCC affect the choice of large biofuel or feedstock producers in particular, and that legitimacy (understood as participatory inclusion) may not necessarily translate into uptake and compliance:

> In Europe, it may also be that the voluntary Roundtable on Sustainable Biofuels certification scheme, as the initiative that is perhaps the most inclusive, responsive to NGO and small producer concerns and explicit in acknowledging Northern over-consumption and indirect land use change, may achieve wide and widest legitimacy. On the other hand, large producers may prefer the familiarity of, for example, ISCC's nonprofit company status coupled with a lack of close NGO involvement at a governance level. (Upham et al. 2011, p. 2676)

Furthermore, the fact that the 2BSvs expanded almost exclusively in Argentina may also be linked to a comparatively divergent awareness for sustainability issues. Like in Brazil, biodiesel in Argentina is also based on soybean oil. However, the Argentine industry appears to be perceived less critical regarding its impact on land use and deforestation than the Brazilian industry although there is evidence that in Argentina, too, soy expansion occurred at the expense of native forests (HLPE 2013) and public health due to the use of agrochemicals.[12]

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[12] Contrary to patterns in Brazil and elsewhere, expansion of agricultural frontiers into the Argentine Chaco was driven by agri-business directly, not by poor farmers (Tomei et al. 2010).

Table 2.5 Overview of sustainability aspects covered in relevant sustainability standards with a focus on LUC, land rights, and food security. (Sources: EPA 2010; EU 2009; RSB 2010; ISCC 2011; RTRS 2010; RTRS 2013d; RSPO 2013c; Bonsucro 2011; RSPO 2012; Bonsucro 2011; 2BSvs 2012)

	EU RED	US RFS	RSB EU RED	ISCC EU	RTRS EU	Bonscuro EU	RSPO EU	2BSvs
GHG emissions	35 % (increasing to 50/60 % in 2017/18), incl. from dLUC	20/50/60 % depending on fuel type, incl. from dLUC and iLUC	50 % incl. from dLUC	According to EU RED	According to EU RED	According to EU RED	According to EU RED	According to EU RED
Conservation/ LUC	After 1 Jan. 2008, no production on land with high biodiversity value (primary forest, other wooded land; designated HCV areas); highly biodiverse grassland; land with high carbon stock (e.g., forested areas, wetland); land that was peatland; limited exploitation of designated HCV areas, high carbon stock land, peatland	–	EU-RED criteria; conduct screening of local/regional/global conservation values and assess impact if necessary, no conversion without screening; maintain/enhance affected ecosystem functions; protect/restore/create ecological corridors and buffer zones; prevent invading species	EU-RED criteria	EU-RED criteria[a]; after May 2009, no use of land cleared of native habitat except for if in accordance with RTRS maps; in case of no maps: land used for agriculture/pasture for 12 years before 2009; no conversion of native forests; no use of protected or HCV native habitats; maintain on-site biodiversity and natural vegetation	EU-RED criteria; assess impacts on biodiversity and ecosystems services (incl. HCV identification); no conversion of HCV areas after 1 Jan. 2008 establish environmental management plan to mitigate adverse impacts	EU-RED criteria[a]; assess environmental impacts incl. endangered species and HCV areas; establish environmental management plan to mitigate negative impacts; no conversion of primary forest or any designated HCV area after Nov. 2005	EU-RED criteria

Table 2.5 (continued)

	EU RED	US RFS	RSB EU RED	ISCC EU	RTRS EU	Bonscuro EU	RSPO EU	2BSvs
Soil	−	−	+	+	+	+ (no core criterion)	+	∼
Water	−	−	+	+	+	+ (no core criterion)	+	∼
Air	−	−	+	+	+	+	+	∼
Waste	−	−	+	+	+	+	+	−
Land tenure/ rights	−	−	Asses formal/informal land and land use rights prior to any land use; FPIC is basis for any transfer of any rights to land (use) and compensation	Identify and respect existing land rights; proof legal land use and secured traditional rights	Demonstrate legal, uncontested rights; avoid/resolve conflicts with traditional land uses; FPIC is basis for transfer of any rights to land	Demonstrate legal, uncontested rights; (no core criterion)	Demonstrate legal uncontested rights; FPIC is basis for transfer of any rights to land (use)	−
Human rights	−	−	+	+	−	+	+	−
Labor rights/ conditions	−	−	+	+	+	+	+	∼
(Local) food security	−	−	Assess risks to regional/local food security and mitigate negative impacts in food insecure regions; enhance local food security of directly affected stakeholders	No replacement of staple crops; local food prices do not rise as a direct effect (minor must)	−	−	−	−
Rural/social development	−	−	+	+	+	−	+	−

+ included, ∼ recommended, − not included; equal marks do not imply equal rigor and enforcement of criteria

[a] Stricter criteria apply for conflicting standard and EU-RED criteria

A recent survey by the IEA (IEA Bioenergy 2012a) sheds light on the consequences of mandatory certification introduced especially by the EU: biofuel producers say that increased costs for certification mandated for entering the US and EU markets are usually met by choosing cheaper feedstock suppliers. Thus, the pressure is passed down the production chain, which favors large, efficient, and internationally experienced suppliers. For the LAC region, this could translate into a strategic advantage for large agro-industrial producers already dominant in flex crop production (Pacheco 2012; Borras et al. 2012) and thus further promote standards perceived as more appealing and feasible to these audiences (Zezza 2013).[13] This raises the question whether the transnational governance network for sustainable biofuels established by the EU and its reliance on certification may cause a development that runs counter to domestic and international policy objectives of contributing to rural development and social inclusion (Franco et al. 2010).

Having acquired a better picture on production, trade, and certification in the LAC region, we now want to look deeper into sustainability problems associated with biofuel production in the region and assess how standards address specific issues.

2.4 International Standards and Regional Sustainability Issues

Most sustainability problems with biofuels arise in feedstock production stages (German et al. 2011; Burritt and Schaltegger 2012). In this section, we introduce three hotspots of biofuel sustainability in LAC—LUC and resulting GHG emissions, land tenure conflicts, as well as effects on food security (Janssen and Rutz 2011; Chap. 1). Further, we review sustainability aspects covered by relevant international standards and in brief discuss their approaches to critical sustainability issues of the region.

2.4.1 LUC and GHG Emissions

LUC, i.e., the conversion of prior land uses and resulting changes of ecological functions, presents a particular challenge to the sustainability of biofuels produced in LAC. Most prominently, the expansion of agricultural frontiers in Latin America driven by growing flex crop cultivation has posed threats to native forests as well as other natural vegetation rich in carbon stocks and/or biodiversity (Seghezzo et al. 2011).

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[13] Research that addresses the role of smallholder producers in sustainability governance through certification schemes supports this line of argument. Assessing sustainability certification in tropical agriculture Edwards and Laurance concluded that "current certification schemes select against small-holder producers, because schemes are complex, expensive, and difficult to apply at the scale of just a few hectares" (Edwards and Laurance 2012). Lee et al. (2011) confirm this result for biofuel feedstock production in particular and point out the need to understand and integrate the specific circumstances of small-scale producers as their buy-in is critical for truly sustainable biofuel markets.

As stated above, the EU RED precludes the direct conversion of forests, legally protected areas, and highly biodiverse grassland as well as land with high carbon stocks (e.g., wetland and forests) and peatland (see also Table 2.5). Being qualifying RED schemes all voluntary certification standards reviewed here thus are aligned with these criteria.[14] Most certification standards furthermore stipulate high conservation value (HCV) assessments and ban conversion of HCV areas. However, HCV areas are 'no-go-areas' according to the RSPO, while the EU RED, 2BSvs, ISCC, RTRS, Bonsucro, and RSB allow for limited exploitation if the conservation value is maintained (Guariguata et al. 2011, p. 9).

Identifying biodiverse and sensitive areas, standard approaches agree that national regulations and international conventions should be followed (van Dam et al. 2010); some also include stakeholders in such assessments (e.g., RSB and RSPO). The RTRS approach is an example of both: RTRS Criterion 4.4 stipulates that (after 2009) land cleared of native habitat shall not be used for soy cultivation unless it is in line with RTRS-approved maps and systems (developed in multi-stakeholder processes), which are at the time of writing were almost finalized for Brazil, and about to be established for Paraguay (according to correspondence with RTRS representative). Where such maps do not exist (Argentina, Bolivia, and Uruguay maps are yet to follow), the RTRS allows the use of areas cleared and used for agriculture or pasture for 12 years before 2009. In the absence of mapping, native forests are no-go-areas and conversion of other native habitat is limited by official ecological zoning rules or must be preceded by HCV assessments.

The approach that the RTRS and other sustainability schemes have developed to address LUC has been criticized because it fails to account for leakage effects that can contribute to iLUC: "Cattle production, for instance, has been assigned much of the blame for deforestation rates that was once reserved for soy. This however, neglects the expansion of soy onto former pasture, pushing cattle production (. . .) into newly deforested regions" (Elgert 2013, p. 7; see also Barona et al. 2010).[15] Furthermore, the standards have also been challenged by affected countries on the basis of specific provisions. For example, the EU's definition of grassland has been opposed by Brazilian authorities and stakeholders for lack of a clear scientific basis and international agreement. Hence, while in Brazil an area with native grasses is considered natural grassland despite cattle grazing, the EU's definition excludes many such areas with limited human intervention (Zezza 2013).

LUC, especially at the expense of native forests, may lead to loss of terrestrial carbon and an increase in GHG emissions associated with biofuel production (Searchinger et al. 2008). GHG emissions are addressed by all the governmental and certification standards reviewed here. They are also prominent in national biofuel policies within the LAC region, as we examine further below. However, GHG

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[14] RSPO, RTRS, and Bonsucro incorporate EU RED criteria as voluntary, complementary modules which, if adapted, have to be fully complied with. RSB and ISCC integrate EU RED in their core principles and criteria, whereas the 2BSvs consists of EU RED criteria only.

[15] At the time of writing, the RSB announced the development of a "Low Indirect Impact Biofuels" module (RSB 2013c).

assessments and reduction requirements differ among sustainability schemes (see Table 2.5).[16] The US RFS includes iLUC in its GHG emission reduction calculation method, while other standards and schemes do not.

2.4.2 Land Tenure and Property Rights

Conflicts over property rights and land tenure characterize agrarian and welfare politics in the LAC region. Although Borras et al. (2012) refrain from labeling most of the recent developments in LAC as 'land grabs', incidents of violent and nonviolent conflicts are still numerous (Johnson 2012; Garcia-Lopez and Arizpe 2010). In contrast to the governmental standards, most voluntary certification standards agree on the need for respecting and securing land tenure (Table 2.5), although in the Bonsucro standard land rights are not a core criterion. Only the 2BSvs does not mention land tenure issues at all.

Most standards (e.g., Bonsucro and RTRS) primarily require clear proof of legal title to land. The ISCC, for example, in Principle 5 requires producers to identify and respect existing land rights, and to prove that "land is used legitimately and that traditional land rights have been secured" (ISCC 2011, p. 29). In order to proof compliance, however, land titles appear to be emphasized, as producers must provide documents that "show legal ownership or lease, history of land tenure, and the actual legal use of the land."

While the land titling approach is much in line with some scholars and practices of development organizations, critics have also noted that title requirements may lead to a concentration of benefits for some, while disenfranchising others (Hirsch 2011). Selfa et al. in their case study on Bonsucro in Colombia (Chap. 7) show that such practices may disadvantage people with informal and traditional rights to land and little power. Showing an awareness of such critiques, the RSB emphasizes respect for both formal and informal rights, by requiring every operator to assess any type of land and land use rights and forbids any activity before negotiations with affected stakeholders have been concluded with free, prior, and informed consent (FPIC, van Dam et al. 2010). FPIC is also essential to safeguard indigenous people's rights (RSB 2010). Yet, even assessments utilizing FPIC approaches have been criticized. For example, these processes may leave wiggle room. They are susceptible to variable interpretations of who must comply and subject to alternative views of compliance (German and Schoneveld 2011).

2.4.3 Food Sovereignty and Security

While there is some uncertainty over the size of the impact, current and future biofuel production is expected to affect prices of grains and edible oils. This can have

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[16] Methodologies utilized to estimate GHG emissions also differ. See for example, Hennecke et al. (2012), who compare calculation methodologies accepted under the RED. There is also divergence between the RED and RFS2 (Khatiwada et al. 2012).

direct impacts on food security, particularly among poor populations in developing countries who allocate large proportion of their income to buy food (Janssen and Rutz 2011). Typically, this issue is associated with feedstock production for biofuels either "diverting or replacing food crops" (Bailis and Baka 2011, p. 8). This dichotomous perspective, however, overlooks inseparable links of current biofuel crops to food and feed markets, with many overlapping sustainability issues.

Only the ISCC and RSB approach food security at all and thereby differ considerably in their charges (Table 2.5, see also Chap. 1). As with land rights, the RSB is the only standard dedicating a separate principle to food security. It charges a screening exercise that identifies regions of food insecurity. When operating in such regions, additional steps are required such that operators enhance food security for directly involved stakeholders (RSB 2010, p. 17). In the ISCC, food security is a "minor must" criterion which, if followed, prohibits the replacement of staple crops and demands that "local food prices do not rise as a direct effect of biomass production" (ISCC 2011, p. 28).

Factors affecting food security are interlinked with other social and environmental impacts of flex crop production. For example, large-scale land acquisitions for oil palm plantations in Ecuador have not only driven LUC and deforestation, but also displaced farmers who subsequently migrated into areas occupied by Afro-Ecuadorians and indigenous people raising tensions and increasing the potential for conflict (Hazelwood 2012). Diminishing access to land for small-scale farming and to forest resources for subsistence can directly threaten food sovereignty and imperil rural livelihoods (Buitron 2002; Elgert 2013).

Overall, the standards reviewed here differ greatly in scope.[17] While most standards agree in a broad sense on safeguarding environmental sustainability, particularly GHG emission reductions, they are far less consistent with social issues. As German and Schoneveld criticize "climate mitigation interests of developed countries as the sole metric for evaluating the performance of feedstock sourced from the global South—in essence, ignoring the national aspirations enshrined in domestic policies that place social and economic development at the forefront" (German and Schoneveld 2011, p. 20). The industry-led 2BSvs is an example for certification schemes accepted under the RED that followed the bare minimum standard and require no more than the EU criteria to be met.[18] This creates pathways for biofuel production to be certified as sustainable while paying little or no attention to social issues. As a tendency, standards that were developed in multi-stakeholder processes are more likely to include social aspects such as human rights, indigenous rights, and labor standards, as well as social and economic well-being of the community (Vogelpohl and Hirschl 2011). However, these standards differ highly in their

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[17] For more detailed discussion see German and Schoneveld (2011), Guariguata et al. (2011), Scarlat and Dallemand (2011), and van Dam et al. (2010).

[18] In addition, the Abengoa company scheme covers EU-RED criteria only and is applicable to Abengoa's production in Brazil. Red Cert, Red Tractor, SQC, and Ensus—though not applicable for production in the LAC region—are further examples of RED-recognized schemes that do not cover sustainability aspects beyond EU RED.

responses—notwithstanding the varying approaches where such issues are included (German and Schoneveld 2011).

2.5 Intersection of International Standards and National Policies and Regulations

In this section, we look at intersections of international standards and domestic regulatory and policy frameworks. Domestic public policies and regulations at points of production are regarded as decisive determinants of whether and to what extent sustainability standards matter. Weak ability to create and enforce appropriate legal and policy frameworks to manage natural resources has been identified as barriers in the uptake of forestry and fishery certifications (ITC 2012; Barry et al. 2012; Gulbrandsen 2010). In particular, uncertain and/or disputed property, land tenure, and community rights present barriers to adoption of certification standards (Gulbrandsen 2010; Barry et al. 2012). However, the mechanisms and effects of such interplay are complex and contextual. For example, Bartley (2012) finds evidence for two opposing concepts: rivalry and complementarity. Rivalry refers to crowding out effects of private standards over existing or future governmental regulation. Complementary effects may occur when local government regulation and standards are independent but compatible and thus strengthen each other. Alternatively, global standards may work in conjunction with domestic public policy and promote upgrading of regulation (Cashore et al. 2007). Complementarity can also arise from explicit adoption or support of standards by governmental regulation.

In order to highlight some of the key factors that shape the relevance of standards in specific LAC contexts, we briefly review LAC biofuel policies and identify objectives in the following (see also Chaps. 3–10). Further, we look for evidence of general compatibility as well as rivalry and complementary effects.

2.5.1 National Biofuel Objectives

In promoting biofuel policies, LAC governments are motivated by economic, social, and environmental benefits. Table 2.6 provides an overview of biofuel policy objectives within 15 LAC countries that either already have established a biofuel industry or have been identified as potential emerging biofuel markets. There is a consensus among policy makers in LAC that biofuel production should occur to the advantage, or at least not to the detriment of the environment. Of course, as elsewhere, biofuel policies are also introduced to reduce consumption of fossil fuels or decrease GHG emissions.[19] However, in contrast to the USA and the EU, biofuel policies in the LAC region do not stipulate any GHG emission reduction targets.

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[19] For example, in Brazil, however, energy security and autonomy as well as socioeconomic development were initial goals of deploying a ethanol industry; reducing negative climate change impacts and other environmental objectives were later on added (Guariguata et al. 2011, p. 15).

Table 2.6 Overview of biofuel policy objectives in the LAC region

	Argentina[a]	Bolivia[b]	Brazil[c]	Chile[d]	Colombia[e]	Costa Rica[f]	Dominican Rep.[g]	Ecuador[h]	Guatemala[i]	Jamaica[j]	Mexico[k]	Panama[l]	Paraguay[m]	Peru[m]	Uruguay[n]	Total
Contribute to energy security/provide energy access in remote areas	●	●	●	●	●	●			●	●	●	●		●	●	12
Achieve energy autonomy/competitive advantage/enter new markets	●	●	●	●	●	●	●	●	●	●			●		●	12
Encourage investments/stimulate economic growth	●		●	●			●		●	●		●	●	●	●	10
Promote rural and socioeconomic development	●		●	●	●		●			●	●	●		●	●	10
Strengthen/diversify agricultural sector	●		●		●	●	●	●			●	●	●	●		10
Create employment opportunities	●	●	●	●	●			●	●		●	●	●	●	●	12
Reduce poverty/promote social inclusion/increase income of farmers/improve living conditions	●		●	●	●	●					●		●			7

Table 2.6 (continued)

	Argentina[a]	Bolivia[b]	Brazil[c]	Chile[d]	Colombia[e]	Costa Rica[f]	Dominican Rep.[g]	Ecuador[h]	Guatemala[i]	Jamaica[j]	Mexico[k]	Panama[l]	Paraguay[m]	Peru[m]	Uruguay[n]	Total
Reduce GHG emissions/mitigate climate change/engage in carbon markets	●	●	●	●	●	●	●	●		●	●		●		●	12
Protect the environment/safeguard environmental advantages	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15
Food security		●	●			●		●	●	●	●					7

[a] Joseph 2012a; Infoleg 2006; Secretaría de Energia 2009; Morgera et al. 2009
[b] IICA 2010; Presidente Interino de la Republica 2005
[c] Morgera et al. 2009; IICA 2010
[d] CNE 2008; Minenergía 2012; IICA 2010
[e] MINMINAS 2008; DNP 2011
[f] MAG-MINAE 2007; MINAE 2008; MINAET 2011
[g] DENC-SEIC 2003; El Congreso Nacional 2007; IICA 2010
[h] Presidente Constitucional del Ecuador 2004
[i] Congreso Guatemala 2003; MEN 2011
[j] MEN 2010
[k] Secretaria de Energia 2008; Morgera et al. 2009; Cámara de Diputados 2008
[l] Gobierno Panamá 2011; Secretaría Nacional de Energía 2012
[m] IICA 2010
[n] Cámara de la Republica Uruguay 2007; IICA 2010

Governments are also led by strategic concerns, focusing on energy independence or on competitive advantages that may be reached with the new technology. Some governments also aim to take advantage of external demand for biofuel feedstock to strengthen agricultural trade, enhance agricultural production, and stimulate the economy. Many governments consider their domestic biofuel industry as an opportunity to create employment opportunities and enhance socioeconomic development in rural areas. Related objectives described in national policies include a strengthening of the agricultural sector as well as the development of regional economies. Although to a lesser extent, poverty reduction and improvement of living conditions of marginalized as well as food security are still mentioned explicitly in about half of the country policies reviewed. Interestingly, Peruvian policy makers explicitly stipulate the objective of biofuel production as an alternative to the illicit cultivation of coca leaves contributing to the National Strategy to Combat Drugs (El Presidente de la República 2005).

Obviously, some of these goals, such as entering new markets or combating drugs, are set on a macro-level that is not within the sphere of influence of producer-level standards. Yet, in a very broad sense, it appears that there is potential compatibility of the majority of domestic biofuel strategies vis-à-vis the sustainability aspects promoted by the standards reviewed in the previous section. Foremost the voluntary standards that include environmental, social, and (to fewer degrees) economic aspects of biofuel production, show considerable overlap with most domestic strategies presented in Table 2.6. Brazilian and Argentine policies stand out for their multiple objectives. Furthermore, all biofuel strategies examined also emphasize socioeconomic objectives to some extent. Given the focus on GHG reduction targets of governmental standards in the EU and the USA, the question of which certification standards will prevail, especially under the EU-RED scheme, is a critical one.

Yet, even where governmental regulations exist, complementary effects of standards cannot be assumed. Corruption, lack of capacity, and unwillingness or inability to implement policies and enforce laws often create barriers to effective policy implementation (e.g., Schoneveld et al. 2010; Suich and Tacconi 2012). Further, policies within other sectors may conflict with the objectives of biofuel policies, impede their implementation, and crowd out sustainability efforts (Durst et al. 2006). Next, we therefore highlight contextual factors in broader policy and regulatory frameworks that influence whether and to what extent sustainability standards matter.

2.5.2 Factors in National Policy and Regulatory Frameworks

All of the flex crops described above are affected by other agriculture and/or forestry policies that impact cultivation practices, zoning, and socioeconomic outcomes (Marin et al. 2011; Tomei et al. 2010). Deploying a sustainable bioenergy industry requires a holistic approach that creates conditions conducive to socially and environmentally positive outcomes. Thus, the potential interactions with policies affecting other sectors are crucial for understanding the relevance of any intervention attempting to govern biofuel production and use. In an anecdotal manner, we review evidence that illustrates existence of relevant policies and regulations in LAC and issues of implementation as well as their intersection with standards.

In Argentina, biofuel deployment has two main drivers: the nation's energy policy promotes biofuels to enhance domestic energy security and reduce dependence on oil imports while also articulating socioeconomic and environmental objectives (Recalde 2012). To this end, the Argentine government promotes biodiesel production for domestic markets through several policy instruments. At the same time, for Argentina's domestic agribusiness, biodiesel is tightly linked to the Argentine "soy revolution" (Tomei et al. 2010). The past 15 years have witnessed the evolution of a highly capitalized, large-scale soy industry, oriented primarily toward foreign markets. "In the absence of strong policy, it has been left to agroindustry to determine the development of the nascent biofuels sector, toward one focused primarily on the export market" (Tomei and Upham 2011, p. 45), which is argued to bring economic benefits to the country (Recalde 2012). Tomei et al. (2010) show that the beneficiaries of these developments are large agribusinesses and multinationals, while small- and medium-scale producers are structurally disadvantaged.

There are also several often-overlooked negative social and environmental impacts. Within Argentina, enforcement of agricultural and environmental legislation has proven to be problematic. This context of national dependence on the soy sector and a relatively weak public sector, has implications for certification that "presume[s] well-functioning institutions for environmental protection and monitoring, which often do not exist" (Tomei et al. 2010, p. 387). Nevertheless, certification is prevalent in Argentina. However, as we note above, the majority of certificates are with the 2BSvs standard, which requires the *minimum* of EU-RED sustainability criteria. Against this backdrop the question of effectiveness arises: Can certification succeed where domestic policy fails?

In our focal region, Brazil has the longest-standing biofuel policy and industry. As is discussed in Chaps. 3 and 4 of this collection, the country has enacted general environmental legislation including a strict Forest Code as well as Agro-ecological Zoning to prevent deforestation in the Amazon and other high-conservation value areas. However, these laws have a history of inconsistent enforcement (Nepstad et al. 2006; Lima et al. 2011). The Brazilian Forest Code specifically has raised concerns among civil society organizations because of a lack of enforcement, compounded by lobbying from sugar and soy producers to relax the law (WWF 2012; Lima et al. 2011).[20] Furthermore, it is also widely recognized that poorly defined property rights present an important reason for ongoing deforestation and land conflicts along Brazil's agricultural frontiers (Hospes et al. 2012).

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[20] The Forest Code, Lei n°4.771, was established in 1965 and in 2012 modified by Lei n°12.651, though these modifications are disputed and may be decided upon by the Supreme Court. It limits the amount that can be cleared on any plot of land based on a legal requirement that 80 % of each plot in the Amazon must not be deforested and 35 % of native vegetation cover has to be conserved in the Cerrado. The law also regulates use of sensitive landscapes such as riversides, hilltops, and steep slopes. These are called Areas of Permanent Preservation (APP) and are not allowed for agricultural production and expansion (Hospes et al. 2012).

Analyses of policies governing land acquisition in Brazil and Bolivia find that mechanisms supporting small farmers and indigenous communities' rights conflict with policies supporting development of large agribusiness (Pacheco and Benatti 2012). Such policy incoherence may hinder effective implementation of sustainable practices (Howlett and Rayner 2007). Similarly, conservationist objectives included in land policy may impose unbearable burdens on small landholders and are therefore frequently violated (Pacheco and Benatti 2012). In complex settings with specific socio-political and economic contexts, policy instruments might not lead to the envisioned outcomes. To the extent that sustainability standards rely on such national regulation, their adoption and efficacy may thus be at risk.

This incongruence is evident in Colombia as well, where oil palm and sugarcane expansion has been induced by governmental incentives such as tax reductions, tax holidays, and access to land and loans (Pacheco 2012, p. 20; also see Chap. 7). The domestic biofuel industry was among the main beneficiaries of these incentives, boosted by a blending mandate that created demand for biofuel feedstock. Despite striking a normative tone about employment and rural development, Colombia's *General Policy for Biofuels* does not prescribe specific details (MINMINAS 2007). Instead, biofuel policies reinforce existing inequalities in land distribution to the advantage of large-scale agribusiness. Moreover, sugarcane production contributes to water access and quality problems in rural communities. Chapter 7 in this collection illustrates how neither the Bonsucro standard nor GBEP indicators can overcome existing power structures and thus are not objectively operationalized to mitigate negative effects for neighboring communities.

Additional incoherence between the rhetoric of sustainability objectives and actual agricultural and biofuel strategies is evident throughout the LAC region. For example, in Paraguay, a FAO assessment finds that the country's biofuel policy contradicts the government's sustainable development strategy, which emphasizes food sovereignty, land reforms, and promotion of family farming (Rodriguez and Dietze 2010). Socioeconomic development in Paraguay is actually impeded by large-scale soybean cultivation, which crowds out family farming and poses a threat to food security among vulnerable parts of the population (Rodriguez and Dietze 2010; Elgert 2013). Similarly, Ecuador's government has articulated policy objectives that include creating more employment opportunities, enhancing energy security, and boosting social and environmental welfare especially among rural communities (Alban and Cardenas 2007). At the same time, biofuel investment and land acquisition policies have been enacted supporting rapid expansion of the oil palm frontier for large agribusiness. The latter has contributed to "rapid deforestation, conflict and displacement resulting from the legal and illegal large-scale acquisitions of land for palm cultivation" (Johnson 2012, p. 2), contravening the state's sustainability objectives.

According to Bartley (2012), voluntary standards may also be directly used as frameworks, indicators of compliance, or employed in due diligence processes and thereby complement public policy (see also Pattberg 2012). This is evident for biofuel standards in the LAC region where the RSB's principles and criteria formed the backbone for several regional efforts including the IADB Scorecard (Janssen and

Rutz 2011), an assessment of biofuel sustainability commissioned by the Colombian government to inform policy making (MINMINAS 2012), and Mexico's "Flight Plan toward Sustainable Aviation Biofuels" (ASA 2012).[21] The fact that governmental and industry actors acknowledge a standard as a benchmark indicates that it is seen as the most appropriate standard, which also implies discursive effects (Pattberg 2012). In the case of the RSB, this is particularly interesting, because its governance structure excludes state and intergovernmental organizations from voting (Fortin 2011). One reason for its widespread acceptance might be the unprecedented degree of consensus-based standard formulation, which saw more than 120 member organizations from over 30 developed and developing countries contribute (RSB 2013a, b). Yet, as we showed in Sect. 2.3 of this chapter, RSB adoption by producers remains low.

At the same time, international approaches to govern toward sustainability are not always accepted by regional actors. As discussed earlier, Argentina as well as Brazil challenged sustainability criteria imposed by both, the US and European policy makers, and allocated efforts to develop domestic alternatives. Besides the Argentine CSCS initiative (see Sect. 2.3.1), a Brazilian group of domestic stakeholders attempted to introduce a national certification scheme in direct response to the proliferation of external standards. The objective was to "avoid the internationalization of models alien to our reality and reverse the traditional trend of the county being struck by and submitted to rules that do not always meet our interests" (Menezes 2008).

Indeed, Brazil presents a striking example of domestic voluntary initiatives and market-based instruments developed on national and subnational levels. For example, aiming toward sustainable soy production, Brazilian agribusinesses and NGOs formed three kinds of initiatives: The *Soy Platform of Brazil* was started by a Brazilian NGO and four Brazilian networks. In 2006, the *Soy Moratorium* was signed by two Brazilian associations, ABIOVE (Brazilian Association of Vegetable Oil Industries) and ANEC (National Association of Grain Exporters of Brazil), to declare that they would not purchase soy grown on Amazon land deforested after 24 July 2006 for at least 2 years. These two associations, Aprosoja (Mato Grosso Soybean Producers Association), and the NGO ARES (Responsible Agribusiness Institute) initiated *Soja Plus* (Hospes et al. 2012). By developing a certification scheme, Soja Plus aims at a "simple, voluntary, participative, transparent, verifiable process that is adapted to the realities of the Brazilian rural property and meets the consumer's desire for the sustainable production of soybeans" (Soja Plus 2013).

In addition, with a focus on social inclusion the Brazilian National Biodiesel Program (PNBP) incorporates the *Selo Social* (Social Stamp) program. The Selo Social promotes social inclusion in the biodiesel industry by creating a tax incentive for producers to obtain feedstock from small-scale family farmers and provide them with technical support (see Chap. 4). On a subnational level, the state of Sao Paolo in 2007 initiated the *Etanol Verde* (Green Ethanol) certification scheme in the framework

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[21] The *Plan de Vuelo* was closely aligned with other regional and global aviation biofuels initiatives that sought to facilitate production chains in adherence with RSB principles (e.g., International Air Transport Association (IATA 2012) and Sustainable Aviation Fuel Users Group (SAFUG 2012)).

of the Agro-environmental Protocol in order to promote environmental compliance and decent labor conditions in its sugarcane industry (Janssen and Rutz 2011).

While these initiatives represent conceptual spillovers of voluntary market-based instruments and partnerships with private actors, their implications for international standards and their adoption remain unclear and will depend on many factors. Producers might find the barriers of adopting an international certification standard reduced if they are familiar with domestic schemes (Ponte and Riisgaard 2011), which might imply a structural complementarity of domestic policy approaches and international standards. On the other hand, competition between domestic and international certification standards might occur if the domestic certification standards seek recognition under the EU RED.

2.6 Concluding Thoughts and Directions for Future Research

Standards have evolved as the major mode of sustainability governance in international biofuel markets. In particular, the EU through its meta-standard approach grants legitimacy to multiple certification standards, which in some cases differ substantially in their scope as well as in their governance structures and deliberative capacities. Particularly for those LAC countries with an export-oriented biofuel sector, the US RFS and EU's RED are critical policy instruments. As is apparent from our discussion, however, it is possible that the RED's recognition of standards with differing scopes, variable degrees of rigor, and stakeholder inclusion will lead to a "lowering of the bar" in standard uptake. In LAC, the consequence would be that critical issues of sustainability (such as multiple social and socioeconomic issues) will remain unaddressed.

In this context of competing standards, it is thus also important to ask which schemes will prevail. In the broader field of research on sustainability standards, legitimacy of standards and standard organizations is assumed to be a significant driver of uptake. The marginal uptake of the RSB vis-à-vis the fast-growing 2BSvs under the EU RED show, however, that this concept requires refinement. Which audiences are critical to grant acceptance to a standard? What are the dynamics behind legitimacy granting by different groups of stakeholders? Could mounting pressure from civil society groups mediate and increase traction among the more rigorous biofuel standards? Further research in this area will help informing governmental policy as well as standard systems design.

With view to standards' intersection with LAC policies, it becomes apparent that the goals of international governance schemes and national biofuel objectives within the LAC region are not necessarily incompatible. International state-based standards originating from the EU and the USA emphasize climate change mitigation, while most international voluntary schemes cover a broader range of environmental and socioeconomic aspects. National policy objectives within the LAC region mention a wide range of issues, although not all with hard targets. Challenges are raised when new modes of governance are layered atop preexisting laws and regulations. Biofuel policies are always embedded in a broader policy context, with preexisting regulations within other sectors such as transportation, energy, agriculture, and forestry creating competing interests and objectives. For producers seeking compliance with standards (and possibly certification) on a voluntary basis in contexts of insufficient governmental regulation or enforcement, research results from other sectors suggest that this might pose a barrier to standard adoption. Given the EU market pressure, a fierce price competition, and general preoccupation of the sector with certification, however, biofuel markets may differ from other commodity markets in which certification is largely voluntary. Due to the EU's coupling of market and certification demand, standard adoption is more likely to also occur in countries with weak legal and political frameworks, as is the case in Argentina.

Whether standard adoption in rivalry situations will then be symbolic lacking substantive effects, or whether it might close governance gaps where adequate measures and legal frameworks are missing and thus complement domestic policy frameworks, requires further research. A discussion of the potential of biofuel standards and certification to contribute to sustainability of production where they are adopted is outside the scope of this chapter. Yet, we also note that for certification standards effective and equitable governance is not straightforward. In Latin America in particular, capture of the state by agribusiness translates into a risk of capture for standards, even if—or exactly when—standards are respondent to local contexts by means of stakeholder inclusion. However, in order to contribute to domestic and international policy goals of environmental protection and socioeconomic development the current international sustainability governance architecture would need to overcome existing political and agrarian structures to also include and benefit smallholder producers and rural communities.

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Chapter 3
Brazil: Ethanol

Suani Teixeira Coelho and Patricia Guardabassi

Abstract Brazil has been a leader in fuel ethanol production since the Proálcool program began in 1975. The industry received decades of government support, but it is now largely self-sufficient and cost-competitive with gasoline. Somewhat surprisingly, however, the last few years have seen Brazil change from a major ethanol exporter to an importer from the USA due to reductions in sugarcane agriculture and in ethanol production. Among starch and sugar crops currently used for commercial ethanol production, Brazilian sugarcane shows the highest returns on energy investment and the most favorable carbon balance. Indeed, the Brazilian model is considered by many to be a success story worthy of emulation across the global south. However, sustainability challenges still remain in some issues that are discussed here, along with recent policies to address such concerns. In addition, there are concerns about the social conditions of sugarcane production. Cane production in Brazil was expected to almost double in the next decade in order to satisfy domestic demand, as well as a growing international trade in fuel ethanol, but recent figures show a significant decrease. These pressures raise concerns about the environmental and social impacts of the industry going forward. Several initiatives are in place to promote sustainability, which will be examined in this chapter, including agro-ecological zoning.

3.1 Introduction

Brazil scaled up a long-standing sugarcane ethanol program into Proálcool in 1975 as a result of the world oil crisis that led to rising prices of imported petroleum (Santos 1985). Since then, the experience, changing needs, and more recently, concerns with the environment have shown the necessity to move toward more sustainable production (economic, environmental, and social). Investments in research and technology

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resulted in constantly increasing yields for both agricultural and industrial segments, with an average global growth of 3 % per year (Goldemberg et al. 2008).

As a consequence of these successful developments, production costs decreased rapidly making ethanol economically competitive with petroleum. Concomitantly, social and environmental legislation more consistent with the need for the sustainable use of natural resources and social welfare conditions were introduced at both the federal and state levels. This is important, as biofuels today are the subject of some controversy, mainly based on environmental and social concerns, and also because of their use as an economic development tool.

Among the starch and sugar crops currently used for commercial ethanol production described in Chap. 1, Brazilian sugarcane shows the highest returns on energy investment and the most favorable carbon balance. Indeed, the Brazilian model is considered by many to be a success story worthy of emulation across the global south. Somewhat surprisingly, however, the last few years have seen Brazil change from being a major ethanol exporter to an importer from the USA, as discussed further.

While biofuels allow the possibility of reducing global greenhouse gas (GHG) emissions by replacing fossil fuels and providing local environmental and social benefits, many studies point to negative impacts such as the promotion of deforestation and competition with food. Studies from Fargione et al. (2008), Pimentel (2003), and Searchinger et al. (2008), inter alia, claim that biofuels can emit GHGs at an even higher rate than fossil fuels when they are produced in native forests that are deforested for bioenergy crops. Other studies, however, indicate that not all biofuels are responsible for such impacts, particularly in the case of sugarcane ethanol (Macedo et al. 2008; Nassar et al. 2010).

Nevertheless, several controversies remain. Brazilian policies were implemented to guarantee sustainable production of sugarcane ethanol. This chapter discusses the environmental zoning of sugarcane introduced at the federal as well as the state level, such as in São Paulo and Minas Gerais. In 2009, Mato Grosso do Sul also announced the establishment of an economic-environmental zoning to protect the Pantanal wetlands and other fragile biomes in that state.[1]

It is important to note that São Paulo is the most industrialized state in the country and that (perhaps because of this) it has the strictest air emission legislation and a large and organized database for agricultural production. In addition, most environmental legislation adopted in the state of São Paulo is subsequently adopted in other states.

It is also the largest sugar/ethanol producer in the country (accounting for 60 % of sugarcane produced in Brazil). Indeed, Brazil's Center-West and Southeast regions are responsible for 80 % of sugarcane production.[2]

This chapter begins by presenting a general overview of ethanol production from sugarcane in Brazil as well as past and present policies for sugarcane ethanol. It

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[1] Law 3.839, 28 December 2009: "Primeira Aproximação do Zoneamento Ecológico-Econômico do Estado de Mato Grosso do Sul (ZEE/MS)." http://www.semac.ms.gov.br/zeems/index.php?inside=1&tp=3&show=2259; http://ww1.imprensaoficial.ms.gov.br/pdf/supplements/DO7612_29_12_2009_SUP01.pdf.

[2] Sugarcane production moved to the Southeast and Center-West mainly due to the higher agricultural productivity and lower production costs because sugarcane in the region is not irrigated.

continues with a discussion on environmental and social issues. Finally, it analyzes the barriers that still exist to improve the sustainability of sugarcane ethanol in Brazil.

3.2 Current Situation and Perspectives: The Brazilian Ethanol Program

Bioenergy has contributed to the Brazilian energy matrix for nearly a century (Santos 1985). Ethanol production was reinvigorated in 1975 through a subsidized program. Over time, however, improvements in technology and economies of scale have driven down production costs. Since 2004, ethanol has become economically competitive with petroleum without subsidies (Goldemberg et al. 2004; Meyer et al. 2012).

At over 20 billion liters per year, Brazil is the world's second largest producer of ethanol (and the largest producer of sugarcane ethanol) after the USA, which produces ethanol from maize. In the 2009/2010 harvesting season, 427 mills in Brazil produced ethanol and sugar, with a planted area of 8.6 million hectares of sugarcane. The national average yield of sugarcane in 2010 was almost 78 t/ha, with some regions reaching 100 t/ha (MAPA 2012).

As discussed elsewhere (see, e.g., Goldemberg et al. 2008), to evaluate the replacement of gasoline with ethanol an analysis of energy and GHG ratios has to be done using life-cycle analysis (LCA). Different feedstocks for ethanol production must also be compared in such terms, as well as their land-use efficiency (tC/ha/a[3]). Ethanol from sugarcane is attractive as a replacement for gasoline because it is essentially a renewable fuel, while gasoline derived from petroleum is not.

The use of cane-based ethanol does not result in significant net emissions of GHGs (mainly carbon dioxide, i.e., CO_2). Its CO_2 releases are taken out of the atmosphere by photosynthesis and are mainly returned during the use of the ethanol and by-products. In addition, all the energy needs for its production (heat and electricity) come from the bagasse, with excess bagasse used to generate additional electricity that is fed into the national grid, reducing the need for thermal or hydro-based power generation. Moreover, there is a limited consumption of fossil fuels; they are only used for transportation, in harvesting machines, and indirectly in fertilizer manufacturing.

Figures 3.1 and 3.2 show the energy and GHG balance of ethanol production for ethanol produced from sugarcane. When compared to ethanol produced from other feedstocks, it has a very favorable GHG balance. Several studies indicate that ethanol from sugarcane can reduce GHG emissions by up to more than 80 % when replacing gasoline, as shown in Fig. 3.2.

Initially, ethanol was available for ethanol-dedicated engines (hydrated ethanol, 96 % ethanol) or as an octane enhancer (anhydrous ethanol, 99.5 %), replacing lead and the additive, methyl tertiary-butyl ether (MTBE). The federal government mandates the blending of anhydrous ethanol with petroleum in ranges from 20 to 25 %. Currently, instead of being used in ethanol-dedicated vehicles, hydrated ethanol is

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[3] Tonnes of cane per hectare per year.

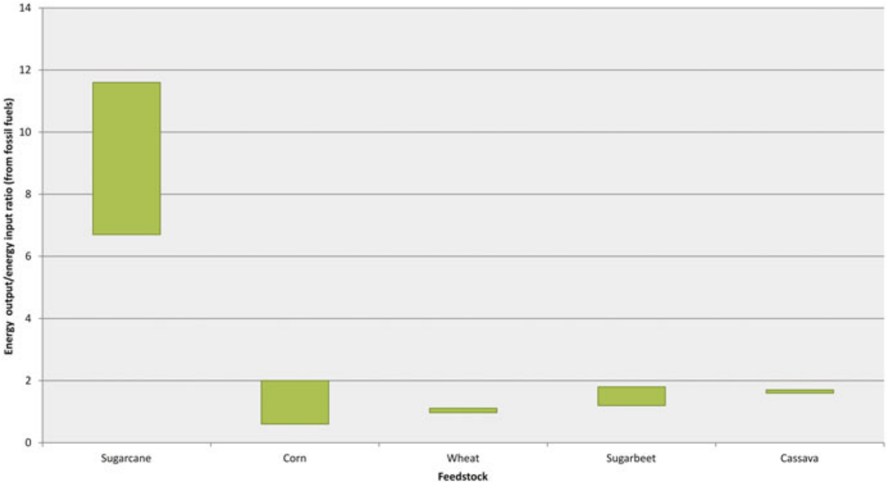

Fig. 3.1 Energy balance of ethanol production from several feedstocks. (Source: Macedo et al. 2004; UK DTI 2003; and Shapouri et al. 1995)

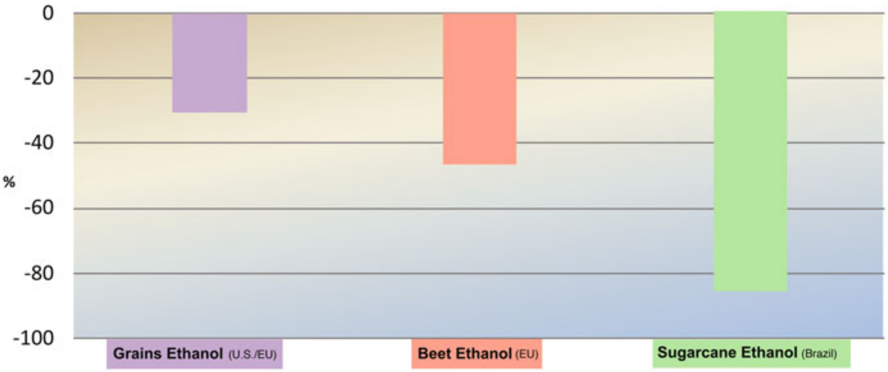

Fig. 3.2 Indicative direct greenhouse gas emissions avoided with the replacement of gasoline by ethanol produced from several crops. Note: GHG emissions reductions calculated through *life-cycle basis, well-to-wheel*. Reduction presented in CO_2 equivalent per kilometer, when ethanol replaces gasoline. (Source: IEA 2004)

used in flex-fuel vehicles. These vehicles now represent more than 90 % of all new cars sold in Brazil. They can run on any blend of petroleum or ethanol, allowing drivers to make price-driven fuel choices (ANFAVEA 2010). In the domestic market, ethanol replaces 41.5 % of the light duty transportation fuel used in the country (DATAGRO 2010).

Projections anticipate an increase in ethanol production to almost 57 billion liters over the next 10 years, which would provide 51.7 % of the total light duty transportation fuel consumed in the country (CONAB 2011). This corresponds to a huge

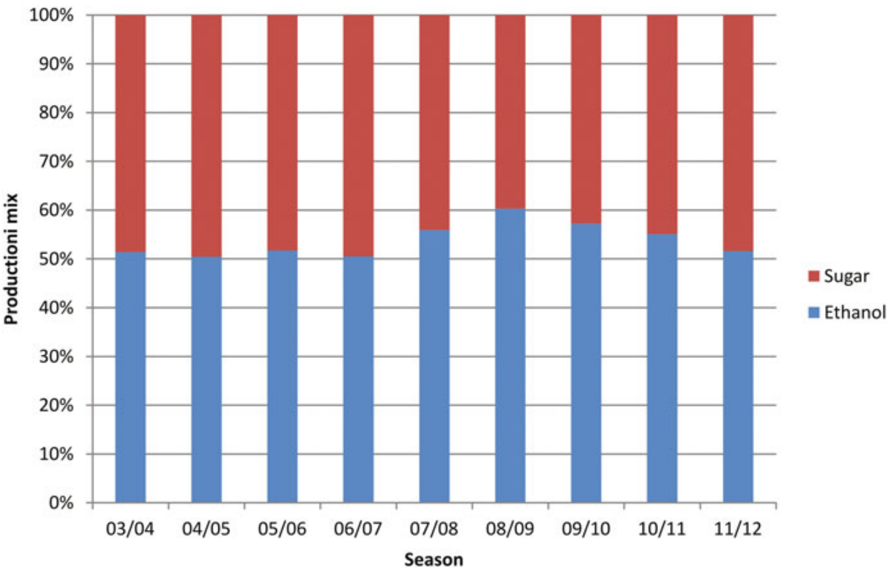

Fig. 3.3 Recent evolution of the destination of sugarcane crushing in the Center-West region of Brazil. (Source: UNICA 2012)

increase in sugarcane production, reaching 1,000 million tonnes by the 2020/2021[4] season (CONAB 2011). For comparison, the 2011/2012 harvest was 560 million tonnes.[5] For 2012/2013, 595 million tonnes of production were forecast with an increase of 6.25 % but still below the production in 2010/2011 (CONAB 2012). For the Center-South region, forecasts indicate a production of 535 million tonnes, 8.2 % more than the previous forecast. The land area to be occupied by sugarcane was forecast to be 8.52 million hectares in the 2012/2013 season, compared to 8.2 million hectares in 2011/2012 and 7.8 million hectares in 2007. However, two issues must be considered:

1. In the area planted with sugarcane, around 50 % is for ethanol and the other 50 % is used for sugar production (see Fig. 3.3). This means that 4.1 million hectares were used for ethanol production in 2011/2012.
2. These figures must be compared to the total agricultural area of Brazil (354 million hectares) and to the 64 million hectares considered available by the sugarcane zoning policy, as discussed later in this chapter.

Bagasse (the residue from sugarcane crushing) is used for combined heat and power generation (cogeneration) in the sugar mills, both for own consumption and for the sale of electricity surpluses to the grid (Figs. 3.4 and 3.5). The installed capacity

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[4] The season mentioned is 2020/2021 because sugarcane production occurs from April to November in Southeast/Center-West Brazil and from November to April in Northeastern Brazil.

[5] The 2011/2012 season reflects a decrease of 9.6 % relative to the previous year because of several economic and climatic factors.

Fig. 3.4 Equipav sugar mill in the state of São Paulo. (Photo courtesy of CENBIO)

Fig. 3.5 High-pressure boilers at the Santa Adélia sugar mill in the state of São Paulo. (Photo courtesy of CENBIO)

from bagasse was almost 6,000 MW (megawatts) in 2010 (CONAB 2011).[6] In the 2009/2010 harvesting season, the total electricity produced from sugarcane bagasse was 20,031 GWh (gigawatt-hours), using different cogeneration systems based on

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[6] For comparison, the installed capacity of the Itaipu hydroelectric power plant is 14,000 MWe.

boilers and steam turbines up to 80 bar (but there are still several mills using 21 and 40 bar boilers). Considering these parameters, 28.2 % of the mills sold their surplus power to the grid (EPE 2011). Cogeneration of electricity can be further increased by using the best available technology. To provide an idea of the potential, an indicative scenario considered the use of high-pressure boilers (99 bar) in all mills and an overall sugarcane production of 1.04 billion tonnes per harvesting season. In this case, electricity production from sugarcane bagasse would increase to 68,730 GWh over the next decade (CONAB 2011). This corresponds to around to 13.5 % of all Brazilian electricity produced in 2010 (EPE 2011).

As discussed elsewhere (Coelho et al. 2012a, 2012b), a possible trade-off for the use of bagasse as feedstock for cellulosic ethanol production could exist once this technology is commercially available. In fact, it is possible that bagasse could be used for ethanol production through second-generation technology. However, there is almost no bagasse surplus in Brazil, only 10 % on average according to the assessment by CENBIO for cogeneration (CENBIO 2009). Further, if the bagasse currently used for cogeneration was diverted to second-generation distilleries, there is still the possibility of using the tops and leaves of the cane in boilers. Even so, exiting boiler technology cannot burn 100 % of the tops and leaves (only combined with bagasse) and additional research and development (R&D) is needed in this area. Finally, bagasse use for animal feed does not seem to be competitive in Brazil because all mills use it for energy production.

Another option sometimes proposed is the use of natural gas for co-firing boilers (Walter 1994). However, this would significantly reduce the energy balance of ethanol in Brazil (currently at 8:1–10:1, as discussed further) and would increase CO_2 emissions, as already is happening with ethanol production from other crops.

3.3 Past and Present Policies: Lessons Learned

3.3.1 Energy Policies

The Proálcool program was initiated in 1975 by the Government of Brazil to increase the production of alcohol for fuel purposes in response to rising oil prices on the international market. In the early stages of the fuel alcohol program, ethanol use became viable to consumers through a pricing policy applied to fuels in Brazil (Moreira and Goldemberg 1999). At that time, the international prices of sugar were low and it became advantageous to shift away from sugar. As the efficiency and cost-competitiveness of ethanol production evolved over time, and fuel prices were liberalized, this support was no longer needed and was eliminated. Governmental incentive thus did exist in the past, but the industry has matured significantly today and relies exclusively on private investments.

There were two distinct phases in the program. The first phase was from 1975 to 1979, emphasizing the production of anhydrous ethanol for gasoline blending as an additive to substitute lead and MTBE, which were used as gasoline additives to increase performance. Lead is toxic and MTBE can contaminate water supplies. Once ethanol was added to gasoline, both lead and MTBE were eliminated as additives. Ethanol has a higher octane number than gasoline and performs the same role as lead and MTBE (without the presence of the toxic lead). Other support actions to increase the competitiveness of ethanol were low interest loans for the construction of distilleries, guaranteed purchase of ethanol by the state-owned petroleum company (Petrobras), and subsidies. In this phase, gasoline was blended with 20 % of ethanol and a fixed price system was adopted, where 44 l of ethanol corresponded to 60 kg of sugar (Coelho et al. 2012a).

The second phase was from 1980 to 1985, when the focus was on the production of hydrous ethanol for engines designed to run this fuel. The supply side was stimulated by diminishing the parity of 60 kg of sugar to 38 l, and for the demand side there were incentives over the fuel price and tax reductions, among other measures (Goldemberg et al. 2004).

As discussed elsewhere (e.g., Moreira and Goldemberg 1999), three main policies were introduced by the federal government to launch the Alcohol Program:

1. Petrobras, the state-owned oil company, purchased a guaranteed amount of ethanol;
2. Economic incentives were provided for agro-industries willing to produce ethanol, offering low interest rates in the period from 1980 to 1985;
3. Sales prices of hydrous ethanol at pump stations were set at 59 % of gasoline prices, which was only possible because gasoline prices were set by the government.

The foundation of the technological development of engines to run on pure ethanol (E-100) was laid in 1975 when the federal government learned about the research done by the Air Force Technological Center in São José dos Campos, São Paulo, to develop ethanol-fueled cars using hydrous ethanol in a proportion of 95.5 % pure ethanol to 4.5 % water (Moreira and Goldemberg 1999).

Ethanol had high production costs and several subsidies were then introduced to make it competitive with gasoline. Later on, as a consequence of cost reductions, subsidies were eliminated by 1997. Ethanol prices are no longer government-controlled and hydrous ethanol is sold to consumers for less than 70 % (by volume) of the gasoline price, corresponding to the ethanol break-even price vis-à-vis gasoline (Fig. 3.6). Since then, alcohol has been economically competitive with gasoline without subsidies (Goldemberg et al. 2004; Coelho 2005).

Ethanol production rose from 0.6 million cubic meters in 1997 to 22.7 million cubic meters in the 2011/2012 harvest season, with increasing agricultural and industrial productivities. In Brazil, ethanol is blended in a proportion of 20–26 % (E20–26) and also used in dedicated ethanol or flex-fuel vehicles running with up to E100 (Fig. 3.7).

Recently, however, ethanol production has decreased and in some recent seasons Brazil had to import ethanol from the USA in order to fulfill internal demand (see Chap. 1). This was due to several factors including reduced sugarcane production and increased sugar production for export, which occurred in response to high sugar prices in the international market.

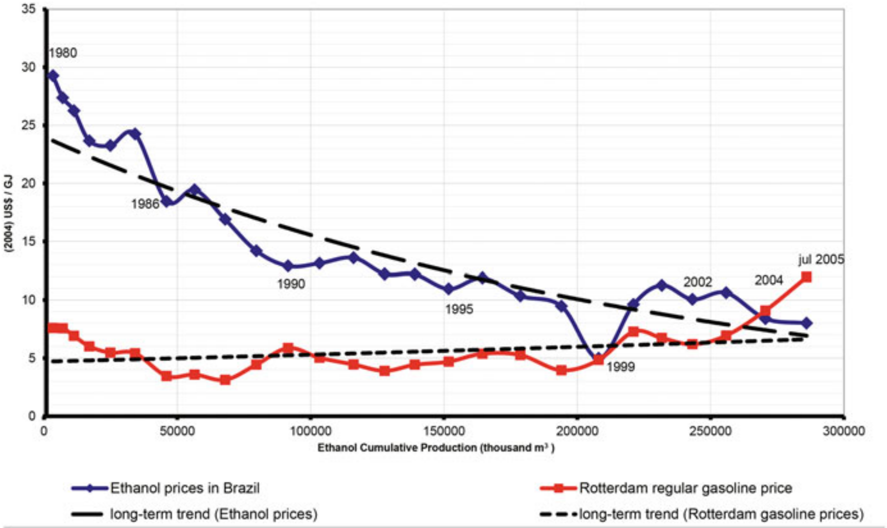

Fig. 3.6 Economic competitiveness of ethanol in Brazil. (Source: Goldemberg et al. 2004, updated by Nastari 2006, personal communication)

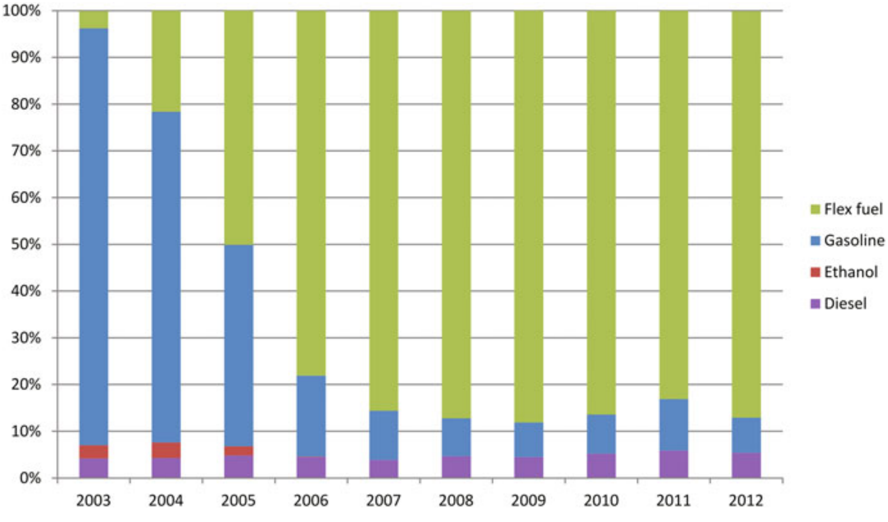

Fig. 3.7 Total sales of motor vehicles in Brazil. (Source: UNICA 2012)

Figure 3.3 depicts recent figures related to the destination of sugarcane toward ethanol and sugar in recent seasons and Fig. 3.8 features the total production of ethanol in the country, showing this decrease. Brazil then had to import ethanol from the USA to guarantee the mandatory blend of anhydrous ethanol and gasoline (20–25 % in volume of ethanol). The country has experienced shortfalls in ethanol production in the past (1940–1975 and the early 1990s) under different

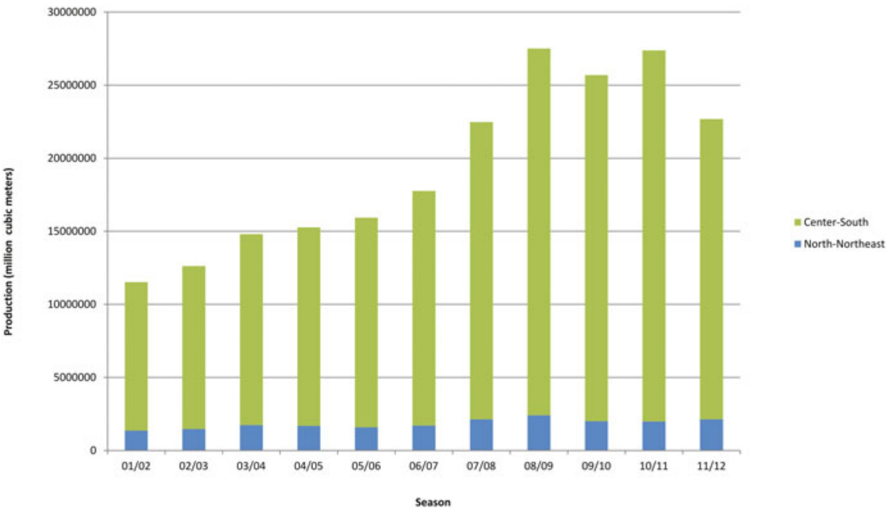

Fig. 3.8 Ethanol production in Brazil from 2001–2002 to 2011–2012. (Source: UNICA 2012)

circumstances. In the early 1990s, when production was planned by the government and most light vehicles were fueled with E100, there was an ethanol shortage that caused major problems for consumers because they had no alternative fuel. While the government took measures to alleviate the problem, such as the introduction of a controversial MEG (methanol–ethanol gasoline) blend using imported methanol,[7] Brazilian consumers lost confidence in E100 and the sales of new ethanol vehicles decreased very quickly. In 2003, with the introduction of flex-fuel vehicles, hydrous ethanol started to be used again (Coelho et al. 2006; Correia 2007, among others).

Ethanol is no longer subsidized today and it competes economically with gasoline. With flex-fuel technology,[8] consumers choose the fuel they want to use considering the prices offered at the retail stations. All Brazilian consumers know that hydrous ethanol price must not exceed 70 % of gasoline prices. This figure takes into account the higher compression rate of ethanol, as well as the fact that the heating value of ethanol lower than for gasoline and so ethanol vehicles consume more ethanol than gasoline ones.

3.3.2 Environmental Policies

Policymakers realized the potential environmental and social benefits of ethanol fuel many years after the start of the program. In addition, improvements in environmental

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[7] The MEG blend was composed of 60 % hydrated ethanol, 34 % methanol, and 6 % gasoline and, due to that policy, the country was obliged to import 1 billion liters of alcohol during 1989–1995. Available at http://www.biodieselbr.com/proalcool/pro-alcool/programa-etanol.htm (accessed on 5 July 2013).

[8] More than 90 % of new vehicles sold in Brazil are flex-fuel.

and social legislation have been implemented, enhancing the sustainability of ethanol produced from sugarcane (Goldemberg et al. 2008), as discussed further.

As already noted, lead and MTBE additives were reduced as the amount of alcohol in the gasoline was increased. They were eliminated by 1991, making Brazil one of the first countries to eliminate both lead and MTBE from gasoline.

Considering the production of sugarcane ethanol, several improvements regarding both the agricultural and industrial phases were introduced, not only to increase the productivity but also to improve environmental issues. Two laws were introduced to address environmental issues arising in the agricultural phase of production:

a. *Harvesting burning practices*: Traditionally, cane fields are burned before harvesting, to dispose of tops and leaves prior to harvest. Burning results in intense air pollution, but in conjunction with an increase in mechanized harvesting, burning is being phased out (Goldemberg et al. 2008). In addition, mechanized harvesting results in 30 % more biomass available for cogeneration, increasing electricity production (Coelho et al. 2011). The phase-out started with the approval of the State Law 11,241/2002 in São Paulo, followed by similar policies for new crops in other states of the Center-West region. Also in São Paulo, burning practices are controlled and authorized by the São Paulo State Secretary for the Environment according to atmospheric conditions. In 2007, the São Paulo Secretariat for the Environment and UNICA (Sugar Cane Agro Industry Association) signed a voluntary environmental agreement (Green Protocol, "Ethanol Verde"), which rewards good practices in the sugarcane sector (SMA 2011). This accelerated the timetable for phasing out burning in the state. There is also a schedule adjustment with the Government (both federal and state levels) specifically for the gradual reduction of the cane trash before burning (Fig. 3.9 and SMA 2011).

   In the last season (2011/2012),[9] 1.67 million hectares were burned in São Paulo, according to the Secretariat for Environment of the State of Sao Paulo. This represents 34.5 % of the total area harvested. As of February 2011, 149 out of the 196 ethanol plants in São Paulo, representing more than 90 % of the state's cane crushing, have adhered to this agreement, meaning that they should establish a timetable to phase out burning. Following the timetable, 65.5 % of sugarcane was mechanically harvested in the State of São Paulo in 2010. Further, by 2014 the use of fire must be avoided in areas that can be mechanized according to the voluntary agreement. In May 2013, 72.6 % of the areas that could be mechanized were harvested without burning, corresponding to 3.38 million hectares,[10] against 34.2 % in 2006.

b. *Environmental zoning of sugarcane*: Due to the expansion of sugarcane production in recent years, concerns about the direct impacts of land-use change led federal and state governments to adopt policies to determine which areas are suitable for cultivating this crop, with adequate protection to existing biomes. The

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[9] Personal information to authors.

[10] http://www.ambiente.sp.gov.br/acontece/colheita-mecanizada-da-cana-cresce-em-sao-paulo/.

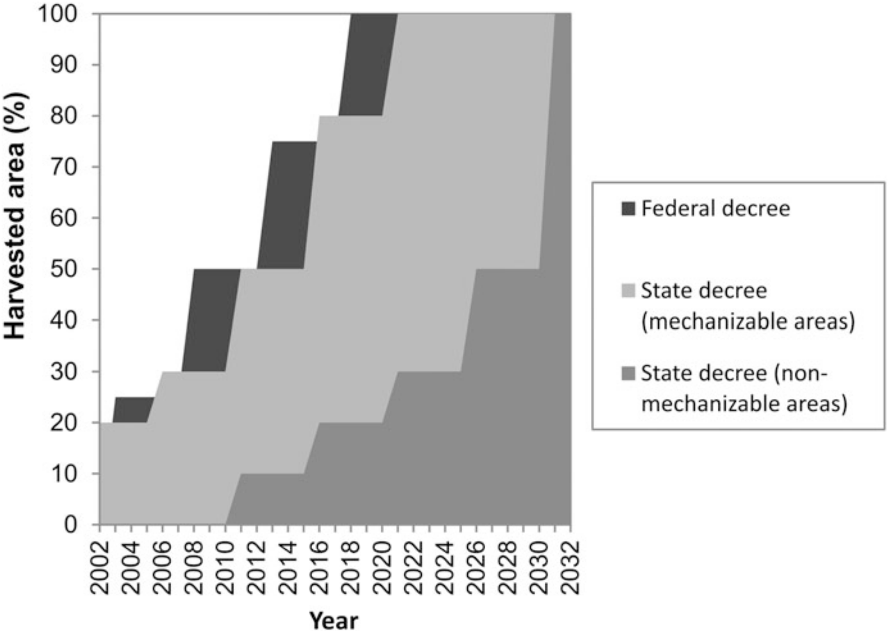

Fig. 3.9 Phase-out schedules for sugarcane burning practices. (Source: SMA 2011; EMBRAPA 2009)

> state of Minas Gerais was the pioneer in this process and launched its economic-environmental zoning policy in 2007.[11] This is based on social, economic, and environmental data that show regional characteristics, potential, and vulnerabilities. It is an orienting tool that can support policy makers and entrepreneurs from different sectors. In the state of São Paulo, agro-environmental zoning was launched in September 2008 (Fig. 3.10). This policy was implemented by the State Secretariat for the Environment in partnership with the State Secretariat for Agriculture and Food Supply, aiming to discipline and organize the expansion and land use by the sugarcane sector, in addition to informing public policy. This zoning comprises information about soil and climate potentials, surface water availability, underground water vulnerability, restrictions to mechanized harvesting, and the protection of biodiversity and conservation units.

Resolution SMA 88/2008, which defines parameters and guidelines for environmental licensing of sugarcane facilities, has been based on agro-environmental zoning

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[11] This Ecological-Economic Zoning (ZEE) was prepared from the methodological guidelines proposed by the Ministry of Environment in accordance with the guidelines of the Environmental Legislation and the Environmental Policies of the state of Minas Gerais, guided by the following issues: (1) regarding the regional units (Copam, Minas Gerais State Council for Environmental Policy), (2) regarding Watershed State, (3) referring to meso- and micro-regions, and (4) for the planning council. Available at: http://www.zee.mg.gov.br/ (accessed on 7 June 2013).

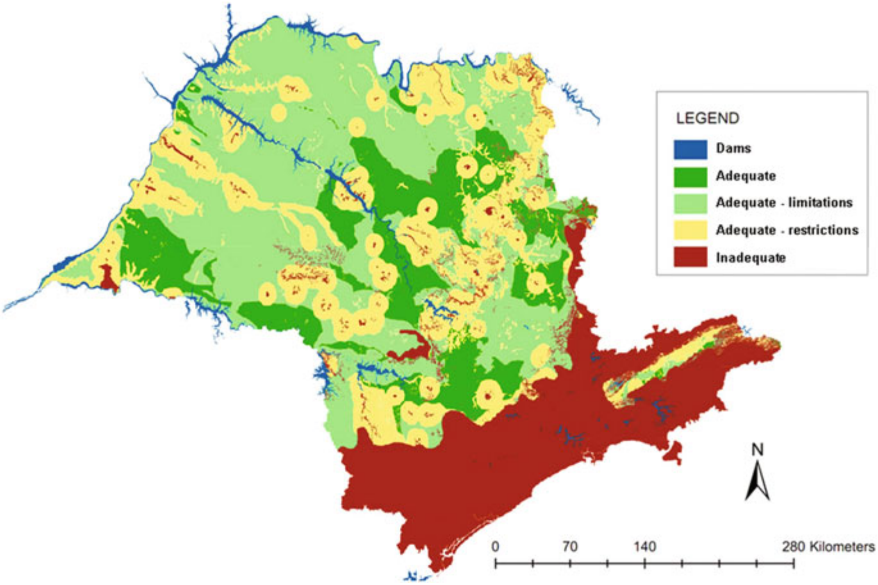

Fig. 3.10 Sugarcane agro-environmental zoning in São Paulo. (Source: SMA 2008)

information.[12] The parameters established in the resolution must be accomplished by existing mills and new ones. The text stipulates a set of measures to be followed, regarding the environment and also anticipates the legal deadlines for the elimination of sugarcane harvest burning and the immediate halt to burning practices in any sugarcane harvests located in expansion areas, as already mentioned. In addition, the protocol targets the protection and recovery of riparian forests and water springs in sugarcane farms, controls erosion and the content of water runoff, implements water conservation plans, stipulates the proper management of agrochemicals, and encourages reductions in air pollution and solid wastes from industrial processes.

The federal government launched two national agro-ecological zonings: for sugarcane in September 2009 (EMBRAPA 2009) and for oil palm in 2010 (EMBRAPA 2010). In this process, maps were produced showing soils, climate and rainfall, and topography. The agro-ecological zoning is an important policy tool and has taken into account environmental, economic, and social aspects as an answer to challenges in sustainable expansion, mainly of sugarcane production. This regulation enables a guidance to credit policies and use for public banks as a condition for production financing. The zoning identified areas where sugarcane crop expansion could take place (Fig. 3.11, indicated areas in green color). It forbids sugarcane cultivation in 92.5 % of the national territory. It has identified 64 million hectares (EMBRAPA 2009) that comply with environmental and productivity requirements, mainly from the intensification of cattle ranching, which is currently very inefficient (less than 1 head/ha; Strapasson et al. 2012; also see Chap. 4).

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[12] http://www.ambiente.sp.gov.br/etanolverde/zoneamento-agroambiental/.

Fig. 3.11 Agro-ecological sugarcane zoning in Brazil. (Source: EMBRAPA 2009)

For the sugarcane agro-ecological zoning, strict rules were considered to map the national territory. It was an important and innovative initiative because it considered both environmental aspects along with technological criteria and agricultural productivity. The guidelines set were:

- Exclusion of areas with native vegetation, prohibiting in the entire national territory the removal of native vegetation for the expansion of sugarcane cultivation;
- Exclusion of areas for cultivation in the Amazon and Pantanal biomes and in the Upper Paraguay River Basin;
- Identification of areas with agricultural potential without need for full irrigation, to select areas in which sugarcane production uses the lowest volume of water possible;
- Identification of areas with slopes below 12 %, which allow mechanized harvesting;

- Respect for food security guiding the expansion of sugarcane production so as to avoid any risk to food production or food security;
- Prioritization of degraded areas or pasture, indicating land currently underutilized or occupied by livestock or degraded pastures as suitable for sugarcane production (EMBRAPA 2009), together with the intensification of pastures for more intensive ranching.

Other states, such as Mato Grosso do Sul (as noted earlier), have also launched their own environmental economic zoning for sugarcane as well as Eucalyptus plantations, which are grown for pulp and charcoal production. The aim is to limit new cultivation to degraded areas and areas previously used for cattle pasture.[13]

Another important law recently discussed and changed in Brazil was the Forest Code, first passed in 1965 and later revised in 2012.[14] In general, forestry practices are directed by the (New) Forest Code (Law 12727/2012). Deforestation, however, is connected to the "National Environmental Policy" as a whole. The Forest Code sets general rules for the protection of natural vegetation, Permanent Preservation Areas, the Legal Reserve (LR), and important biomes. Depending on the biome, the LR corresponds to a given percentage of the total area:

4. 80 % of rural properties in the forest area of the Legal Amazon;
5. 35 % of rural properties in the "cerrado" grasslands—Brazilian savannah of the Legal Amazon;[15]
6. 20 % of rural property in forests or other native vegetation areas elsewhere in Brazil;
7. 20 % of rural properties located in general field ("campos gerais") areas, anywhere in the country.

The revised Forest Code allows rural property owners inside the Legal Amazon to set aside just 50 % for their LR if the state has granted more than 65 % of its total area "protected status" and if a state has approved a law specifically authorizing the reduction of the LR. In a permanent preservation area (APP) for rivers up to 10 m wide, the area set aside should be at least 15 m from the riverbank to protect the so-called riparian forests. Rules were also set for larger rivers. The definition of this new rule encourages farmers to sign a term recovery for APP (*TAC, "Termo de Ajustamento de Conduta"* in Portuguese); otherwise, the farmers are fined.[16] The federal government sanctioned Decree 7830 of October 17, 2012 in order to create a national database and make uniform the analysis of the environmental status of rural properties in Brazil.

Other specific information on environmental sustainability of sugarcane crops in Brazil has been discussed in previous studies (e.g., Goldemberg et al. 2008) and

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[13] http://www.semac.ms.gov.br/zeems/index.php?inside=1&tp=3&show=2259.

[14] Law 12.651, 25 May 2012. Available at http://sbcpd.org/portal/images/stories/Novo-Codigo-Floresta-Lei-12651-2012.PDF.

[15] The new legislation allows that 15 % of the areas to be reforested to fulfill the LR can be in other locations.

[16] Law 12.651, 25 May 2012. Available at http://sbcpd.org/portal/images/stories/Novo-Codigo-Floresta-Lei-12651-2012.PDF.

is presented later, including the different issues related to water consumption, land use and land-use change, competition between fuel and food, use and disposal of vinasse, air quality, energy balances, and other social issues.

3.4 Environmental Sustainability of the Production of Sugarcane Ethanol

3.4.1 Water Consumption

Water is used in the production of sugarcane as well as in the industrial stage. In the agricultural phase, irrigation is more frequent in the Northeast, but is also used in the Center-South, mainly in the states of Rio de Janeiro, Espirito Santo, and west of São Paulo. There are three types of irrigation: (a) sprouting irrigation, applied after planting sugarcane in order to ensure its growth; (b) supplementary water, which is held at the most critical time of growth of the plant in order to alleviate water deficits; and (c) full irrigation, which takes place throughout the cycle (Souza 2005a).

Virtually no irrigation is needed in the Center-South region, because the hydrological regime, which concentrates rainfall from November to March, is compatible with the period and the amount required by the crop. The expansion of sugarcane plantations in the Center-South region has led to the incorporation of new areas into regions with higher water deficit. By using effective techniques, irrigation can be economically viable (Souza 2005a).

In the industrial phase, the average use of water in a distillery is about 22 m^3/t cane; however, as the water is used in a closed-loop cycle, this does not mean that all this is the amount withdrawn (Elia Neto and Shintaku 2009a).

Surveys conducted in different years in the state of São Paulo have shown that levels of water uptake and release have been reduced, from about 5 m^3/t cane raised in 1997 to 1.85 m^3/t cane in 2004. The current withdrawn level is close to 1 m^3/t cane (Elia Neto and Shintaku 2009b).

Over the years, there has been a change in the main uses of water in the ethanol industry, because of technological innovations introduced in the production chain. The higher consumption of water remains in the cooling processes. Reduction of water is observed in the sugarcane washing process, which is increasingly replacing dry cleaning (using compressed air). A new use that was not accounted for in the first survey is the cleaning of exhaust gases from the boiler, which currently represents 5 % of the water demand of the distillery.

According to Elia Neto (personal communication),[17] the main technological developments that led to the reduction of water consumption in the biofuels industry in the state of São Paulo are: (a) billing for water use, (b) the difficulty and high cost of effluents treatment for release into water bodies, and (c) environmental marketing of the ethanol sector.

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[17] Message received on 23 March 2011 (andre@ctc.com.br).

3.4.2 Land Use and Land-Use Change

Sugarcane is a semi-perennial crop, i.e., it can be cut several times before needing to be replanted. The average cane production cycle is 6 years, with five cuts. Appropriate agriculture practices are essential to ensure the sustainability of production and have evolved over the years. Significant improvements were observed with respect to longevity and productivity of sugarcane, therefore lowering production costs (CGEE 2009).

Since the start of Proálcool, several dimensions of sugarcane production have improved substantially including: the development of sugarcane varieties suitable for many different climate and soil conditions (today there are about 500 varieties of cane available); biological control of pests, which reduces the use of pesticides, wastewater recycling as vinasse[18] and filter cake; and improved agricultural management and mechanization of agriculture (CGEE 2009).

With respect to land use, erosion is the most harmful process causing land degradation. However, sugarcane has been cultivated in the same areas for more than 30 years with relatively low impacts. Comparatively, the loss of soil under soybean cultivation is 62 % higher than that under sugarcane (Donzelli 2005). The evolution of farming techniques, especially the introduction of mechanized harvesting of the green cane, is helping to reduce even further the loss of soil in sugarcane crops (Fig. 3.12).

Green cane harvesting and the subsequent maintenance of trash in the field allow the implementation of a no-tillage system that reduces erosion and improves the soil's physical conditions and fertility, while increasing the content of organic matter, nutrients, and water stored (CGEE 2009). It also reduces the use of agricultural machinery and hence lowers the consumption of fossil fuels, which increases the environmental sustainability of sugarcane cultivation (CGEE 2009).

The impacts of these new agricultural activities on carbon storage in the soil have been studied. According to Galdos (2007), the carbon content in areas harvested without the use of fire is 30 % higher than the burned ones. However, there was no increase in carbon levels due the maintenance of trash in the field, because the organic material was not incorporated to the soil, but deposited on it.

In the state of São Paulo, the results obtained by the Biota-State of São Paulo Research Foundation (Biota-FAPESP) Project (Rodrigues and Bononi 2008) identified the need for increased connectivity throughout the state, through the protection of natural fragments and restoration of riparian areas using the existing legal mechanisms. In total, there are 3.5 million hectares of remaining forest fragments. These forests, if properly managed and protected, can play a more effective role in biodiversity conservation.

Of course, with any large-scale biofuel program, land-use change is a concern. If the program is not based on sustainability standards, it can not only be responsible by land-use change but also impact biodiversity, and it can also cause GHG emissions

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[18] Vinasse is the by-product of ethanol distillation. It is a very polluting substance, produced in large quantities (around 8–10 l per liter of ethanol produced).

Fig. 3.12 Mechanical harvesting of green cane. (Photo courtesy of Agricef Soluções Tecnologicas Para Agricultura Ltda, Brazil; reprinted with permission)

that negate some of the benefits of switching from fossil to biofuels.[19] However, a methodological consensus regarding CO_2 emissions due to land-use change is still lacking. One approach was developed by Nassar et al. (2010) to quantify the GHG emissions from direct and indirect land-use changes (iLUCS) due to the expansion of sugarcane. Using a causal allocation methodology based on the best historical data on Brazil (IBGE 2009 secondary data micro disaggregated) combined with geo-referenced data and remote sensing techniques, the study looked at the period from 2005 through 2008. It measured an expansion of the sugarcane area of 2.4 million hectares. In the same period, ethanol production increased from 16 billion liters (2005) to 27 billion liters in 2008 (ANP 2012). The results showed that the sugarcane expansion was directly responsible for the conversion of 9,700 ha of native vegetation, with indirect changes contributing to an additional loss of 181,000 ha. Together, the direct and indirect effects were responsible for the emission of 2.4 million tonnes of CO_2 equivalent.

Other approaches find different impacts. For example, the US Environmental Protection Agency's Renewable Fuel Standard (RFS2) estimates that the iLUC-based

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[19] In 2011, the Global Bioenergy Partnership (GBEP), together with the Food and Agriculture Organization (FAO), launched sustainability indicators for biofuels, which are being introduced by several countries worldwide (GBEP 2011).

GHG impact of sugarcane ethanol produced in Brazil is 4 gCO_2eq/MJ,[20] but the figure and impacts on life-cycle emissions are under continuous review (EPA 2010; Murphy et al. 2011). In the case of the European Union Directive, no rules to calculate iLUC have been developed yet (Khatiwadaa et al. 2012). Johnson and Rosillo-Calle (2010) reinforce the need for further development of iLUC methodologies, as existing methods use a combination of land-use data and economic modeling that can produce biased results.

3.4.2.1 Competition with Food

Another controversial point in relation to the production of biofuels is the impact of land use for energy crops instead of food crops and the consequence of this practice for food prices. Globally, there are controversial results about the relationship between the rising price of oil and agricultural commodities. For example, Esmaeili and Shokoohi (2011) and Zhang et al. (2010) affirm that there is no direct relationship between these long-term prices, while Gohin and Chantret (2010) and Chen et al. (2010) confirm the existence of such a relationship. However, Von Braun and Pachauri (2006) argue that high oil prices are an incentive for biofuel production, which in turn puts pressure on food production, causing higher global food prices. The increase in food prices that occurred in 2008 was alarming and the increasing production of biofuel was quickly identified by some as the cause of this crisis. In fact, what happened was an increase in the price of all commodities, caused mainly by the increase of oil prices in the international market and speculation (Ajanovic 2010).

An interesting analysis is presented by Paarlberg (2010), which reinforces the importance of keeping the food price problem in perspective. Although 70 % of the additional global maize production between 2004 and 2007 was diverted to ethanol production and half of rapeseed production was used in biodiesel production, increased demand for biofuels in the period was supplied by increasing supply, reducing the competition between the two uses. If ethanol production had been responsible for the increase in maize prices, these prices should have risen more sharply than the price of wheat, which did not occur. Paarlberg argues that a 100 % increase in oil prices corresponds to a 20 % increase in the price of grains. Further, the amount of arable land occupied by crops for biofuels is small: 5 % in the USA and less than 4 % in the other four major countries that produce renewable fuels (Paarlberg 2010). The area devoted to agriculture in 2009 was 1.45 billion hectares (FAO 2011) and approximately 16 million hectares were allocated to the production of feedstocks for ethanol production in the countries that produce the largest quantities of ethanol, the USA and Brazil, respectively.

In the case of Brazil, sugarcane has been a driver in modernizing the national agricultural system, due to better management techniques and improved technology, as well as promoting collaborative research between the private sector and public

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[20] The iLUC factor is 4 gCO_2eq/MJ and the other factors included in the LCA account for 32 gCO_2eq/MJ, resulting in a total impact of 36 gCO_2/MJ or a 61 % decrease relative to gasoline.

institutions. Currently, Brazil's productivity of cereals, meat, oranges, and coffee has achieved unprecedented levels (Cortez et al. 2010).

The cultivation of sugarcane occupies an area of approximately 8.7 million hectares in Brazil, and about 3.8 million hectares were added in the last 10 years, a 79 % increase (IBGE 2011). However, the area dedicated to food production was not reduced. Sparovek et al. (2009) concluded that the expansion of sugarcane that took place from 1996 to 2006 in the states of São Paulo, Minas Gerais, Paraná, Goiás, and Mato Grosso do Sul came at the expense of cattle pastures, without contributing to deforestation in these states. This expansion contributed to economic growth that exceeded areas in which there was no expansion of sugarcane.

Conversion of pastures to crop cultivation is occurring in São Paulo (Camargo et al. 2008), where increased stocking levels of livestock freed up land for sugarcane. This intensification is also observed elsewhere in Brazil, but the national average is still slightly higher than one head of cattle per hectare. Egeskog et al. (2011) and Reis et al. (2006) identified that intensification of livestock without loss of productivity is possible, but lack of training and guidance to small producers was observed.

While Sao Paulo is intensifying pasture, sugarcane expansion in other Brazilian states, like Mato Grosso and Mato Grosso do Sul, has been associated with a reduction in forest area. However, the sugarcane expansion in those states was significantly lower than deforested areas, and increased soybean cultivation had more impact (see Chap. 4). Thus, Walter et al. (2011) conclude that increasing the acreage of sugarcane in São Paulo is not related to deforestation occurring in the Center-West of the country, which reinforces the hypothesis that the expansion generally occurred on pastures.

3.4.3 Use and Disposal of Vinasse

Vinasse is produced in large quantities from sugarcane ethanol refining and is the residue with the highest pollution potential (Elia Neto and Shintaku 2009a). However, its high organic matter and potassium contents create an opportunity to apply it to the field for ferti-irrigation. Research has shown that vinasse application benefits physical, chemical, and biological soil properties, provides water and nutrients, and restores soil fertility (Souza 2005b). Of course, poor management of vinasse can result in negative impacts on soil quality and contaminate groundwater. This occurs in some areas in the North and Northeast. In order to prevent such negative outcomes, the Companhia de Tecnologia de Saneamento Ambiental de Brasil (CETESB) established standards for the storage, transportation, and disposal of vinasse on the soil (CETESB 2005).[21] The industrial process wastewater is applied together with vinasse in ferti-irrigation or separately for sprouting irrigation. However, the available quantity of wastewater tends to decrease with the rationalization of industrial uses, as mentioned earlier (Elia Neto and Shintaku 2009b).

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[21] In general, enforcement by CETESB as well as by the Environmental Military Police of the state of Sao Paulo is considered quite well performed.

Vinasse may also be used for energy production. Due to the large amount of organic matter, anaerobic digestion of vinasse produces biogas with a methane concentration of 50–60 %. This process also reduces the pollution potential of vinasse, though not enough for it to be legally released into water bodies. Considering the production of 22.5 billion liters of ethanol (for the 2008/2009 season), Brazil has the potential to produce 3,500 GW of electricity through biogas during the season (Elia Neto and Shintaku 2009b).

3.4.4 Air Quality

In the stages of ethanol production, harvesting has historically been responsible for the largest share of pollution due to the burning prior to harvest as well as the use of machinery running on fossil fuels. However, as was discussed earlier, the burning of tops and leaves followed by manual harvesting is being gradually replaced bymechanized harvesting, which eliminates the need for burning and reduces air pollution. Elimination of burning and resulting carbon sequestration in the soil reduces GHG emissions by 47.8 % in comparison to traditional practices (Figueiredo and La Scala 2011).

A survey conducted by the National Reference Center on Biomass (CENBIO) for the 2007/2008 season identified that, among the sugarcane-producing states in the North and Northeast, Pará and Rio Grande do Norte used mechanical harvesting for 50 and 20 % of the planted areas, respectively. In Central Brazil, Rio de Janeiro used mechanical harvesting on 7 % of cultivated area. Other states had greater penetration of mechanized harvesting (CENBIO 2009), probably due to state legislation. Braunbeck and Oliveira (2006) argue that a high slope is the limiting factor for the suitability of mechanized harvesting, which is restricted to landscapes with no greater than a 12 % gradient.

Air pollution also rises as a result of burning bagasse in boilers. Emission limits are established by the National Environment Council (CONAMA). In addition, the fermentation of biomass for ethanol production is a source of CO_2 emissions (IPCC 2005), with each liter of ethanol emitting 0.77 kg CO_2.

3.4.5 Energy Balance

An energy balance study of ethanol from sugarcane was carried out by Macedo et al. (2008), considering the introduction of public policies and technological innovations. The study considered the mechanized harvesting of sugarcane and the use of flex-fuel vehicles. Moreover, the study considered productivity gains (both in agricultural and in industrial phases) and the increased production of electricity surplus when more efficient technologies are used for cogeneration. The study was based on figures for the 2005/2006 season. The study found a ratio of 9.3 units of renewable energy for each unit of fossil energy consumed. GHG emissions avoided were found to be from 2,181 $kgCO_2$ equivalent/m^3 for the use of E100 and 2,323 $kgCO_2$ equivalent/m^3 for E25. The authors projected a scenario for the year 2020 based on currently available technologies, in which the energy balance can reach 11.6 and avoided GHG emissions are 26 % higher than the scenario for the 2005/2006 season. To give some perspective on how to interpret these figures, in the case of gasoline, the production of 1 unit of energy demands 1.23 units of fossil energy (U.S. DOE 2013).

Compared to ethanol produced from other feedstocks such as maize in the USA, wheat and sugar beet in Europe, ethanol from sugarcane has the most positive results partially because it uses bagasse and only uses fossil fuels in agricultural operations, transport, and fertilizers (Fig. 3.1).

3.4.6 Social Sustainability of the Production of Sugarcane Ethanol

As discussed in detail elsewhere (Coelho et al. 2012a), biofuels production may generate significant social benefits for developing countries as has happened in Brazil, though social vulnerabilities may also increase (Ribeiro 2013). Examples of such benefits include economic growth and job creation in rural areas. In addition, the investment needed to create these jobs is lower in the biofuels sector than in others. In Brazil, investments in the ethanol industry are roughly US$ 11,000 per job created; for the petrochemical industry, the investment is 20 times larger (Goldemberg et al. 2008).

Other important dimensions include the quality of jobs created and the segment of the population that accesses the jobs. Normally, the agricultural sector creates many informal sector jobs, which do not include workers in the national social security system. However, Brazil's main sugar-producing regions present a better situation. In 1992, 54 % of the jobs in the sugarcane sector were formalized; currently, the figure is 73 %. Of course, there are regional differences. In São Paulo, the formal employment rate is 94 %, whereas in the North/Northeast region, it is only 61 % (Coelho et al. 2012a).

Regarding wages, in the Center-South production region people working with sugarcane earn more than those working with coffee, citrus, and maize but less than those working with soybeans, which is highly mechanized and requires more specialized workers. In the Northeast, people working in sugarcane crops earn more than those working in coffee, rice, banana, manioc (cassava), and maize crops (Gorren 2009).

Enforcement of labor regulations in some regions of Brazil could be improved in order to bring other regions into parity with the major sugarcane-growing regions. Working conditions have raised concerns, particularly for seasonal work. Nevertheless, relatively few violations of labor legislation are reported, mainly in the Northern and Northeastern regions, which are the less developed regions of the country.

Lessons learned from São Paulo can be used for the North and Northeast regions. Social issues are being addressed through the policies discussed earlier. Environmental issues have already been adapted by the *Conselho Nacional de Meio Ambiente*

(CONAMA, National Council for Environment) to be applied in the whole country, while considering regional characteristics.[22] However, the introduction of mechanical harvesting of green cane in the Northeast region presents difficulties, considering the geographic conditions to be discussed later.

Temporary migration of rural workers during the crop season occurs because the places where they come from do not offer many job opportunities (Moraes and Figueiredo 2008). Brazil's agricultural modernization policy has not been favorable to small producers, who were not prepared for competition or who work in the urban centers and then become seasonal workers (Ribeiro et al. 2002). This is true for workers in the northeast (NE) regions who become seasonal workers in the southeast (SE) region. The successful experience with small sugarcane farmers in the state of Parana through cooperative systems shows different perspectives.[23]

The labor workday of rural field workers, according to the Brazilian law, is 8 h a day with a 1-h break for lunch. Considering rural workers in the sugarcane crop, the number of workers in 2004 was 493,162 and about 50 % were seasonal workers (Baloadi 2008). This sector is the second most seasonal one in the country, though seasonal work is a characteristic of agriculture (IBGE 2009; Aguirre and Bianchi 1989). However, Goldemberg et al. (2008) show that the sugar alcohol sector in São Paulo presented 93.8 % of formal jobs in 2005, higher than the Brazilian average (72.9 % in 2005; Goldemberg et al. 2008).

Regarding educational level, the category holding the lowest educational level corresponds to the rural workers. The sugarcane cutters are now being trained for other jobs, as discussed below. In fact, the harvesting of sugarcane is an old practice in every country producing sugarcane and the main problem is the working conditions.[24] In order to facilitate the work and prevent accidents with poisonous spiders and snakes, it is a regular procedure to burn the sugarcane leaves before harvesting. Usually, sugarcane harvested manually occupies ten workers per hectare (Valor Economico 2004). The Brazilian Labor Law has resulted in strict regulations on working conditions, but there are violations. Thus, there is a need for tougher enforcement in order to improve the welfare of all rural workers.

In 2004, the National Secretary of Human Rights of the Presidency of the Republic asked the International Labour Organization and Repórter Brasil to develop a study on the identification of supply chains of slave labor. This research led to the launch of the National Pact for the Eradication of Slave Labor in May of 2005, in order to economically boycott slavery in Brazil. Due to the importance of the National Pact, promotion and defense of this agreement were incorporated into the second National Plan for the Eradication of Slave Labor, approved on April 17, 2008, and officially

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[22] Personal experience of one of the authors (S. Coelho) in CONAMA meetings (former Deputy Secretary for Environment of the State of São Paulo).

[23] Personal visit of S. Coelho.

[24] In African and Asian countries, this situation is worse since the workers are obliged to cut the green cane manually, despite all the risks of this hard labor (personal information that the authors received in field visits in 2011).

launched in August by the federal government (Brasil 2008),[25] making the defense and promotion of the National Pact national policy. The Brazilian government has also introduced "*Fome Zero*" (Zero Hunger), which includes initiatives such as "*Bolsa Famılia*" (Family Allowance), an aid to rural families ensuring minimum price for their crops and tax reduction on basic nutrition items.

Mechanization can also reduce labor needs in the sugarcane sector, leading to a loss of jobs in harvesting of sugarcane, particularly among workers with low education levels who could have difficulties competing in the labor market. Of course, this is happening in other agricultural sectors in Brazil and around the world (Gorren 2009). The process is not proceeding uniformly in Brazil (Kageyama 2003).

After the introduction of legislation for the mechanization of sugarcane harvesting in 2002 as mentioned before, some mills have invested in capacity building for rural workers aiming to train them to manage the mechanical harvesters, which are sophisticated computerized machines. Some sugarcane cutters were also trained for other jobs in the *Renovação* project discussed ahead, such as construction.

In fact, it is possible to improve the skills and qualifications of the workers. The cane-ethanol sector runs one of the world's largest training programs for manual sugarcane cutters, their families, and members of the surrounding communities who have been replaced by mechanized harvesting, through the *Renovação* project (Retraining Program for Sugar Cane Rural Workers, introduced in 2009).[26]

Additionally, there are significant social positive impacts from electricity production in rural areas using bagasse from sugarcane and ethanol processing. It is well known that developing countries have a high potential to produce biomass because of more favorable climate conditions and lower labor costs, and this can be done in a sustainable way (Coelho et al. 2012a). The use of biomass for electricity can help to develop economic activities, making energy supply economically sustainable and affordable for the local population. In Brazil, the surplus of sugarcane-bagasse-based electricity is sold to the interlinked grid and distributed all over the country. In other developing countries with huge electricity access difficulties, this could be used to supply rural households directly. An example of such a possibility is the current use of agro-industrial residues to produce electricity for rural households around sugar mills and tea factories in sub-Saharan African countries. In Kenya and Uganda, the electricity surplus generated by the plants is being used to supply households around the industries, in the "Cogen for Africa" GEF/Project (Cogen for Africa Project 2012).[27]

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[25] Available at http://www.reporterbrasil.com.br/pacto/conteudo/view/9.

[26] The Renovação project is a partnership between UNICA, the Federation of Rural Workers in São Paulo State (Feraesp), the Solidaridad Foundation, and supply-chain companies, with support from the Inter-American Development Bank (IADB). In the 2012/2013 season 4,350 workers have been qualified. Available at http://www.unica.com.br/noticia/1671572892036406485/projeto-renovacao-por-cento3A-mais-de-quatro-mil-trabalhadores-requalificados-em-dois-anos/ (accessed on 5 July 2013).

[27] Information from field visits in sub-Saharan African plants by S. Coelho (coordinator of the Mid Term Review by invitation of UNEP-Nairobi 2011).

3.5 Sustainability Barriers in Ethanol Production and Use: Proposals for Improvement

3.5.1 Water

The reduction of water withdrawn to levels close to 1 m^3 per tonne of cane is being achieved by closing circuits and basic engineering. However, the achievement of lower levels, below 0.5 m^3 per tonne of cane, still depends on technological innovation based on the use of the sugarcane water embodied contents. Brazil is conducting research to develop so-called "water plants."

3.5.2 Biodiversity

Although there is a huge legal framework aimed at protecting nature and biodiversity conservation, it is known that the sugarcane sector has a very large environmental liability in this area. For example, in the State of São Paulo there are approximately 265,000 hectares of riparian forests to be recovered. Seventy-seven percent of this area is located in the sugarcane-ethanol industry areas and the remaining belongs to third-party feedstock suppliers. In addition, according to information from the Secretariat for Environment of the State of São Paulo, actions to recover these areas have been initiated (SMA 2011).

3.5.3 Mechanical Harvesting

Steep terrain is a major constraint to the full implementation of mechanized harvesting, particularly in Northeast Brazil as shown in Table 3.1 (Torquato et al. 2010). Thus, the development of technologies that allow harvesting of sugarcane on land with greater slopes (> 12 %) is essential for the maintenance of the culture in much of the territory of some states as the Northeast region mentioned, where sugarcane is harvested manually after burning.

3.5.4 Vinasse

Although attractive, currently few units in Brazil are developing projects of vinasse bio-digestion due to technical problems.[28] The most important one is the presence

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[28] Usina Ester, in the state of São Paulo, is one of the few mills operating a biogas digester from a vinasse plant (personal visit).

Table 3.1 Possible mechanizable area ($< 12\,\%$ slope) in the main Brazilian Northeast sugarcane producing states and the state of São Paulo. (Torquato et al. 2010)

State	Area of sugarcane crops in municipalities responsible for 75 % of the state production		Total cane area	
	ha	% mechanizable[a]	ha	% mechanizable[a]
Paraíba	89,200	63.34	116,115	80.93
Pernambuco	253,918	38.42	336,765	49.97
Alagoas	305,467	48.23	402,253	61.51
São Paulo	2,455,813	68.38	4,122,000	84.10

[a] Based on IBGE data for the year 2006

of antibiotics used to inhibit the proliferation of microbial contaminants during the process of fermentation, which interferes with the digestion process.[29] The presence of these microorganisms is responsible for more than one-third of the losses occurring in the manufacturing process of ethanol, and its management is based on intensive use of sulfuric acid and antibiotics, also contributing to the development of more resistant strains (Copersucar Technology Center 1996; Nolasco Jr. 2010).

One study found that heat treatment of sugarcane juice to control contaminants in the fermentation process reduced the need for natural antibiotics and increased the alcohol concentration in the fermentation process by 30 %, while reducing the volume of vinasse produced by an equivalent amount (Nolasco Jr. 2010). Therefore, the volume of vinasse can be reduced through technological development and optimization of industrial processes.

Another study found that the capture and storage of CO_2 produced in the fermentation process could lead to the production of a biofuel whose life-cycle emissions are negative. However, the technology that would allow this benefit would be available only by 2050 (IPCC 2005).

3.5.5 Land Use

Despite the fact that environmental legislation (including the Forest Code) exists to control land-use change and avoid deforestation, enforcement in some states still needs improvement. This is particularly challenging because of the huge size of these states. In addition, the recently approved version of the Forest Code, as mentioned above, does not help to avoid deforestation and to control adequate land use,[30] despite the important policies of environmental zoning.

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[29] Personal communication from José Marcos Gryschek/BRASMETANO. Lecture: Oportunidades do biogás da vinhaça. 3° Seminário Bioenergia: Desafios e Oportunidades de Negócios. São Paulo, 24 November 2011.

[30] In fact, the new version of the Forest Code introduced less strict environmental rules for the agricultural sector, when compared to the previous version.

3.6 Conclusions

Brazil has been a leader in fuel ethanol production ever since it initiated the "Proálcool" program in 1975 and it has been able to learn several lessons during the evolution of the program that can be shared with other developing countries, especially those in Latin America and the Caribbean. The three pillars of sustainability have been (and are still being) addressed:

1. Economic sustainability: The program started with strong subsidies paid to sugarcane and ethanol producers and now ethanol is competitive with gasoline without any subsidies being paid since the 1990s.
2. Environmental resources sustainability: Several improvements on environmental legislation have been introduced all over the country, mainly related to land use, as in the environmental zoning policy. However, some issues still have to be addressed, as discussed in this chapter.
3. Social sustainability: In general, the social situation of rural workers is not adequate and is at a lower level than for other workers. However, it must be recognized that (maybe because sugarcane is a rather well-organized sector quite) the general conditions of the workers in sugarcane crops is much more advanced than in other rural areas. Moreover, the introduction of the mechanical harvesting of green cane can be an incentive to implement capacity building of such workers, as is happening in Sao Paulo.

Among the conventional starch and sugar crops currently used for commercial ethanol production, Brazilian sugarcane shows the highest returns on energy investment and the most favorable carbon balance. In fact, the Brazilian model can be considered a success story across the global South. However, sustainability challenges still remain and these issues have been discussed herein, along with the recent policies to address such concerns. For example, there are concerns about the social conditions of sugarcane production.

Cane production in Brazil was expected to almost double in the next 10 years in order to satisfy domestic demand as well as a growing international trade in fuel-ethanol, but recent figures show a significant decrease. These pressures raise concerns about the environmental and social impacts of the industry going forward. Several initiatives are in place to promote both social and environmental sustainability, which were examined in this chapter, including the agro-ecological zoning and the experiences of the state of São Paulo. These initiatives can indeed contribute to increase the sustainability of sugarcane ethanol in Brazil.

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Chapter 4
Brazil: Biodiesel

Robert Bailis

Abstract Biodiesel in Brazil is relatively new in comparison to ethanol and is currently used in a 5 % blend (B5) nationwide. The biodiesel program is based on three "fundamental pillars": social inclusion, environmental sustainability, and economic viability. The majority of the nation's biodiesel is derived from soy, which raises problems for both social inclusion and environmental sustainability. Soy has been implicated in destruction of Amazon and Cerrado biomes. However, as the world's second largest soybean producer, Brazil's soy complex serves multiple domestic and international markets. The tremendous expansion of soy largely predated the introduction of biodiesel. The cultivated area grew much more rapidly in the five years prior to the policy than in the five years after its implementation, possibly driven more by demand for soymeal than for oil used to make biodiesel. Thus, attribution of environmental impacts is unclear. Further, while the policy of social inclusion requires that a portion of feedstock be sourced from small farmers, the industry's dependence on soy makes this questionable. Soy tends to be planted in large and heavily mechanized monoculture plantations that are not amenable to smallholder inclusion. Efforts to introduce alternative crops deemed more environmentally or socially sustainable, like *Jatropha curcas*, castor, oil palm, and some native palms, have not gained much momentum and they have seen little utilization as biodiesel feedstocks. This chapter examines the implications of dependence on soy for the sustainability of Brazil's biodiesel industry and discusses the prospects for larger volumes of alternative feedstocks to be introduced.

4.1 Introduction

Although Brazil's biofuel industry has been dominated by ethanol, the country also ranks among the world's top biodiesel producers. As in many countries, demand for biodiesel in Brazil results from a legislated blending mandate that was implemented gradually beginning in 2005. The blend currently stands at 5 % (B5), which required

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approximately 2.7 billion liters of biodiesel in 2011 (ANP 2012). Now a proposal to increase the mandate to B10 by 2020 is under consideration (USDA FAS 2012b).

Brazil's experience with biodiesel dates to well before the current blending mandate. As far back as the 1920s, the government's *Instituto Nacional de Tecnologia* began studying renewable fuels (Gazzoni 2012). There was periodic experimentation with biodiesel in the intervening decades, but it was not until the oil shocks of the 1970s that a concerted effort was made to develop a commercially viable industry. Like *Pro-Álcool*, the program that initiated Brazil's ethanol industry, *Pró-Òleo* (Plano de Produção de Òleos Vegetais para Fins Energéticos) was introduced to mitigate the impacts of the oil price shocks induced by the Organization of the Petroleum Exporting Countries (OPEC)'s embargo of 1973–1974. The program's initial objective was an ambitious 30 % (B30) blend of diesel substitutes derived from vegetable oil largely through transesterification, and gradually hoped to achieve full substitution in the long term (Pousa et al. 2007). However, while *Pro-Álcool* persisted, the biodiesel program was abandoned when oil prices fell and Brazil suffered through an extreme financial crisis in the early to mid-1980s (Gazzoni 2012).

Interest in biodiesel remained minimal through the 1990s, a period in which oil prices remained relatively low and stable. However, by the early years of the new millennium, the government began to reintroduce research programs and consider new policies. In 2002, the Ministry of Science and Technology introduced a new program, PROBIODIESEL, which proposed achieving a B5 blend by 2005, and increasing to B20 within 15 years (Pousa et al. 2007). In addition, the program also proposed a national biodiesel network aiming at gathering agents from different sectors in the country to integrate efforts and develop the biodiesel technology and production in Brazil (Finco 2010). However, the program did not carry the force of law and did not result in much activity.

President Lula da Silva was elected in 2002 based largely on a platform of social justice and redistribution (Flexor et al. 2011). Soon after President Lula took office, he convened an interministerial commission that was created to consider the viability of biofuels derived from fats and oils. The commission concluded that their potential as feedstock for biodiesel production was quite high, and recommended that a program be introduced immediately, based on three main principles. First, they stressed that the program should explicitly promote geographical and socioeconomic inclusion in order to spread the benefits to Brazil's less developed regions in the North and Northeast, as well as smallholders in the South and Southeast, which are wealthier overall, but highly unequal with large pockets of poverty (Garcez and Vianna 2009). Second, they stressed that biodiesel should *not* be mandatory. Finally, they suggested that policies should not define a preferential pathway for feedstocks or fuel production; instead, they should be open to multiple resources and technologies. These recommendations were the impetus for Brazil's National Program of Production and Use of Biodiesel (known by its Portuguese acronym PNPB), which went into effect in late 2004 (Pousa et al. 2007).

The PNPB's policies reflect some, but not all, of the tenets articulated by the interministerial working group. For example, the principles of geographical and social inclusion were directly incorporated into the PNPB as one of several "fundamental pillars" of the program (Flexor et al. 2011). Other pillars included explicit calls for environmental sustainability and economic viability. In addition, there were numerous other prescriptions that related more directly to the nuts and bolts of the policy. For example, the PNPB called for a gradually increasing blend of biodiesel. Initially, the blends were set as optional targets, but soon they became mandatory, which contravened one of the interministerial commission's suggestions. In addition, echoing the need for flexibility identified by the working group, the law initially defined biodiesel very broadly as any fuel that is "derived from renewable biomass for use in internal combustion engines with compression ignition or, according to regulations, for generation of another type of energy, which can partially or totally substitute fossil fuel."[1] However, additional resolutions were quickly put in place defining quality control criteria that essentially narrowed the range of acceptable biodiesel to fatty acid methyl (or ethyl) esters (FAME or FAEE), the products of transesterification, the most common pathway to producing biodiesel. The rapid transition to mandatory blends contributed to the dominance of soy oil as the primary feedstock for the industry. This has consequences for the potential sustainability of the industry as well as the degree to which it can meet other stated objectives of the national program.

This chapter proceeds as follows. First, the role of social inclusion in PNPB is reviewed. This is followed by a discussion of the implications of the industry's heavy reliance on soy oil as feedstock. Second, we examine the geographical distribution of biodiesel production in Brazil and explore potential alternative pathways that might reduce the use of soy. Finally, we examine the future prospects of both soy and its alternatives.

4.2 Social Inclusion

Social inclusion was another principle that emerged in early discussions of biodiesel policy. The significance of this principle is best understood by examining the broader context out of which the policy emerged. For decades, Brazil's agricultural sector has undergone a massive process of modernization. Tax incentives, the introduction of input-intensive 'green revolution' techniques, the widespread cultivation of exotic cash crops like soybeans, and, more recently, agricultural biotechnology (both discussed in more detail below), have increased economic efficiency and created a set of vibrant export-based agro-industries (Hall et al. 2009; Binswager 1991; Warnken 1999; Helfand and Castro de Rezende 2004). As a result, by the beginning of the twenty-first century, the country emerged as an "agricultural superpower" (Barros 2009). However, these advances largely favored large landowners and agribusinesses, leading to a concentration of large holdings and doing little to benefit small family farmers.

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[1] Translated from the original Portuguese, which defined biodiesel as "biocombustível derivado de biomassa renovável para uso em motores a combustão interna com ignição por compressão ou, conforme regulamento, para geração de outro tipo de energia, que possa substituir parcial ou totalmente combustíveis de origem fóssil" (Government of Brazil 2005).

Table 4.1 Tax structure for biodiesel favoring poor regions and by family farmers. (USDA FAS 2010)

Primary Material	Region[a]	Type of agriculture	Federal tax (R$/m^3)
Fossil diesel	Any region	NA	218
Any feedstock	Any region	Commercial farms	178
Any feedstock	North and semiarid Northeast	Commercial farms	151
Any feedstock	Any region	Family farms	70
Castor or oil palm	North and semiarid Northeast	Family farms	0

[a] Brazilis split into five regions: North, Northeast, Center West, Southeast, and South. Semiarid regions are in the North and Northeast as well as parts of Northern Minas Gerais (IBGE 2007b)

Socioeconomic inequality, which has long been a divisive issue in the Brazilian political economy, was already being addressed in some ways by Henrique Cardoso, Lula's predecessor (de Souza 1997). For example, under Cardoso, Brazil implemented the "Bolsa-Escola" program, which provided financial incentives promoting school attendance among poor families (Glewwe and Kassouf 2012). But Lula, a leftist labor leader, implemented wider reaching programs. He was specifically elected on a populist platform of social justice and deeper reforms to reduce inequality in the country. PNPB was one such program (Flexor et al. 2011).

PNPB attempts to promote social inclusion through the *Selo Social* or "Social Stamp," which creates incentives for fuel producers to obtain a fraction of their feedstock from family farmers (*agricultores familiares* in Portuguese). The incentives take the form of tax breaks that are available to biodiesel producers, who procure feedstock from the poorer North and Northeast regions of Brazil and/or from family farmers. The level of tax incentives varies depending on the combination of region, feedstock, and farm type (described in Table 4.1). The favored regions include the North, Northeast, and other semiarid parts of the country. These are Brazil's least developed areas, where per capita income and access to basic services like education and health are well below the national average (IBGE 2010). Favored feedstocks include castor and palm oil. To be in compliance with *Selo Social*, producers must conform to the following criteria (MME 2012a; MDA 2009):

1. Purchase a minimum percentage of feedstock from family farmers, which vary by region: 30 % in the Northeast and semiarid regions. Initially the Southern and Southeastern regions were also set at 30 %, but this was increased to 35 % during the 2012/2013 harvest and is supposed to increase up to 40 % in 2013/2014. Finally, a minimum was initially set to 10 % and increased to 15 % in the North and Central-West regions
2. Establish contracts with family farmers or cooperatives consisting of groups of family farmers from whom the raw materials will be purchased; and
3. Present a plan of technical support services and training to be rendered to the family farmers including support for productive activities unrelated to the production of biodiesel feedstock

In addition to the tax breaks described above, producers in compliance with *Selo Social* also gain the right to participate in periodic auctions held by the ANP (Agência

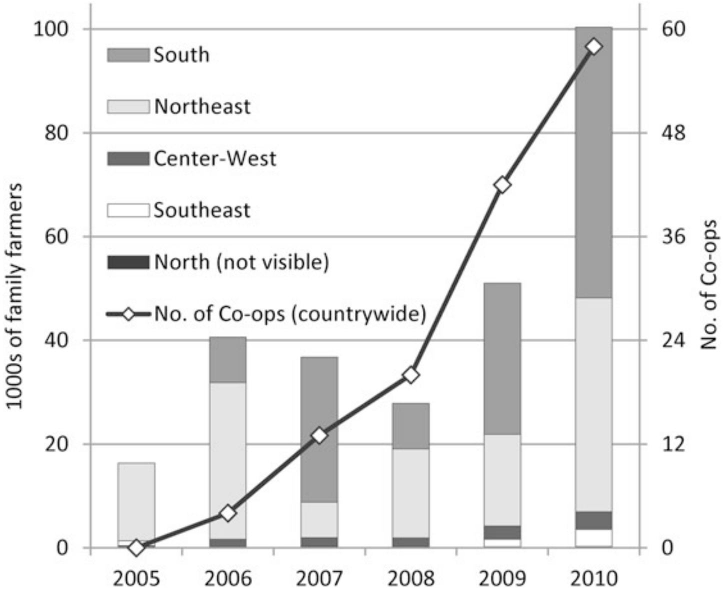

Fig. 4.1 Family farmer participation in biodiesel feedstock production between 2005 and 2010. (Source: DIEESE 2011)

Nacional do Petróleo, Gás Natural e Biocombustíveis), Brazil's national petroleum agency. These auctions were implemented at the start of PNPB to ensure that producers provide sufficient fuel to meet projected demand to meet the blending target in place at the time. Producers who do not participate in the *Selo* must sell their product through a secondary auction, which only occurs if the first auction does not meet projected demand and may fetch lower prices.

Participation in the *Selo Social* has climbed steadily since the start of PNPB. By 2010, over 100,000 family farmers were participating in the program, capturing roughly one-fourth of the value generated by feedstock sales (DIEESE 2011), which is somewhat lower than initial expectations. In addition, nearly 60 rural cooperatives had been formed. However, participation is not uniform. Of the regions singled out by the PNPB for geographic inclusion, the Northeast has achieved considerable participation, while the North, in contrast, lags significantly, with just a few hundred participants each year. The Southern region has the highest participation, which is attributable to the region's history of soy cultivation and high concentration of family farmers. Rio Grande do Sul in particular, which produces nearly 30 % of the nation's biodiesel (ANP 2012), has a history of family farmer co-ops working with soy (Gomes et al. 2009b). Figure 4.1 shows regional breakdown of family farmer participation in feedstock sales to biodiesel producers.

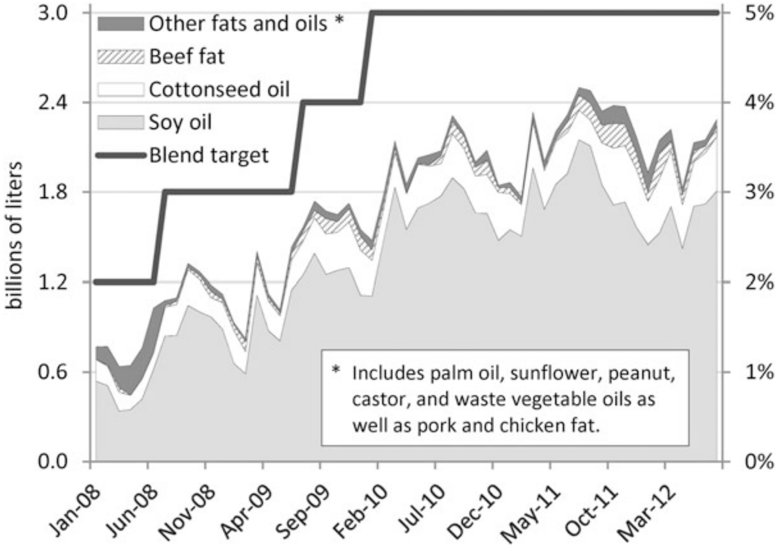

Fig. 4.2 Brazil's biodiesel production and feedstocks utilized from January 2008 to August 2012. (Source: ANP 2012)

4.3 A Biodiesel Industry Based on Soy

The tax incentives defined in PNPB serve as a motivation for biodiesel refiners to use feedstocks like oil palm and castor beans. However, since the program's inception, the mix of feedstocks used to produce Brazilian biodiesel has been dominated by soybean oil (Fig. 4.2). Since 2008, soy oil has constituted ~80 % of all biodiesel feedstock. The balance consists of beef fat or tallow (14 %), cottonseed oil (3 %), and several other minor contributors including chicken and pig fat as well as palm, sunflower seed, and used fryer oils (collectively making up around 4 % of total feedstocks). Figure 4.2 shows the mix of feedstocks used since 2008. This strong dependence on soy oil has raised doubts about the sustainability of Brazilian biodiesel.

To understand the challenges that are raised by Brazil's use of soy oil as its primary biodiesel feedstock, it is worth examining the evolution of soybean cultivation in the country. Soybeans are the most prevalent oilseed grown in Brazil (IBGE 2012a). The dominance of soybean oil is the result of several decades of rapid development linked to the widespread modernization of agriculture and livestock, which coincided with the introduction of green revolution technologies throughout the developing world in the 1960s and 1970s. As occurred elsewhere, this period initiated tremendous changes in Brazilian agricultural production, as well as land ownership and rural life more generally.

Soy production in Brazil began in the early 1960s. As Hall and colleagues note, initially soy was not well adapted to environmental conditions in Brazil, but EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária), a governmental organization that

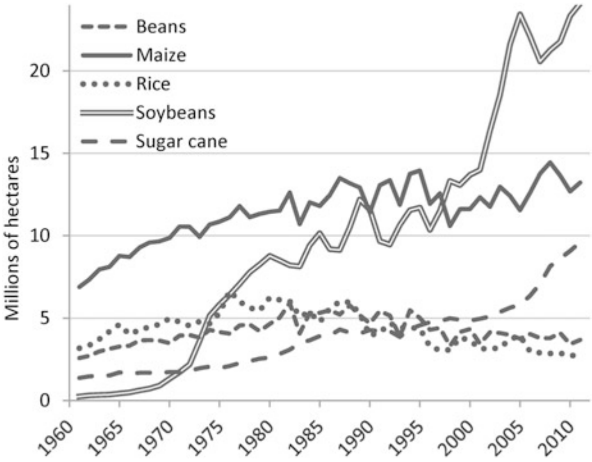

Fig. 4.3 Cultivated area of Brazil's main agricultural crops from 1961 to 2011. (Source: FAOSTAT 2012; IBGE 2012a)

conducts research and development in agriculture and livestock, helped to develop varieties that are better adapted to the country's conditions (Hall et al. 2009). These early advances led to a rapid expansion of soy production, with the cultivated area increasing from 1.3 million ha in 1970 to 8.7 million ha in 1980. The area continued to expand steadily at 3–4 % per year through the end of the 1990s, and then experienced another rapid expansion between 2000 and 2010, which coincided with the introduction of varieties that are better suited to the warm and moist conditions that prevail in the Amazon region as well as transgenic varieties, which were quickly adapted in the South (Fearnside 2001; Massarani 2012). Over a period of four decades, soybean became Brazil's top crop, and currently accounts for 35 % of all cultivated area (IBGE 2012a). For comparison, sugarcane, which is the country's primary biofuel feedstock (see Chap. 3), occupies just 14 % of the country's cultivated area. Figure 4.3 shows the planted areas of Brazil's major crops since 1961.

The rapid growth of soy cultivation occurred in two phases: the 1970s and early 2000s. In each phase, a series of disparate factors drove demand for soymeal. For example, in the 1970s, anchovy fisheries off the coast of Peru, which supplied fishmeal for animal feed in North America and Europe, collapsed. The collapse created demand for a high-protein substitute, which soymeal was able to fulfill. Drought in the USA curtailed its soy exports to Europe and created additional incentives for Brazil to boost its own production. In addition, in the 1970s southern Brazil was shifting away from coffee production, both because of rising labor costs and unseasonably cold weather that caused severe frost damage in many areas (Fearnside 2001). Soy presented large landholders with an attractive alternative to coffee. As a result, Brazil's soy cultivation increased nearly sevenfold through the 1970s (shown clearly in Fig. 4.3). At the time, production was centered largely in the South of the country. Indeed, the southern states of Paraná and Rio Grande do Sul would dominate the country's soy production until the 1990s, when soy began to expand into

Cerrado and Amazon biomes, particularly into the state of Mato Grosso (Fearnside 2001; Nepstad et al. 2006).

Soy cultivation got another boost in the late 1990s, as new seed varieties were introduced. These seeds were better adapted to production in hot, moist conditions found in Amazon regions (Fearnside 2001). Other factors also contributed to this second phase of Brazil's soy expansion. For example, in the 1990s, Europe suffered an outbreak of bovine spongiform encephalopathy (BSE), known colloquially as "mad-cow" disease, which had numerous ripple effects (Nepstad et al. 2006). First, it increased demand for open-range cattle, which Brazil produced in huge quantities. While Brazilian cattle fed primarily in natural pasture, ranchers increasingly utilize feedlots to "finish" the cattle, feeding them a diet that is high in soymeal during the months before slaughter (Millen et al. 2009). Brazil added nearly 50 million head of cattle to the landscape between 1996 and 2006 (IBGE 2012b), in part to meet this demand. In addition, the use of ruminant protein in livestock feed was implicated in the spread of BSE; thus there were soon global restrictions on that practice, which further boosted demand for soymeal (Nepstad et al. 2006). At the same time, and quite independent of the BSE outbreak, demand for soy products in China rose dramatically, forming another major source of demand for Brazilian exports. In recent years, roughly one-third of China's soybean imports (∼ 29 % of total supply) were of Brazilian origin (USDA FAS 2012c).

As this discussion highlights, prior to the implementation of Brazil's biodiesel policy, the expansion of soy production in Brazil was largely based on demand for protein derived from soy meal. The oil, which constitutes ∼ 20 % of soybean mass, was a secondary product. With PNPB's blending mandates in place, biodiesel production now represents a significant source of demand for soy oil. However, as we see below, soy oil used for biodiesel is just a small fraction of the total production of Brazil's soy complex. This must be kept in mind as we explore issues affecting the sustainability of the industry.

The dominance of soy oil as a biodiesel feedstock in Brazil raises concerns about sustainability because of the association that soybeans in Brazil have with deforestation. Other sustainability issues arise with respect to the use of genetically modified soybeans as well as social issues. We explore each of these in the following sections.

4.3.1 Soy and Deforestation

While Brazil's early soy expansion occurred primarily in southern Brazil on land that was previously farmed, the second phase occurred as an unprecedented encroachment into Cerrado and Amazon biomes (Brannstrom et al. 2008; Nepstad et al. 2006; Sawyer 2008). Between 2000 and 2005, when Brazil's cultivated area of soybeans peaked, the area of soy cultivated in the Legal Amazon Region (LAR) increased by 120 %, accounting for 40 % of nationwide soybean expansion (IBGE 2012a). This expansion was divided between land that was recently deforested and land that had been deforested prior to 2000, but used for pasture prior to being converted to soy (Macedo et al. 2012). Specifically in Mato Grosso, which alone accounted for one-third of the country's soybean expansion between 2000 and 2005, about one-quarter of new soybean production occurred as direct expansion into forest, while the remainder occurred as expansion into former pasture land, the majority of which was deforested prior to 2000 (Macedo et al. 2012; Morton et al. 2006).

Although the majority of soybeans were planted on former pastureland rather than recently deforested land, many analysts think that there is still a negative impact on forest cover. This land-use change occurs *indirectly* in the following way: When soybean prices are high, as they have been throughout much of the last decade (CEPEA 2012), the price of land that is suitable for soy production increases. This creates an incentive to sell off pasturelands and induces the spread of cattle deeper in the Amazon region, where cheaper land is available (Nepstad et al. 2006; Lapola et al. 2010). Indeed, differences in the value of former pasturelands targeted for soybean production during this period and land in undeveloped areas of the Amazon allowed ranchers to purchase and clear significantly larger areas of land than they sold. This gave rise to a significant indirect effect of pasture–soybean transitions (Arima et al. 2011).

In mid-2006, just a year after Brazil began producing biodiesel, the country implemented a moratorium on soy production in "recently deforested" areas of the LAR. The area under soybean cultivation ceased growing at about that time and contracted for 2 years, but has since recovered to 2005 levels (visible in the upper right of the time series in Fig. 4.3) in Mato Grosso and elsewhere. The moratorium has been extended several times,[2] but its contribution to slowing soy expansion is not clear. Some analysts claim that the moratorium was effective at inhibiting further expansion of soybean cultivation into the LAR (Rudorff et al. 2011). However, soy prices, which are well correlated with agriculturally induced deforestation (Morton et al. 2006), may have played a role. Between March 2004 and March 2006, real soy prices declined 54 % and remained erratic until late 2011 (CEPEA 2012). Others have noted that advancement of the agricultural frontier into the LAR has continued since the moratorium went into effect, driven in part by the indirect effects of soybean production on pasture expansion described above, which the moratorium does little to address (Arima et al. 2011).

Brazil's biodiesel industry established itself during a period when the cultivated area of soybean experienced little overall growth. Between 2006 and 2011, while annual biodiesel production grew from less than 1 million liters to more than 2.6 billion liters, the cultivated area of soybeans increased by just 3 % (IBGE 2012a). Brazil's biodiesel industry achieved its B5 mandate in 5 years, deriving nearly 80 % of the required feedstock from soybean oil with very little increase in the cultivated area of soybeans. This reflects two important aspects of Brazil's soy industry. First, the industry has increased annual yields by an average of 51 kg per hectare between

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[2] The moratorium defined any land deforested after July 24, 2006, as "recently deforested." Originally in place for 2 years, the moratorium has since been extended several times, and is now in place at least until 2014 (Greenpeace 2007, 2012).

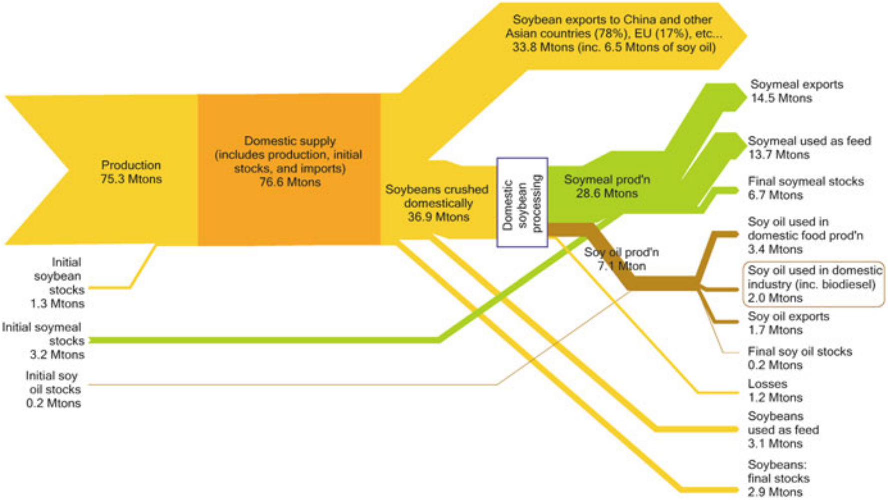

Fig. 4.4 Material flows in Brazil's soy complex during the 2010/2011 crop year. (Source: based on USDA FAS 2012a. During the 2010/2011 crop year, Brazil imported ∼41,000 tonnes of soybeans and 51,000 tonnes of soymeal. They are omitted for clarity because representing them requires lines that are just 25 % of the thickness of the thinnest flows shown)

1990 and 2011.[3] Second, the 2 million tonnes of soybean oil utilized as biodiesel feedstock in 2011 represents less than 3 % of the total mass of material throughput in the nation's soy complex. As such, it is a relatively minor piece of a large and complicated puzzle (Fig. 4.4). Comparing 2011 to 2005, the year Brazil first began producing biodiesel, it is apparent that the additional demand for soy oil created by biodiesel production in this period was met in part by reducing the volume of soy oil that was exported. The rest of the industry's demand was met by increasing production, which also allowed the supply of beans, meal, and oil used in nearly all other sectors of the economy to remain the same or increase over the same period (Fig. 4.5).

4.3.2 Genetically Modified Soy

Reliance on soybeans as a primary feedstock for biodiesel raises another challenge for the sustainability of the industry. After early opposition, cultivation of genetically modified (GM) soybeans was legalized in 2005, after it was discovered that the majority of the crops produced in the southern state of Rio Grande do Sul were grown from Roundup Ready (RR) varieties that were smuggled in from Argentina

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[3] This is estimated from the slope of a simple linear regression of average annual yield data from 1990–2011 (based on IBGE 2012a).

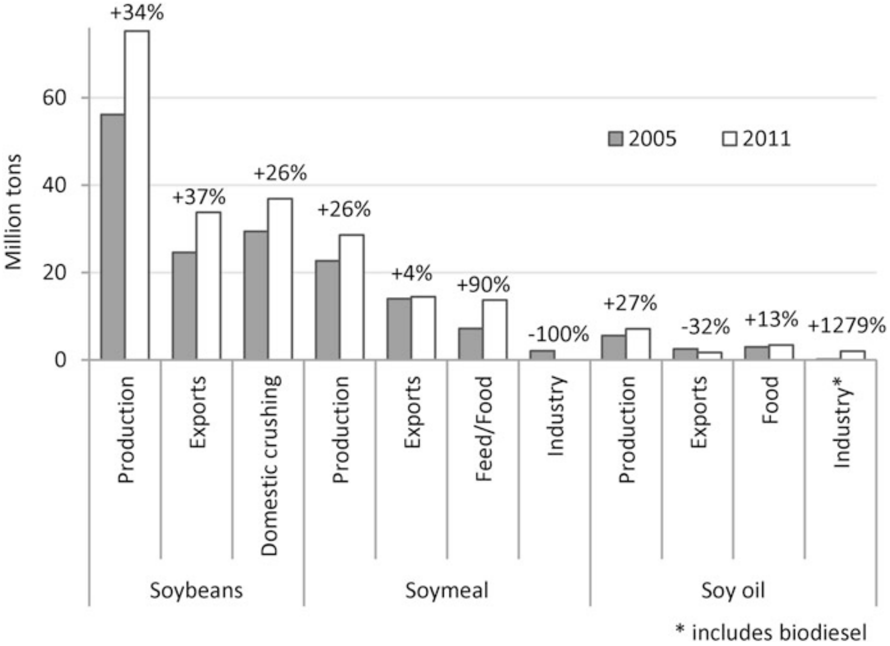

Fig. 4.5 Volumes and changes in major flows through Brazil's soy complex between 2005 and 2009. (Source: based on data in USDA FAS 2006, 2012a)

(Massarani 2012).[4] The overall penetration to RR soybeans is not well established, but some estimates are as high as 85 % of the total crop (Massarani 2012).

While biodiesel only accounts for a small fraction of the total volume of materials moving through the country's massive soy complex, the cultivation of GM soybeans still raises several challenges for sustainable biofuel production. First, RR varieties have led to an increase in the use of glyphosate (the active chemical in Roundup). In Rio Grande do Sul, where RR varieties were first cultivated, the application of glyphosate increased by 162 % between 2000 and 2004 (Fernandes 2009). While glyphosate alone has not been shown to carry negative consequences for human health (Williams et al. 2000), research has shown that common formulations of glyphosate, which include "inert ingredients" like solvents, surfactants, and preservatives, can be harmful to people as well as amphibians (Peixoto 2005; Cox and Surgan 2006).

Indiscriminant application of glyphosate in RR soybeans cultivated in Brazil (and Argentina) has been implicated in the development of herbicide resistance in some weeds (Vila-Aiub et al. 2008). In response to this resistance, farmers may increase the application of the herbicide, which increases production costs as well as the likelihood that the toxic residues will remain after harvest. One test of soybeans

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[4] GMO Compass, an EU-funded information clearinghouse presents a time series of data from Brazilian soy up to 2009, at which time they estimate 71 % of the crop consisted of GM varieties, and appeared to be in an upward trajectory going forward (Compass 2010).

conducted in Paraná found glyphosate residues in 70 % of sampled beans; of these, 5 % exceeded the legal limit of 10 mg/kg (Fernandes 2009).

There also are numerous cases of contamination, in which RR varieties of soybeans are inadvertently mixed with non-GM crops (Fernandes 2009). The contamination occurs through a variety of pathways and has several negative consequences. For example, farmers may opt to cultivate non-GM varieties in order to target specific markets that desire non-GM products. European importers pay a premium for non-GM soybeans. Similarly, organic producers, who must follow a wide range of production practices in order to be certified, also obtain a premium for their product. In both cases, contamination can cost farmers access to these premiums, and lead to financial losses.

Contamination can also lead to legal battles. For example, RR cultivars are patented by the agribusiness giant Monsanto, which charges a 2 % royalty to farmers who plant them. The company also tests Brazilian soybeans marketed by farmers as non-GM and, if it finds RR varieties, charges a 3 % royalty to those farmers (Massarani 2012). This charge is levied regardless of whether the RR varieties were planted intentionally, or if they contaminated a farmer's non-GM harvest. In 2009, some 5 million small- and large-scale farmers filed a lawsuit against Monsanto, petitioning for the return of all royalties collected since 2004, which by then exceeded 2 billion dollars. A judge in Rio Grande do Sul decided in favor of the farmers and ordered Monsanto to reimburse them, but the firm appealed. The case is now in Brazil's federal courts, pending a decision in 2014 (MercoPress 2012).

4.3.3 Soy and Social Inclusion

In addition to impacts on deforestation and widespread use of GM crops, heavy reliance on soybeans as a biodiesel feedstock raises numerous concerns about social sustainability. Soybean production has been associated with large-scale land concentration and conflict (Steward 2007; Sheis and Swette 2012; Wilkinson and Herrera 2010). Analysts have recorded instances of land sales under coercion as well as outright appropriation, including soy-based land acquisitions in indigenous territory (Gomes et al. 2009b; Sheis and Swette 2012).

Even in the absence of overt conflict, there are questions about the degree to which soybeans are compatible with social inclusion in biofuel production. For example, soybean cultivation has the lowest rate of participation by family farmers among all agricultural production (Table 4.2). Production is heavily skewed towards large landholders. Three-quarters of the revenue from soybean sales is captured by the top 10 % of landholders, who plant an average of 500 ha (IBGE 2007a). In contrast, castor, which was singled out by PNPB because it is well suited to smallholder production, has average plots sizes of just 4–5 ha. Three-quarters of castor producers plant fewer than 20 ha and those small-scale farmers capture nearly 60 % of the total revenue generated by seed sales (IBGE 2007a).

Table 4.2 Relative contribution to agricultural production by family and corporate farmers in 2006. (DIEESE 2011)

	Family farmers (%)	Corporate farmers (%)
Crops		
Manioc	87	13
Cowpeas	84	16
Black beans	77	23
Robusta coffee	55	45
Red beans	54	46
Maize	46	54
Arabica coffee	34	66
Rice	34	66
Wheat	21	79
Soybeans	*16*	*84*
Livestock		
Dairy goats	67	33
Pigs	59	41
Dairy cows	58	42
Poultry	50	50
Cattle	30	70

Although soybeans cover ~35 % of Brazil's land under annual crops, the sector accounts for only 8 % of employment in annual crop farming (IBGE 2007a). Indeed, soybeans are cultivated with such a high degree of mechanization that employment in soy cultivation is among the lowest of all Brazil's agricultural products, including cattle production. This is demonstrated in Fig. 4.6, which shows absolute levels of family and nonfamily employment in Brazil's major agricultural sectors, as well as employment per hectare of land occupied by each activity.

4.4 Geographic Distribution of Feedstock Production and Refining Capacity

The dominance of soy oil as a feedstock has led to a concentration of biodiesel production in soy-growing regions of the South, Southeast, and Center-West (Fig. 4.7). Collectively, those three regions have accounted for 86 % of cumulative biodiesel production through mid-2012. Nevertheless, by favoring certain regions to achieve its objective of geographical and social inclusion, PNPB did lead to investment in places that would have been unlikely to see such investment in the absence of the program (Hall et al. 2009).

The North and Northeast regions of Brazil are less developed than the South and Southeast regions (PNUD 2012). In addition, Northern states, together with the Mato Grosso and Maranhão, constitute the LAR, which is a vast and sparsely populated area. Lack of access to energy places constraints on development in the region (Andrade and Miccolis 2010). Lack of transportation networks results in high energy costs (MME 2012b) and many isolated settlements utilize diesel-fueled

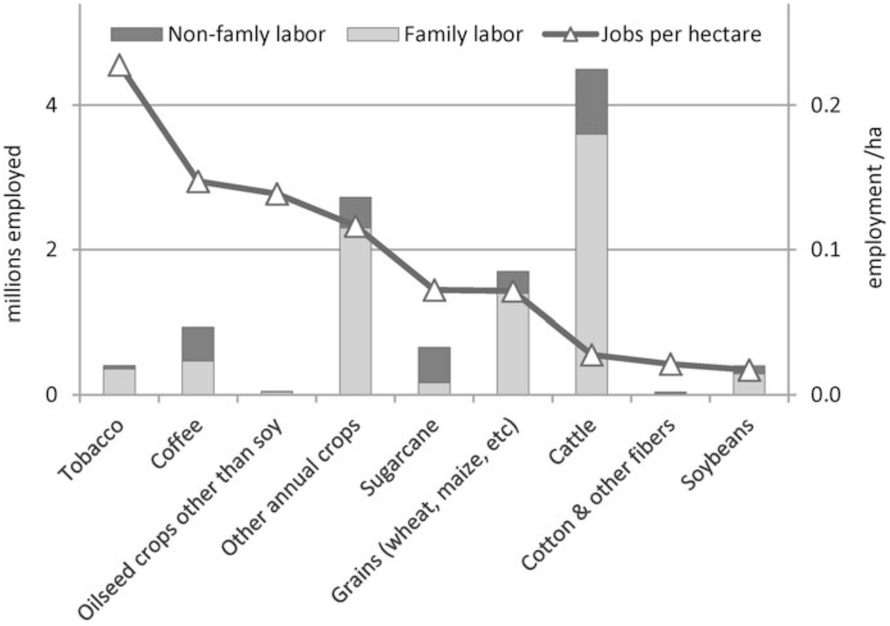

Fig. 4.6 Agricultural employment in different agricultural sectors in 2006. (Source: IBGE 2007a)

generators to provide electricity. There have been several efforts to utilize oil palm or native palms as an alternative source of fuel (Gomes et al. 2009a), which can work in concert with the exploitation of these fuels as biodiesel feedstock.

For example, in 2011, there were 51 active refineries in Brazil. Of these, 10 are situated in the North or Northeast (MME 2012a). These refineries produced about 15 % of that year's total output. Like refineries in the rest of the country, refineries in the North and Northeast rely on soy oil for some of their feedstock (MME 2012a). However, the regions produce just 10 % of the country's soy, and some refineries import soy oil from other parts of the country, which increases costs and creates environmental burdens.

Nevertheless, because PNPB incentivized investment in refining capacity in the North and Northeast, the infrastructure is now in place to take advantage of feedstocks that might be more suitable than soy in those regions. Indeed, in recent months, the mix of feedstock used in the North and Northeast has been more diverse than the mix of feedstock in some other parts of the country. For example, through the first half of 2012, beef fat comprised 40–60 % of raw materials in Northern refineries and cottonseed oil comprised 20–40 % of feedstock in the Northeast (MME 2012a). Interestingly, oil palm, which has been promoted as a potentially suitable biodiesel feedstock (Andrade and Miccolis 2010; Lapola et al. 2010; Souza 2009), has contributed very little to Brazilian biodiesel. We examine oil palm and other alternative feedstocks in more detail below.

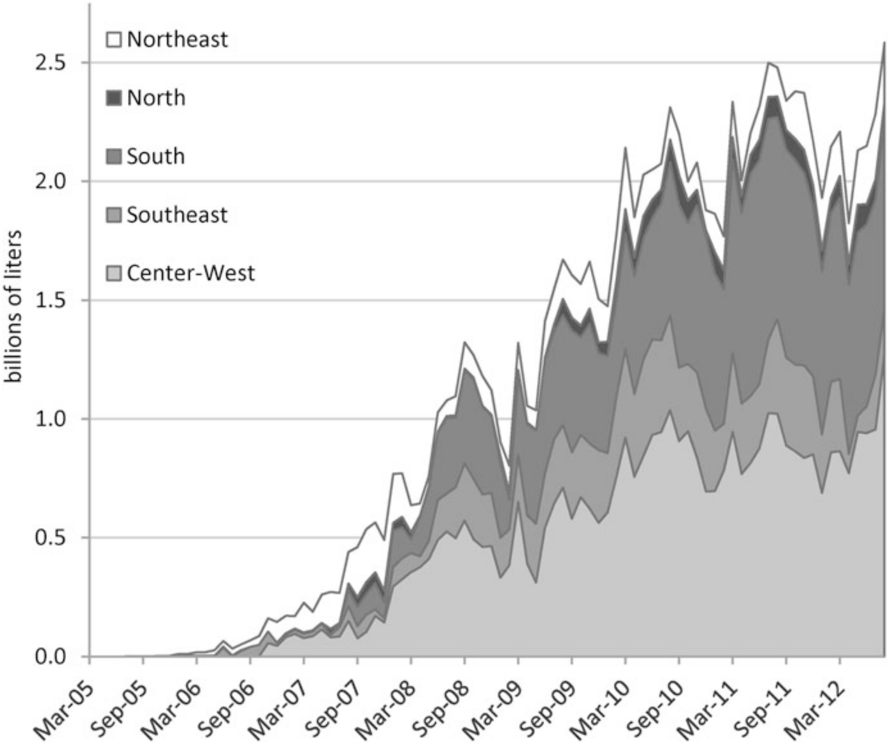

Fig. 4.7 Brazilian biodiesel production by region from March 2005 to August 2012. (Source: ANP 2012)

4.5 Alternative Biodiesel Pathways for Brazil

An understanding of the impacts associated with soybeans has motivated multiple efforts to develop other feedstocks and/or fuel processing pathways, which may lead to more sustainable outcomes. As was discussed above, PNPB created specific provisions favoring castor beans and oil palm, particularly in the North and Northeast Regions of the country.

4.5.1 Castor, Ricinus communis

Castor is a fast-growing perennial shrub in the Euphorbia family that is often planted commercially as an annual crop (NTBG 2012). The toxin ricin is present throughout the plant, making it unsuitable for food or feed applications, but it has a variety of medicinal and cosmetic uses, as well as industrial applications. It can grow in a wide range of conditions, including semiarid environments, and has been planted in

Brazil's semiarid Northeast region for decades (mainly Bahia and Ceará). Between 2005 and 2011, farmers planted an average of 180,000 ha (compared to over 200 million ha of soy). In addition, as was mentioned above, castor is well suited to family farm production. Plot sizes tend to be distributed evenly across different size landholdings, and revenues are not concentrated among large plantation owners as with soy.

Despite its suitability for family farmers and special status under PNPB, very little castor oil has been utilized for biodiesel production in Brazil. Prevailing prices for castor oil, though volatile, tend to be higher than soy (IBGE 2012a), which makes it costly to use as biodiesel feedstock. Moreover, prices, though higher than soy, are not always enough to cover castor's higher production costs (Kouri et al. 2006). As a result, cultivation has declined considerably since the 1980s and has been erratic since PNPB was implemented (FAOSTAT 2012; IBGE 2012a).

4.5.2 Oil Palm, Elaeis guineensis

Like castor, oil palm is singled out with favorable policies by PNPB. However, in contrast to the downward trend in castor production, Brazilian oil palm is on an upward trajectory. Between 2005 and 2011, the area under oil palm increased by 23 % while production increased by 44 % (IBGE 2012a).[5] In 2011, there were roughly 109,000 ha under oil palm plantations nationwide. The planted area is split more or less equally between Pará, within the Amazon biome, and Bahia, in the Northeast. However, due to much higher productivity in the moist Amazon region, Pará accounts for over 80 % of the country's oil palm production.

Oil palm is highly productive and can yield more oil per hectare than other oilseeds when planted in suitable areas (Bilich and Da Silva 2006). In addition, it has low production costs and fruits can be harvested year-round, making it nicely suited to industrial biofuel production. However, despite these favorable characteristics, very little palm oil has been used for biodiesel production in Brazil. One refinery, built by Agropalma, Brazil's largest oil palm producer, ceased production in mid-2010 (ANP 2012) citing low prices offered for biodiesel at the ANP's auctions, which made it impossible to cover their operating costs (Inacio 2010). Moreover, international prices for palm oil have been relatively high, meaning that there is a large opportunity cost if palm oil is utilized as biodiesel feedstock rather than utilized in other markets (Andrade and Miccolis 2010) .

In addition, in Malaysia and Indonesia, which collectively produce over three-fourths of the world's oil palm, plantations have been implicated in deforestation, large emissions of terrestrial carbon, and tremendous loss of biodiversity, as well as a host of negative social impacts (Koh et al. 2011; Koh and Wilcove 2008; Carlson

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[5] New plantations take up to 7 years to their maximum yield; thus the larger increase in production relative to planted area reflects yields from planting that occurred prior to this period.

et al. 2012). Thus, much like soybeans, oil palm raises numerous challenges for sustainable biofuel production.

Further, oil palm faces a number of logistical, biophysical, and economic barriers to broader implementation as a biodiesel feedstock, particularly for family farmers (Andrade and Miccolis 2010):

- Unlike soybeans, which can be stored for extended periods and shipped long distances, palm oil needs to be extracted within 24 h of harvest, which means that extraction facilities need to be located close to plantations.
- Smallholder plots must be located close together to facilitate transport and ensure the supply of sufficient fruit bunches for extraction facilities to be economically viable.
- Oil palm has a high potassium demand. Mature stands require over 200 kg/ha (Corley and Tinker 2008). Brazil lacks a substantial domestic supply of potash (potassium chloride—the main source of potassium-based fertilizers), and currently imports roughly 90 % of its requirements (IFA 2009). Thus, oil palm cultivation is dependent on imported resources.
- Despite relatively low long-term production costs, plantation establishment costs are high and income streams are delayed until the stand matures (5–7 years), tying up land and making investment risky for family farmers.
- Oil palm is susceptible to bud rot, particularly when planted in very wet locations. The disease has had major impacts on oil palm in neighboring Colombia (Maughan 2011).

Despite these challenges and the lack of current use as biodiesel feedstock, investment in oil palm continues. The projected growth of oil palm plantations and the high yields of oil that plantations deliver indicate that oil palm will very likely play a future role in Brazil's biodiesel industry. Even if it is not used directly as biodiesel feedstock, the United States Department of Agriculture (USDA) notes that as palm oil supplies increase, it may play an *indirect role*; as it is increasingly used in food processing, palm oil will "free up additional soybean oil for biodiesel" (USDA FAS 2012a, p. 8).

4.5.3 Other Potential Biodiesel Crops

In addition to castor and oil palm, numerous other crops have been put forward as potential biofuel feedstock, including some that may be more suitable for family farmers, although none are mentioned explicitly in PNPB. These include oils from crops that are already utilized in other markets like cottonseed, sunflower, and peanuts, as well as novel crops like *Jatropha curcas* and native palm species like babaçu (*Orbignya phalerata*) and macaúba (*Acrocomia aculeata*).

Jatropha underwent a mini-boom in Brazil soon after PNPB was enacted, which included interest from researchers and government extension services as well as investments in several large plantations. By 2009, there were $\sim$40,000 ha planted and investors had ambitious plans to expand well beyond this (GEXSI 2008; Bailis and Baka 2010). However, many of the early plantations underperformed and markets contracted with the global financial crisis. As a result, the initial enthusiasm for *Jatropha* waned. In addition, research in Brazil and elsewhere showed that *Jatropha* may not be as suitable for family farmers as initially claimed (Finco and Doppler 2010; Baka 2011). Despite these setbacks, actors in Brazil still demonstrate some interest in *Jatropha* as a biofuel feedstock, although their interest is focused more on aviation fuel than on biodiesel. [6] Recent activity includes large-scale trials using hybrid varieties that are expected to perform better than varieties planted earlier, as well as silvipastoral production systems (Bailis and Kavlak 2013).

Native palms like babaçu and macaúba populate large areas of the Amazon and Cerrado biomes (Clement et al. 2005). They have multiple uses and may be exploited by local communities to access the oil, starch, and/or protein from different components of the fruit either for home use or commercial sale. These native palms have received some interest as potential biodiesel feedstock. Projected yields in commercial plantations rival oil palm (*Elaeis guineensis*), and the fact that they are native species that occur naturally, often in large monospecific stands, means that they may be more suitable to large-scale commercialization than either soy or oil palm. Nevertheless, both research and investment are still very limited and widespread commercialization is many years off.

4.6 Prospects for Sustainability in Brazil's Biodiesel Industry

In just eight years, Brazil has created a biodiesel program that produces enough fuel to displace 5 % of the country's diesel demand, making it the fourth largest producer worldwide. The policies underlying the program promote social inclusion as well as environmental sustainability and economic viability (Flexor et al. 2011). The industry met the mandated B5 blend well ahead of schedule, and perhaps the ease with which the mandate was met is an indication that the system is indeed economically viable. However, the industry is on a path that renders it very heavily reliant on soybeans, which makes it doubtful that the program can meet its social and environmental objectives. Although biodiesel represents a small fraction of the nation's massive soy complex (Fig. 4.4), it is an inextricable component of the industry and, as such, it is inherently part of the large-scale deforestation that threatens the sensitive Cerrado and Amazon biomes. It is also associated with numerous negative social impacts and appears to have minimal promise for small-scale family farmers. These observations lead to several questions concerning the sustainability of Brazil's biodiesel program going forward: What are the future prospects for the soy industry itself? What is the outlook for other crops that might be used alongside or, in place of, soy?

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[6] Although both rely on oleaginous feedstock, biodiesel production is quite distinct from bio-kerosene, which is used as a substitute for jet fuel (see IATA 2008 for details).

As was discussed above, Brazil took steps, via the soy moratorium, to address the most egregious environmental impacts that the crop's rapid expansion was having on land cover in the Amazon. The moratorium addressed direct deforestation induced by soy production, but did nothing to reduce indirect impacts, which is more difficult, because it requires action from a broader set of actors. Other sustainability governance mechanisms relevant for soy-based biodiesel such as the Roundtables for Sustainable Biofuels and Responsible Soy (RSB and RTRS—both introduced in Chap. 2) also target direct deforestation, but do little or nothing to address indirect effects.

However, Brazilian deforestation cannot be addressed by only targeting activities of a single sector of the economy. Brazil's primary attempt to govern its forest resource is through the "Forest Code" (Government of Brazil 1965). In place since the 1960s, it calls for conservation set-asides of 80 % in areas within the forested zone of the LAR, 35 % in the Cerrado zones, and 20 % in the rest of the country. In many areas, these regulations were flouted for decades, but a recent increase in enforcement is credited, along with the soy moratorium, with slowing deforestation since 2004 (Nepstad et al. 2006). The Forest Code was recently revised, with some elements weakened by policymakers in favor of agricultural development, but a presidential veto preserved the set-aside requirements (Tollefson 2012). Additional institutions have emerged that make it possible to exchange "Forest Reserve Credits" between farmers who are out of compliance with their set-aside requirement and those who have an excess of set-aside land (BVRio 2012; Stecker 2012).

Socioeconomic sustainability of soy production touches on two important issues. One is the notion of social inclusion that is explicit in the PNPB. The second, perhaps more basic, relates to avoiding damages and violations of rights from soybean production, which is not stated explicitly in PNPB, but is addressed by numerous other laws regulations. Social inclusion arises because inequality has characterized Brazil's rural landscape for decades. Sustainability in Brazil's soy-based biodiesel production requires attention be paid to the inequalities that the soy complex appears to reinforce. Dominated by highly mechanized production and large landholdings, soy does not appear to be a pathway out of poverty for small family famers. Of course, there are exceptions; perhaps some lessons can be drawn from family farmers in Rio Grande do Sul, who participate heavily in *Selo Social* and earn substantial revenue selling soybeans to biodiesel producers (DIEESE 2011). However, family farming is very different in the South, which is relatively wealthy, than in the less developed regions of the North and Northeast. They may have larger landholdings, more secure tenure, and better access to credit. This may explain why family farmers participating in *Selo Social* in the South earn over 10 times as much from sales to biodiesel facilities than families in the Northeast (DIEESE 2011).

Moreover, where it already has strong foothold, highly mechanized soy cultivation on large landholdings is unlikely to cede to smaller-scale mixed cropping utilizing more labor-intensive production; costs are higher and logistics are more complicated. Beyond satisfying the minimum percentage of feedstock certified with the *Selo Social* (which varies regionally as described in Sect. 4.2, biofuel refiners have little incentive to favor family farmers over large-scale producers.

Brazil has numerous laws in place to avoid damages and violations of rights from agricultural production, including soybeans. Nevertheless, rights infringements and damages have been documented, particularly in "frontier" regions of the North and Northeast (Bolaos 2011; Gomes et al. 2009b; Steward 2007; Sheis and Swette 2012). Clearly, there is a lack of enforcement of existing laws, which, like environmental laws, is often weak. In addition, international voluntary standards like RTRS and RSB, as well as domestic initiatives like "Soja Plus" (Rodrigues 2011), include principles and criteria that target issues like Indigenous people's rights, land tenure, and labor conditions. If national laws may go unenforced, it is possible, though not guaranteed, that market pressures will influence producers to conform to these governance standards and demand enforcement of the principles that they espouse.

Similar questions arise for other crops. Anything cultivated at a volume sufficient to displace 5 or 10% of Brazil's diesel demand is likely to have substantial social and environmental impacts. However, each crop has specific characteristics that could create substantially different outcomes than soy-dependent biodiesel. For example, Lapola and colleagues estimate that meeting Brazil's future biodiesel demand in 2020, using palm oil as feedstock, would require just 4 % of the land area that would be needed if future demand was met by soy (Lapola et al. 2010). Oil palm is also more suitable than soy for smallholder production provided that the high initial costs and various logistical barriers described earlier can be overcome. Some types of native palms discussed earlier are thought to have yields similar to oil palm if planted commercially, but little research has been carried out to understand if these are truly viable options. Some work is underway, but it pales in comparison to the efforts that have gone into creating Brazil's soy complex. Indeed, soy's current position, both as a dominant source of livestock protein and biodiesel feedstock, may create so much momentum that any alternatives are not given serious consideration, regardless of whether they present better prospects for land-use efficiency or suitability for family farming.

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Chapter 5
Argentina

Jorge A. Hilbert and Sofia Galligani

Abstract Soybean production is embedded within a productive system that cannot be analyzed on its own. Several political and market factors, both nationally and internationally, explain the development and growth of soybean production throughout the globe. In the case of Argentina, the evolution of the agricultural system of soybean production has been characterized by continuous technological improvement. This has changed the entire agricultural system and set the base for society's growing demands for environmental and socially responsible goods, including most recently biodiesel. An advancement of regulatory context has allowed for better control of the future development of land usage. In Argentina's case, the Minimum Standards for the Environmental Protection of the Native Forests Act is an example toward that direction. The Argentine soy industry is one of the most dynamic economic sectors of the country, generating almost 30 % of the foreign currencies income due to exports and representing almost 30 % of gross domestic product (GDP) from the agro-industrial sector. Argentina has until recently been the world's leading exporter in soybean oil, soy meal, (soy) biodiesel, and the third highest in soybeans. However, policy changes in 2012–2013, especially an imposition of import duties by the European Union on Argentine biodiesel, have almost paralyzed the sector. Thus, the future expansion of this industry in the country is heavily dependent on internal and external changes in policies and is thus uncertain.

5.1 Introduction

The biofuel industry in Argentina has made great progress in a short time, occupying an important place in the world regarding its production and exports. The evolution of this activity in Argentina is linked with the creation and evolution of a specific

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regulatory framework. This fostered biodiesel as an important subproduct from the already vast soybean production complex and has led to Argentina's global leadership in biodiesel exports. This chapter focuses mainly on the biodiesel sector, since ethanol production is negligible in the country. However, soybean production is embedded within a production system that cannot be analyzed on its own. Several political and market factors explain the development and growth of soybean production throughout the globe. Over the last several decades, soybean cultivation in Argentina has had unprecedented growth. Since the 1970s, implanted areas have grown from 37,000 hectares in the 1970–1971 growing season to more than 17 million hectares today. The growth is probably linked to soybean meal demand from emerging economies and the European Union (EU) after the bovine spongiform encephalopathy ("mad cow disease") outbreak in the late 1980s (FAO 2007; Hilbert et al. 2011).

The Argentine soy industry is one of the more dynamic economic sectors of the country, generating almost 30 % of the foreign currencies income from exports and representing almost 30 % of gross domestic product (GDP) from the agro-industrial sector. The 2012 soybean harvest across the country was around 40.1 million tonnes. Argentina is the leading exporter of soybean oil; the production was estimated to be more than 7.5 million tonnes, with more than 5.2 million tonnes exported, which had an estimated value of more than US$4.3 billion before taxes. China and India are the main importers, purchasing more than 80 % of Argentina's exports. Argentina is also the leading exporter of soy meal, with production estimated at more than 30 million tonnes, of which 29.5 million tonnes were exported, accounting for a value of more than US$10 billion before taxes (Ministry of Agriculture 2012). The EU imports nearly 40 % of the soy meal exported by Argentina. At the later stage of soybean market expansion, producers started to create an added value product from the soybean supply chain—biodiesel. Argentina has quickly become one of the leading producers and the largest exporter of biodiesel, with a production of 3 billion liters in 2012 (Joseph 2012).

In the past decade, the agricultural system has adapted to growing societal and market demand for environmental and socially responsible goods. For social and environmental considerations, institutions are also crucial for both public and private sectors (Diaz-Chavez 2011). Argentina has an important and sophisticated network of institutions related to agriculture and agribusiness, which has had to adapt toward increased social and environmental awareness.

5.2 Ethanol Complex Outlook

Until 2012, 100 % of the ethanol produced in Argentina came from sugarcane, with production concentrated in the north of the country (Tucumán: 70 %, Salta and Jujuy: 30 %). Their main target was not biofuel production, but to supply to food industries, beverages, cosmetics, and agrochemicals. Production of ethyl alcohol from sugarcane was 310,000 m^3 during the 2011–2012 harvest. The quota granted by the Ministry of Energy is 210,691 m^3 for ethanol to be blended with gasoline in 2011.

The quota was distributed among 11 sugar companies, with Ledesma (48,996 m^3), Tabacal (39,500 m^3), and Florida (39,000 m^3) concentrating on 60 % of the domestic market share.

Argentina's ability to significantly expand the area planted with sugarcane and increase production volumes of ethanol is quite limited, since soybean production dominates cultivated land. The area planted with sugarcane could grow, though not significantly, and cane alcohol production could also be increased at the expense of the production of sugar for export. Thus, to respond to projected demand, Argentina has been building five new ethanol plants that use maize as the feedstock, which will increase production capacity to 720 million liters by the end of 2013 (Joseph 2012). As a result, maize will be used to produce 30 % of the country's ethanol in 2013, with the rest derived from molasses and sugarcane. Ethanol production in 2013 is projected to reach a record 400 million liters and could supply 5 % of all fuels by 2014 (Joseph 2012).

5.3 Soybean Complex Outlook

According to the US Department of Agriculture (USDA), 93 % of planted soybean seed is genetically modified (GM) in the USA, expanding from only 8 % in 1997. In Argentina, the growth rate has been similar. In 1996, GM soybeans were approved in the country, specifically Roundup Ready (RR) soy.

Argentina has an important and sophisticated network of institutions related to agriculture and agribusiness. These include INTA (Instituto Nacional de Tecnología Agropecuaria), AACREA (Asociación Argentina de Consorcios Regionales de Experimentación Agrícola), PROSOJA and AAPRESID (Asociación Argentina de Productores en Siembra Directa), which focus on primary production, whilst INTI (Instituto Nacional de Tecnología Industrial), ACSOJA (Asociación de la Cadena de la Soja de Argentina), ASAGA (Asociación Argentina de Grasas y Aceites), and CARBIO (Cámara Argentina de Biocombustibles) are more orientated toward agro-industry and agribusiness (Hilbert et al. 2011).

There has been growing concern about sustainability coming from both the public (municipal, provincial, and federal governments) and private sectors. The development of this trend has been institutionalized through the Social Responsibility Institute (IARSE), with specific tools to address this important issue (Diaz-Chavez 2011). There are important advances that have been reflected in concrete actions such as good agricultural and agro-industrial practices, certified agriculture, certification biofuel schemes, for example, CARBIO, membership in Global Bioenergy Partnership (GBEP), and engagement with several voluntary multi-stakeholder initiatives (see Chap. 2), as well as regulatory advances allowing for better accountability and management of land usage.

The social and economic aspects of biofuel development are important. No conflicts are presented regarding food/fuel tradeoffs from soybean oil use for biofuel, since the industry is based on a food production coproduct (animal feed), which has

Table 5.1 : Production and estimated US$ value taxed within the Argentine soy complex for the 2010–2011 harvest (source: adapted from Ministry of Agriculture (2012))

Export Tax			
Product	Produce in million tonnes	Average FOB price (June 2009–June 2010)	Estimated value in US$
Soybeans	4,375,000	374	1,636,541,667
Soymeal	1,664,000	346	575,633,067
Soybean oil	9,456,000	824	7,793,004,800
Soy Biodiesel	238,000	838	199,498,740
Total	15,733,000		10,204,678,273

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a lower dietary value based on modern medical recommendations. In addition, the soybean industry delivers a large amount of resources to the nation. According to Table 5.1, the public sector received more than US$10 billion from the soybean sector collected via the differential export tax (DET) levied on more than 15 million tonnes of products. The revenue collected by the DET represents nearly 4 % of Argentina's GDP. Around 30 % of the total soybean fund is directly distributed between all the provinces. Additionally, the soy industry accounts for nearly 30 % of the total export tax collected by the government.

Environmental dimensions of soybean cultivation are also critical. Currently, over 82 % of soybean production uses no-till agriculture, along with other modern technologies such as precision agriculture. This gives an important advantage in greenhouse gas (GHG) emissions savings and energy balance. According to studies by INTA, GHG savings from such farming technologies range between 72 % and 80 % (Hilbert et al. 2011). This is discussed further in Sect. 5.6.2.

5.3.1 The Biodiesel Sector

The Argentine biodiesel sector has developed based upon the described production complex and industrial transformation. Economies of scale and the efficiency of the soybean supply chain are exploited to make the Argentine biodiesel a competitive product, despite the increase in soy biodiesel's DET compared to soybean oil, from a low of 14 % in 2008 to a much higher though variable rate in 2012. The export rate was hiked in order to make the domestic fuel more affordable. Agriculture in Argentina is regulated with taxes being paid by the sector in different stages of the supply chain. The commerce is subject to export charges, primarily an export tax for biodiesel (DET), with tax fluctuations according to the government's criteria also being the case with soybean. Table 5.1 shows this public revenue.

The refineries responsible for the principal market share of biodiesel are characterized by their high scale and efficiency. Most are located beside the processing complex and ports (Rosario city, Santa Fe Province), which lowers energy use and emissions. Raw materials typically come from a radius of 300 km or less, which also helps to increase efficiency. At a later stage of the biodiesel industrial development, small- and medium-sized enterprises started building up in peripheral regions. The

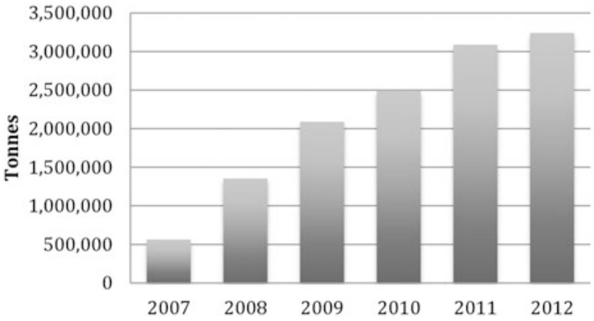

Fig. 5.1 Argentina's soy biodiesel installed capacity. (Source: adapted from Ministry of Agriculture (2012))

enterprises that share a small part of the national market of 50,000 tonnes (2012 estimates) are not concentrated in Santa Fe (AACREA 2005).

New biorefineries were developed to produce not only biodiesel but also higher value products like glycerin as coproducts. This increases the benefits and the country's income. Large national companies (the oil manufacturers, General Deheza, Vicentin and Eurnekian Citrusvil[1]) and transnational corporations (Dreyfus, Glencore, and Bunge) built industrial plants with a capacity exceeding 225 million liters per year[2]. Such volumes can be competitive in the global market. They also participate in the internal market: the national obligation to add 5 % of biodiesel to total diesel fuel could not have been achieved by 2010 without the contribution of these plants.

The installed capacity growth rate reflected a positive outlook that the product had before the new import restrictions were put in place by Spain and the EU in 2012 (see below) and the DET rate was increased within the soybean biodiesel sector (Hilbert et al. 2011). In 2012, there were 26 biodiesel refineries authorized by the Department of Energy's Office, with an installed capacity over 3.2 million tonnes (Fig. 5.1). Additionally, 11 plants are under construction with an aggregate capacity of over 1 million tonnes; thus, projected capacity will exceed 4.2 million tonnes by the end of 2013 (García Kairuz 2012).

The growth of the soybean biodiesel sector has been rapid over the last few years. Moreover, although capacity utilization was relatively low at just 60 % in 2009, utilization rates have significantly increased since 2010, with the new demand in the internal market due to the mandatory blend requirement.

However, a significant market development occurred in May 2013, when the EU expanded its import restrictions on biodiesel. Following initial efforts by Spain to restrict biodiesel imports from Argentina, the EU imposed provisional tariffs for at least 6 months on biodiesel imports from Argentina and Indonesia (Stearns 2013). The EU claimed that the two countries were dumping their products below cost,

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[1] This group installed a biodiesel plant near its soy oil factory (at Frías, Province of Santiago del Estero), becoming the only megaplant located far from Rosario.

[2] On an average, Argentina biodiesel factories have a capacity of 135 million liters per year. By comparison, the Brazilian and European factories can process an average of 80–100 million liters per plant per year.

illegally subsidizing exports, and causing material damage on European producers. Also in mid-2013, the EU was considering imposing separate antisubsidy duties on biodiesel from Argentina. The provisional levies on Argentine producers are as high as 104.92 euros (US$135.46) per tonne, compensating for the DET. Similar duties were imposed on US biodiesel in 2009 (Stearns 2013; also discussed in Chap. 11). The Argentine government, by contrast, has referred to this recent action by the EU as protectionism. These actions have nearly paralyzed biodiesel exports from Argentina to Europe. Currently, with no alternative markets for surplus soybean oil, the product has to be sold at low prices competing with other alternative oil with heavy discounts.

5.4 Industrial Structure and Land Use

The traditional agricultural production model was based on leased or purchased land utilized for vertically integrated agro-industrial production requiring significant capital investment. An alternative model is based on a "no verticality" way of producing and outsourcing the production. It has five pillars (Hilbert et al. 2011; Rossi 2006):

1. Separation between land ownership and companies that use the land for production purposes. The contractors are the dynamic actors in this kind of model. In parallel, a large number of service/inputs providers appear. Given the new demands that the companies may have, it means that a new web of producers, contractors, and service/inputs suppliers are formed
2. Involvement of other companies, that coordinate financial capital, decides which activities to develop and hire land and labor associated with production
3. All of the transactions are by contract
4. Incorporation of state-of-the-art technology
5. Separation between the location where production occurs and the labor supply working the land. Internal migration is high during the farming season, generating a large number of people traveling throughout the country and, in this manner, helping various regional economies due to increased employment and consumption

The traditional way of farming had an important transformation in Argentina, with consequences for the land concentration and organization of farmers. In the first place, in addition to traditional farmers, new actors entered the business to rent the land, largely national firms. Owners of the land either cultivate or rent it, receiving the benefits from soybean production, although income is shared with the renters and government. This is known in Argentina as "two layer" beneficiaries (Aizen et al. 2010). In addition to these traditional actors, the evolution of the agricultural production system in Argentina and positive returns produced new forms of associations and actors.

Planting or farming groups are associations of different actors that may or may not be from the agricultural sector. They invest in farming production and share the

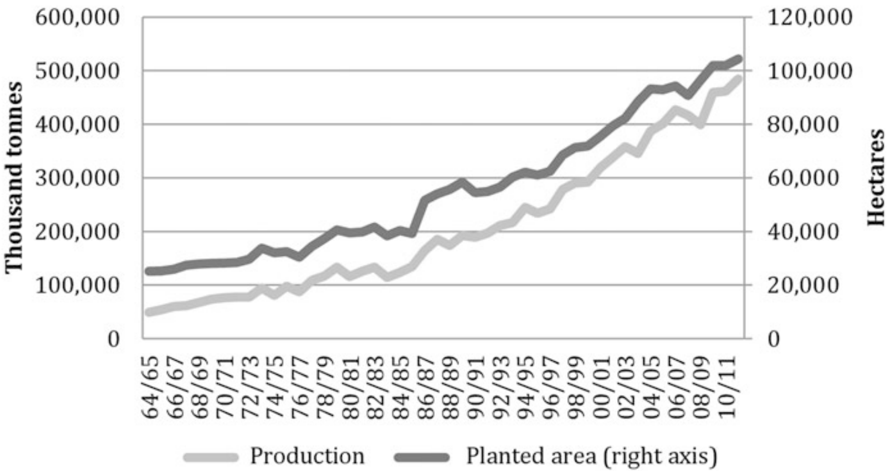
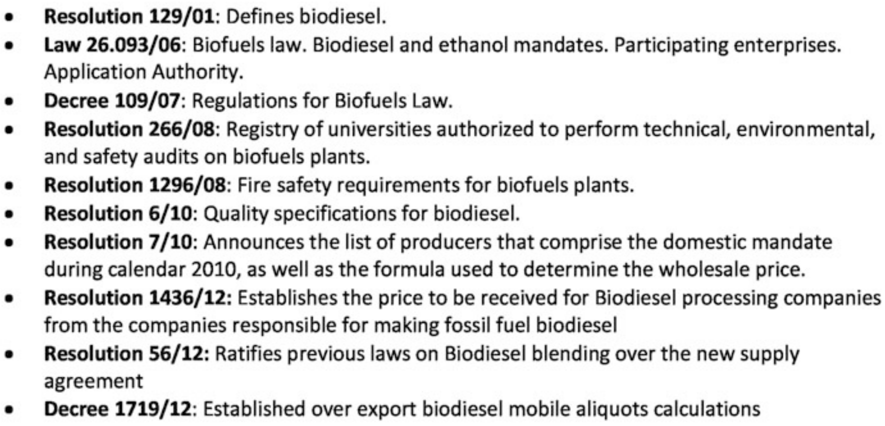


Fig. 5.2 Production and planted areas of soy. (Source: authors' elaboration with USDA's PSD database information; Hilbert et al. (2011))

net benefits after harvesting. These actors inject a new dynamism into rural areas, since they stimulate the whole chain of primary production and enable landowners to receive increasing revenues from renting their land, preventing them from selling, and losing their participation (Aizen et al. 2010; Rossi 2006).

The extraordinary growth of soybean production is correlated with the expansion of cultivated areas in Argentina. Nevertheless, it is worth noting that the growth in cultivated areas has been lower than the growth rate in production, as shown in Fig. 5.2. This reflects the success in the intensification of soybean production caused by improved agronomical techniques, genetic material, and farm machinery improvements. Other factors contributing to intensification include the no-till farming system and the introduction of GM soybeans, which also led to increased applications of the herbicide glyphosate (discussed in more detail below). Additional factors are in the pipeline, such as integrated pest management and precision farming. When this growth started there was no biodiesel production capacity, and thus soybean meal was the main expansion driver (Panichelli 2012).

There is also clear evidence that the expansion of soy cultivation has affected areas that were previously unexploited for agriculture. Nevertheless, such land-use change is also caused by the expansion of pasture for livestock. Several hypotheses are possible in order to explain the difference between the agricultural and livestock land use, including the emergence of feedlots as an alternative for cattle breeding in Argentina, liberating land for higher income agricultural production. During the past several years, government policies to keep meat prices artificially low, along with drought conditions, caused a large decrease in cattle heads, which had a significant impact on conversion of land for agricultural usage, especially soybean production (Hilbert et al. 2011).



- **Resolution 129/01**: Defines biodiesel.
- **Law 26.093/06**: Biofuels law. Biodiesel and ethanol mandates. Participating enterprises. Application Authority.
- **Decree 109/07**: Regulations for Biofuels Law.
- **Resolution 266/08**: Registry of universities authorized to perform technical, environmental, and safety audits on biofuels plants.
- **Resolution 1296/08**: Fire safety requirements for biofuels plants.
- **Resolution 6/10**: Quality specifications for biodiesel.
- **Resolution 7/10**: Announces the list of producers that comprise the domestic mandate during calendar 2010, as well as the formula used to determine the wholesale price.
- **Resolution 1436/12:** Establishes the price to be received for Biodiesel processing companies from the companies responsible for making fossil fuel biodiesel
- **Resolution 56/12:** Ratifies previous laws on Biodiesel blending over the new supply agreement
- **Decree 1719/12**: Established over export biodiesel mobile aliquots calculations

Fig. 5.3 Legal and regulatory framework for biodiesel

5.5 Biofuel Policy Framework

Argentina's biodiesel market, as in the rest of the world, is dependent on government policies. This has generated further demand growth for biodiesel since 2007. Argentine Biofuel Law Number 26.093 was enacted in May 2006, creating a special regime for 15 years that mandated a 5 % blending requirement for diesel fuels (B5). For this to be incremental, in 2010, the production incentives were enforced and increased to 7 %. The reason for government action to stimulate biodiesel production was the need for alternative fuel options in order to reduce Argentina's dependence upon imported oil. At the same time, a global biofuels industry had already been launched, and many large consumers, such as the EU, Brazil, and the USA, had already established ambitious targets (Cámara Argentina de Energías Renovables 2010). However, some of these targets may be changed and restrictions on imported biofuels are possible (see Chaps. 1, 3, 4, and 11; Fig. 5.3).

While the 7 % biodiesel mandate has increased the demand, it was more profitable to produce biodiesel for export until the DET rate was increased in 2012. The Argentine private sector, led by the large oilseed crushers, saw a market opportunity and was among the first to build large biodiesel plants, typically using world-class technology and focusing on export markets. Argentina has developed its export market ahead of the domestic one, driven by an abundance of feedstock, comparatively smaller domestic markets, and a desire to generate hard currency through exports.

Exports from the soybean complex, consisting of soybeans, oils, meal, and soy pellets, are the country's most profitable export complex. This is relevant to the national budget collection given the export duties levied on them. In the period 2005–2010, there was an increasing trend in the export value from the complex. It is interesting to consider the evolution and implications regarding the DET and budget collection. There has been a notable increase in total export duties on the soybean complex exports. The export duties have increased from a value of 38.2 % in 2006 to

54.5 % in 2010. By 2011, this value increased to 57 %. This percentage increase is also reflected in the total budget collection. Analysis of each soy product separately in 2005 shows that the soybean complex export duties contributed 0.9 % of the GDP, while in 2011 they contributed 1.6 % of the GDP. This nearly doubled the relative importance in Argentina's economy (Barraud et al. 2011). Biodiesel is no exception. The growth of the export duties on the soybean complex has also affected biodiesel exports, although, as noted earlier, the 2012–2013 decisions in Spain and the EU have led to a major decrease in exports and, currently, the refineries are operating at low capacity once again (Joseph 2012).

Another interesting point is the coexistence of two policies that seem contradictory. On the one hand, soy biodiesel exports are affected by the DET and, on the other hand, soy production is promoted via the mandate for domestic biodiesel. The existence and extension of such measures are closely linked with tariff progressivity. In the beginning, the DET policy played an important, growing role for promoting the sector. The latest measures regarding a significant increase in the DET levied on biodiesel, together with a decrease in the reference price paid in the internal market for the mandatory blend, are dramatically changing this new industry. As in the rest of the world, biodiesel is highly dependent on variable political decisions upon which the whole system depends.

The fact that several countries, especially in the EU, established similar blending schemes as Argentina opened up an attractive biodiesel export market. As a result, there was continuous investment in refineries for the production of biodiesel, even small- and medium-sized ones. However, in 2012–2013, the EU policies have changed dramatically. The EU amended Directive 98/70/EC relating to the quality of petroleum and diesel fuels and Directive 2009/28/EC on the promotion of the use of energy from renewable energy sources. These measures were enacted to reduce the use of biofuels from food crops, allegedly because of indirect land-use change and lifecycle greenhouse gas (GHG) emissions. These actions, when fully implemented, will have an adverse effect on the Argentine soybean industry. At the same time, the EU actions do not seem to consider the fact that much of its soybean meal supply is imported too (biodiesel being its coproduct). The imposition of import duties, in 2013, on biodiesel exported from Argentina to the EU has greatly damaged the sector (Stearns 2013).

The Argentina biodiesel industry is being jeopardized not only by these new EU policies but also by the changing national policies. The main issue is that the biodiesel export price, through Decree No. 1339 of 10 August 2012 and Decree No. 1719 of 19 September 2012, was determined by a formula calculating variable export duties for biodiesel. In this way, the tax rate is equal to the reference price of biodiesel (PR) less total costs plus return on total capital employed (CRCTE). This calculation is made biweekly using a formula with several variables. This formula also determines the price of biodiesel for the domestic market, which should be equal to the PR, excluding the amount of the export tax, which is currently set at 23.63 %. The price varies depending on the size of the refinery. Small producers receive a price of 5,333.29 pesos, provided that the production is no more than 25,000 tonnes; the mid-sized producer price is 5,182.53 pesos up to a volume of 100,000 tonnes; above that production, the cluster only receives 4,565.34 pesos (García Kairuz 2012).

The Argentine joint resolutions Nos. 438/2012, 269/2012, and 1001/2012 created a registry of soy authorized operators and an interdisciplinary monitoring executive unit. The measures were adopted because of the need to increase the use of installed capacity for grinding soybeans; the sector in 2011 registered a high idle capacity due to the lack of availability of raw material. In addition, the joint resolutions established biodiesel's benchmark prices, applicable in the domestic market.

The resolutions mentioned also created the register, Authorized Soybean Operators Registry (ROSA), under the jurisdiction of the Federal Administration of Public Revenue (AFIP). ROSA seeks to strengthen control and supervision of the Temporary Soy Import Regime and Monitoring Unit. For each tonne of imported goods, 5 tonnes must be purchased for processing in the domestic market. The imported goods must receive industrial upgrading, with an obligation to export them to other countries, and merchandise entered under this regime cannot be exported without processing or nationalization.

The Argentine government significantly increased the DET export duty on biodiesel in 2012, which rose from 14.17 to 24.24 %, and has reduced by 18 % the price of this substitute for diesel in the domestic market (Camara Argentina de Biocombustibles 2012). The impacts of these policies have dramatically changed biofuel markets. In response to the Resolution of the Secretary of Energy No. 1436/2012, several trade associations and companies have been lobbying the national government, various ministries, and secretaries involved in internal policy management on the implementation of biofuel laws and regulations, especially pricing and the increased DET on biodiesel. These include the Argentinean Association of Biofuels and Hydrogen, Argentina Chamber of Biofuels, and numerous small- and medium-sized enterprises. These associations and companies believe that the recent policy shifts have created an economic imbalance that could ultimately lead to the inability to continue producing biodiesel.

5.6 Sustainability Initiatives

5.6.1 Verification and Land-Use Change

As discussed in Chap. 2, certification of biofuels is growing fast in Argentina. While there were no companies certified as sustainable in 2010, 30 certificates were issued in 2012 and 89 by mid-2013. During 2011, approximately 5×10^4 tonnes of sustainable biodiesel were exported to the EU, which has increased since then. One of the main drivers of this growth has been a mandatory requirement being enforced in different European countries (Diaz-Chavez 2011). In addition, there is a tendency to spread these requirements to other markets besides biofuels. Verification schemes like the Round Table on Responsible Soy and the International Sustainability and Carbon Certification take into account more than what is strictly mandated by the

EU Directive (also discussed in Chap. 2). For example, food and feed are markets where consumers might demand sustainable processes in the future. Argentina is a member of the GBEP and the Global Research Alliance on Agricultural Greenhouse Gases, among other programs. These efforts, along with market demands, have aided the biodiesel complex to strive for energy efficiency and a sustainable supply chain. The media, however, has mainly focused on the economic aspects of biodiesel and has highlighted Argentina's increased export of this product and the opening of new biorefineries.

Law No. 26.331, Presupuestos Mínimos de Bosques Nativos (Minimum Standards for the Environmental Protection of the Native Forests Act), was approved in late 2007 and is an important step in land-use planning by creating a territorial code with public participation. It is structured on the basis of two central measures: one that strives to immediately stop deforestation and the other producing an environmental territorial code for each province's land uses, including native forests. Its objectives are to achieve conservation, sustainable forest use, and payment for ecosystem services, which are given to the local community. Thus, the code should reflect the different conservation categories—I (red), II (yellow), and III (green)—which reflect the environmental value of the various native forest units and environmental services provided. In February 2009, the National Executive Power dictated the Decree No. 91/2009 that implements the Native Forests Law. Unfortunately, this Decree did not adequately finance the National Fund for the Enrichments and Conservation of Native Forests, whose purpose is to contract for the payment for environmental services (Di Paola 2012), This fund has yet to be adequately supported since then, raising serious concerns about the implementation of Law No. 26.331.

The Argentine environmental planning process, Ordenamiento Ambiental del Territoria (OAT), is an instrument of national environmental policy and management enshrined in the General Law of the Environment No. 25.675 of 2002. This is the set of technical, political, and administrative actions including studies, proposals, and adopted actions on the organization of a territory to suit the purposes of the policies and overall development objectives, including the Native Forests Law. This is a public function that is delegated to the territory in accordance with the general interest, determining powers, and duties of land property rights under this target. The OAT requires strong citizen participation and involvement of various stakeholders and is consistent with the concept of sustainable development. It is worth noting that the OAT includes both terrestrial and aquatic territories, which should also be the subject of strategic planning. Unfortunately, while Law No. 25.675 was enacted over a decade ago, it has yet to be implemented (Di Paola 2012).

There are currently two major challenges for the Native Forests Law. The first is getting sufficient allocation and distribution of financial resources to support its implementation and to achieve a serious and transparent consolidated payment for environmental services provided by forests. Second, Argentina awaits the development of a participatory and inter-sector environmental planning at the national level. Twelve of twenty-three provinces have completed their forest management plans and, thus, are able to claim payment for environmental services, upon presentation to the Secretaria de Ambiente y Desarrollo SustenTable (INTA 2011).

As discussed earlier, the majority of soybeans planted in Argentina are “Roundup Ready” GM crops. As a result, this allows no-till cultivation, which may improve GHG balances. However, it also requires widespread application of the herbicide glyphosate. While glyphosate is less aggressive to the environment and human health than alternatives for large application volumes to grow soybeans, it is essential to be alert and enforce the handling and application recommendations. There have been isolated accidents in Argentina from the improper use or handling of glyphosate. Nevertheless, there is a continuing improvement in pesticide education, handling, and training techniques. The main recommendations for safer handling that are followed are to: (i) adjust the timing and dose of herbicide application and avoid precipitation close to applications; (ii) rotate crops and/or implement cover crops to reduce the amount and concentration of glyphosate on soybeans, and in surface runoff or deep drainage; (iii) create buffer zones for protection of biodiversity and surface freshwater bodies; and (iv) prevent contamination by pesticide spray and dust drift, and protect the human population in urban and peri-urban areas (INTA 2011).

5.6.2 Greenhouse Gas Emissions

As noted earlier, Argentina is a member of the GBEP and, in early 2010, joined the Global Research Alliance on Agricultural Greenhouse Gases (GRAAGG). The GRAAGG was established to increase international cooperation, collaboration, and investment to help reduce the emissions intensity of agricultural production and increase its potential for soil carbon sequestration (Joseph 2012).

Several studies have been completed in order to accurately calculate the GHG emissions of the Argentine biodiesel sector according to generally accepted international methodologies. Since the country has different agro-ecosystems and distances from the ports, different analyses were completed for different regions of the country. The key variable to determine the greenhouse emission saving (GES) was the soybean supply area (Panichelli 2012). With respect to GHG emissions (kg CO_2 eq/km), emissions reduction relative to fossil diesel averaged ∼76 % (0.0447–0.0464 kg CO_2 eq/km). The scenario that showed relatively higher GHG emissions was for the southeast of Buenos Aires (0.0447 kg CO_2 eq/km). Compared with conventional oil-based diesel fuel, soy biodiesel’s reduction of GHG emissions was 75.5 %. The scenario that showed the largest reduction in GHG emissions was to the south of Córdoba (0.0464 kg CO_2 eq/km). Compared with conventional diesel, its reductions of GHG emissions were 76.5 % (Hilbert and Galbusera 2012). This study was made using a biodiesel refinery in Viluco as a reference case study.

Other recent studies found GHG reductions from soy biodiesel in Argentina of over 70 % (van Dam et al. 2009). The generation and use of biodiesel results in an overall profit for Argentina from the domestic market, and annual export savings in emissions ranging between 4 and 5.5 million tones of CO_2 equivalents. In the international Clean Development Mechanism (CDM) market, an estimated present value of US$17 per ton for the CO_2 avoided would amount to US$85–93 million of total revenues, which represents the current rating of the GHG emission reduction achieved by the biodiesel exports (Hilbert and Galbusera 2012).

5.7 Conclusions

The biodiesel industry in Argentina is highly concentrated in the Santa Fe province in the heart of the soybean and oilseed crushing industry. The downstream blending terminals are located close to population centers such as Rosario in the Santa Fe province. The mandatory biodiesel blend requirement is increasing and will surely reach a level of 10 % in the near future as part of the national strategy to lower oil imports and vulnerability from foreign providers. However, new constraints emerged in 2012–2013 because of changes in the internal reference prices, the DET, and, most importantly, import duties imposed on Argentine biodiesel by the EU.

The biodiesel industry has become a strategic sector for the country, contributing significantly to hard currency income through the complex (more than US$2 billion in 2011), important tax revenue from the DET, and a decrease in the imported oil expense. The biodiesel industry has brought positive implications for the country: new investment; job creation; a cleaner, domestically sourced renewable energy source; and, above all, one clear stride toward a path of sustainability and respect for environmental obligations. A major part of this success is because of Argentina's abundance of natural resources such as soybean. Argentina currently has an excess of soybean oil. No conflicts are presented regarding food/fuel tradeoffs since the industry is based on a food production coproduct (animal feed), which has a lower dietary value according to modern medical recommendations.

Considering the environmental aspects of the introduction of the biodiesel blend along with the effect of Argentine biodiesel exports, an overall reduction in GHG emissions of more than 4 million tonnes was achieved during 2011. The future expansion of this industry in the country is heavily dependent upon internal and external changes in policies and is thus very uncertain, along with its sustainability. Following the new policies introduced by the EU and several national governments, the growth of the Argentine biodiesel industry is at a very challenging stage in its development.

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Chapter 6
Peru

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Abstract Increasing agricultural productivity and diversity are crucial to reduce poverty and promote rural development in Peru. Bioenergy can boost development in rural areas of Peru if the right feedstocks, technologies, and policies are used. This chapter focuses on key issues for biofuels' production in the Peruvian context, including biodiesel and ethanol. Palm oil and *Jatropha* are identified as key feedstocks for biodiesel, and blending policies are reviewed. Under current conditions, palm oil is a more economic feedstock than *Jatropha* for biodiesel, though shortcomings of palm oil also are reviewed. For the case of ethanol, blending policies and the current production from sugarcane, concentrated in the northern zone of Peru, are discussed. Several cost scenario results are presented for biodiesel and fuel ethanol production under Peruvian conditions. These results increase our understanding of the challenges facing small landholder inclusion in Peru's biofuel production chains.

6.1 Introduction

The ancient Incas were one of the most developed cultures in terms of agriculture (Mann 2006). They used mountains and arable plains in the coastal region of Peru, where the bulk of irrigated agricultural production for trade took place in the river valleys. At that time, agriculture in the Andean region was utilized for subsistence purposes and the jungle was practically unexploited. Today, a similar pattern of use persists. Since those times, the most important crops in Peru have been rice, maize, wheat, and potatoes. Peru is divided into three regions with very different agro-climatic and topographic conditions (Quintero et al. 2012). As discussed by the Food and Agriculture Organization of the United Nations (FAO) in the Bioenergy

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and Food Security project (BEFS) report for Peru (FAO 2010a; Felix and Rosell 2010), bioenergy development in this country will have very different implications depending on where it takes place.

As in other Latin American countries, in recent years, Peru has been promoting the usage of biofuels in its energy matrix as a tool to become less dependent on crude oil and petroleum products. Among current biofuels, biodiesel and ethanol are the most used worldwide and in the region. These fuels use the current gasoline and diesel infrastructure and can be mixed directly with those fuels in conventional engines. Peru is no exception and, in 2007, a blending policy was established by the country imposing different mandates: biodiesel—obligatory 2 % (B2) blending started in January 2009 and increased to 5 % (B5) in January 2011; ethanol—an obligatory blend of about 7.8 % (E7.8) started in January 2009 (Ministerio de Energía y Minas 2007; Quintero et al. 2012).

The objective behind the 2007 biofuel blending mandates was to diversify the energy sources and create growth and employment opportunities for the Peruvian economy, with an emphasis on rural development. Biofuels development is also seen as part of the country's antinarcotics initiatives, representing a profitable alternative to coca production for rural farmers (Nolte 2012).

It is still recognized in this country, however, that one of the main barriers to successful implementation of biodiesel and ethanol industries in Peru is the lack of development in the agricultural sector. Currently, this sector contributes around 8 % of the Peruvian gross domestic product (GDP) (Finanzas 2012) and thus agriculture is critical for social and economic development in the country. As a consequence, Peru is attempting to solve major problems regarding failures in land titling, limited access to water resources, and uncertainties in agricultural productivity, with the intention of stimulating rural development (Ministerio de Energía y Minas 2007).

The rest of this chapter is organized as follows. First, we will provide a short overview of the energy matrix in Peru. The next section will comprise the heart of the chapter, and discuss the emerging biofuels sectors in the context of rural sustainable development in the country. Biodiesel and ethanol will each be addressed in turn, with some cost analysis. The role of smallholders will be given special attention. We will then briefly discuss future analysis of biofuel sustainability indicators for Peru, which will be followed by some conclusions.

6.2 Energy in Peru

The energy matrix of Peru is based mainly on oil, hydroelectric power, natural gas, and coal (IEA 2009). Peru had about 1.2 billion barrels of proved oil reserves as of December 2012 (BP 2013). Additional reserve growth is also expected. Much of these reserves are onshore, with the majority in the Amazon region (Finer et al. 2008; Finer and Orta-Martínez 2010). In recent years, some concerns have been raised about developing oil in Talara and onshore Maranon basins, as well as officially protected areas for the indigenous people in the Peruvian Amazon, given the increase in contracts signed with foreign oil investors. Despite developing these domestic resources, Peru is still a net importer of oil, mainly from Ecuador. In addition, Peru produces natural gas, roughly 40 % of which is liquefied and exported to North America, Europe, and Asia (BP 2013).

Hydropower resources for electricity generation have been developed, and investment in this sector is increasing (FAO 2010a; Felix and Rosell 2010). Peru also has significant firewood consumption for residential use. Consumption of this biomass energy represented 12 % of the total in 2008. Bagasse has shown the largest increase among noncommercial energy sources in recent years (Dellepiane et al. 2003). Solar energy, wind, and geothermal sources are currently marginal in the energy matrix of Peru (IEA 2009).

6.3 Biofuels and Needed Development in Peru

Peru is one of the smaller producers of biofuels in Latin America and the Caribbean. It ranks number four in biodiesel and number six in ethanol production in Latin America (see Chap. 1). One way to encourage rural development in Peru is through the support and promotion of smallholder (i.e., a small farm with a mixture of cash crops and subsistence farming) inclusion into biofuel enterprises (Quintero et al. 2012). Peru approved Law No. 28054 in 2003 (Ley de Promoción del Mercado de los Biocombustibles), which established the general framework for the promotion of the biofuels market (Perú 2003). In addition, Supreme Decrees No. 013-2005 EM and No. 021-2007 EM regulate the promotion, marketing, and distribution of biofuels in Peru. However, these laws are based on free enterprise and entry into the economic activity of biofuel production, with objectives to diversify the biofuel market, enhance rural and agribusiness development, generate jobs, decrease the environmental damage from farming, and offer alternative markets against illegal drugs (Perú 2003). The participation of smallholders is not mentioned as part of the policy. Greater inclusion of smallholders can improve the social acceptability of biofuel policies (Quintero et al. 2012).

Nevertheless, the majority of biofuel production thus far in Peru has been led by agribusiness firms (FAO 2010a; Felix and Rosell 2010). Therefore, feedstock ownership and management will play an important role to ensure the desired employment level for the agricultural stage of biofuels production. Currently, large-scale commercial producers dominate sugarcane and oilseed crop production in Peru, and, as in most Latin American countries, these firms gain most of the economic benefits of this business.

Meanwhile, smallholders make individual efforts but lack adequate investment capital. Even if the Peruvian government tries to support or subsidize these efforts, other issues such as efficiency and organization of small producers present major challenges. This situation results in crops with poorer technical conditions, lower yields, and problems with quality control (Quintero et al. 2012). In addition, the uncertainties and risks associated with sugarcane and oilseed demand, due to the effects of petroleum price fluctuations on ethanol and biodiesel markets as well as the prices of inputs like fertilizers and pesticides, make other smallholder producers reluctant to participate in the bioenergy business (FAO 2010a; Felix and Rosell 2010). Policy makers in Peru could assist smallholders by improving business conditions. More government assistance could also help smallholders establish fair contractual purchase agreements and avoid abuses of local middlemen (Brittain and Lutaladi 2010). In this sense, partnerships between smallholders' associations and commercial producers might be a good option for expanding biofuel businesses in a sustainable and mutually beneficial way (Binns 2007). Smallholders would thereby have a stronger position to negotiate prices, obtain access to better technology, and improve their yields and production practices.

Similar small-scale decentralized bioenergy initiatives have been tested in sub-Saharan African countries such as Mozambique, as valuable alternatives for social inclusion and to stimulate rural socioeconomic development (Jumbe et al. 2009; Schut et al. 2010, 2011). In Peru, there are government efforts in the northern region of the country to promote palm oil and *Jatropha curcas* (hereafter *Jatropha*) for biodiesel feedstocks and sugarcane for ethanol, through increase of production areas, restoration of marginal and fallowed lands, and strengthening of organizational capacities (Proinversion 2005). These efforts can strengthen the participation of smallholders in the biodiesel business, providing an interesting opportunity to improve the energy security of the country and be a catalyst to stimulate rural socioeconomic development. In the following sections, we examine these developments in more detail; first with biodiesel and then with ethanol.

6.3.1 Biodiesel in Peru

More than 350 oil-bearing crops worldwide have been identified as suitable for biodiesel production (Fatih Demirbas 2009). Almost 95 % of vegetable oils used in biodiesel production are edible (e.g., palm, soybean, and rapeseed oils) (Leung et al. 2010). Fortunately, nonedible vegetable oils (e.g., *Jatropha*, castor, and karanja oils) have some potential as biodiesel feedstocks, particularly if they can be cultivated on large-scale degraded lands, preserving the most productive lands for food production (Barnwal and Sharma 2005). However, more recent authors have shown that the use "marginal" lands can be problematic. Such lands may be valuable sources of livelihoods for poor communities (Bailis and Baka 2011).

In order for biodiesel to successfully compete with petroleum diesel, it must be technically acceptable, economically competitive, environmentally friendly, and readily available (Murugesan et al. 2009; Srivastava and Prasad 2000). In addition, the social impact of this industry is a critical issue, especially in developing countries. In Latin America, different attempts have been made to establish biodiesel programs as a tool for rural development, fighting against poverty and assuring social inclusion (Janssen and Rutz 2011). As an example, in 2004 Brazil launched the National Biodiesel Programme: "Programa Nacional de Produçãoe Uso de Biodiesel (PNPB)," using soybean, palm, and castor oils as potential feedstocks (Nitsch 2008, see Chap. 4 for further details.

It has been mandatory in Peru to use 2 % of biodiesel with fossil diesel (B2) since 2009. In 2011, this blending level was increased to 5 % (B5) based on Law No. 28054 (Congreso de la Repulica del Peru 2003). This target was achieved, but largely through imported biodiesel. This biodiesel was imported from the USA, Ecuador, and Argentina, since Peru met only 12 % of its demand in 2012 through domestic production (Nolte 2012).

Palm oil is one of the largest sources of edible oil in the world. It is grown extensively throughout the tropics, with Malaysia and Indonesia accounting for over 80 % of global production (Abdullah et al. 2009; Hoh 2010). This high-yield crop requires relatively small areas to be cultivated. Currently, almost 90 % of this crop is used in food and cosmetic industries, while only 10 % is employed in other applications, such as biodiesel (Elbehri et al. 2009; FAO 2010a; Felix and Rosell 2010). Fresh fruit bunches from palm oil plantations are typically milled into palm oil, shells, kernels, palm fiber, and empty fruit bunches. About 10 % of the remaining material represents cellulose (Papong et al. 2010). Biodiesel production can use both palm and palm kernel oil. However, they have different chemical compositions, with palm oil containing mainly palmitic and oleic acids with 50 % saturated fat, while palm kernel oil is rich in lauric acid with 89 % saturated fat (Demirbas 2003).

Palm oil is the most important oilseed crop in Peru. Estimated national production of fresh fruit bunches in 2011 was 361,724 tonnes produced over a total harvested area of 30,594 ha and crop yields between 5 and 25 tonne/ha (FAOSTAT 2011). Most of palm oil is cultivated in the Amazonian zone, where there are notoriously high poverty levels (Quintero et al. 2012). Experiences in other countries have demonstrated that small-scale cultivation of palm oil could be beneficial for smallholders (Binns 2007). For this reason, local governments have promoted the liquid biofuels industry (including smallholder) as a way to raise the living standard of rural communities (Quintero et al. 2012). At this time, biodiesel in Peru is only produced from oil palm, mostly by Palmas del Espino in the San Martin region. However, nonedible oil production (i.e., *Jatropha*) has been under development since 2008 by Pure Biofuels and most recently by Heaven Petroleum in the southwestern Ica region (Nolte 2012).

Jatropha is a tropical tree native to the Americas. It is a bush or small tree that belongs to the family Euphorbiaceae (Upham et al. 2009). Upon reaching maturity, the crop may yield several tonnes of dried fruits per hectare and the fruits have an oil content of 25–30 %. This crop is a highly resistant plant capable of surviving in fallowed agricultural lands (Achten et al. 2008), and in low to high rainfall areas (Vasudevan and Briggs 2008), leaving more productive land available for food crops (Janaun and Ellis 2010). Originally, *Jatropha* was thought to require minimal effort to sustain. However, this is has not been supported by field experiences (Achten et al. 2010). Indeed, many important issues must be solved and much higher yields obtained before using this feedstock for biodiesel production (Carels 2009; Jain et al. 2012). Nevertheless, with a well-established procedure to stabilize its production, *Jatropha* can potentially be introduced to biofuels markets in the America. Because of this, it is considered a promising feedstocks for biodiesel production (Azam et al. 2005; Kumar Biswas et al. 2010).

Currently the *Jatropha* industry is still in the development phase, but several authors have argued that is possible use this crop as a potential biodiesel feedstock (Kumar and Sharma 2008; Kumar Tiwari et al. 2007; Patil et al. 2009). Furthermore, different experiences in Africa and India promoted by local governments have shown that this crop might also be employed as a tool for rural development. Most of these projects were developed using marginal soils and wastelands in order to avoid food and land competition (Schut et al. 2010). However, experiences have been mixed. For example, in Mozambique there were successful plantings as well as failures, where initiatives were abandoned by farmers due to poor performance of *Jatropha* and lack of appropriate agricultural practices to sustain this crop (Schut et al. 2011). India has had similar experiences (Baka 2013; Kant and Wu 2011; Jain and Sharma 2010). However, other projects supported by the FAO have been somewhat more effective. In Mali, Tanzania, and Zambia, "*Jatropha* systems" have been developed to bring energy support to rural communities along with soil-erosion control and soil improvement. These experiences have shown that while lack of knowledge and low productivity may be obstacles to profitable farming of *Jatropha*, this crop can be planted in extensive wastelands where the selection of plants adapted to the site and availability in sufficient numbers were essential for this development (FAO 2010b; Kumar Biswas et al. 2010; Sinkala and Johnson 2012). In addition, the use of improved agricultural practices, such as intercropping with other oilseed tree species (e.g., castor oil or *Pongamia pinnata*), may result in a valuable strategy to increase net income. Another factor for the success of *Jatropha* planting is the inclusion of other value-added products, combining production strategies. Thus, when income from *Jatropha* oil extraction is supplemented with soap making and alternative uses of seed cake, the viability of this business increases (Brittain and Lutaladi 2010; Nazia 2010).

The *Jatropha* crop has been promoted in Peru as a way to include marginal rural populations and raise their living standards in zones where this crop could be a feasible alternative. Indeed, some experiences have been developed in Pucallpa and Tarapoto to use this crop as feedstock for biodiesel production (Ministerio de Energía y Minas 2007). Current efforts are focused on agricultural parameter definitions, aimed to design technological packages that can meet industrial requirements for this crop (FAO 2010a; Felix and Rosell 2010).

The biodiesel industry in Peru is growing and has been promoted in the northern region of this country, where both palm oil and *Jatropha* might be potential feedstocks. However, in order to have effective support for the development of this industry the whole vegetable oil sector must be improved. Currently, the internal demand for vegetable oil in Peru is high and not completely met by palm oil; therefore, soybean and sunflower oils must be imported to supplement supplies. Although the lack of support from the national government to the oleaginous sector has been traditionally noted as the main cause of this problem (Proinversion 2005), the promotion of a new scheme with major participation by smallholders and support by international organizations such as the FAO may be more appealing to local governments. Thus, the vegetable oil sector can be strengthened along with a contribution to rural and socioeconomic development.

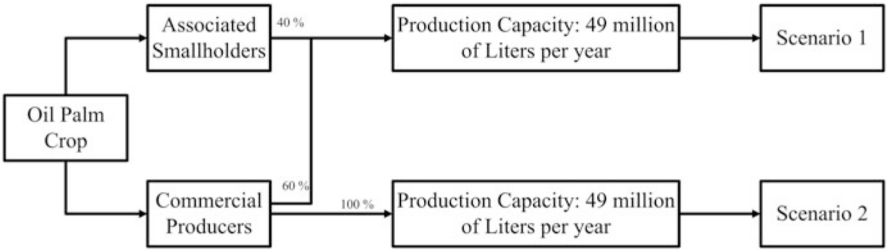

Fig. 6.1 Scenarios for biodiesel production from oil palm supplied by associated smallholders and commercial producers

Table 6.1 Production costs of oil palm biodiesel

	Scenario 1: associated smallholders and commercial producers (US$/liter of biodiesel)	Scenario 2: only commercial producers (US$/liter of biodiesel)
Total raw materials cost	0.2467	0.1664
Total utilities cost	0.0167	0.0167
Operating labor	0.0027	0.0027
Maintenance	0.0014	0.0014
Operating charges	0.0007	0.0007
Plant overhead	0.0020	0.0020
General and administrative Cost	0.0216	0.0152
Capital depreciation	0.0219	0.0219
Total production costs	0.3137	0.2270

One of the main motivations of policies promoting biodiesel is to displace conventional diesel and oil demand. To determine whether this policy is a cost-effective approach, we compared the production costs, in US dollars, of biodiesel from palm oil and *Jatropha* in different scenarios with the production cost of conventional diesel, which is ~0.5 US$/liter (EIA 2010). We found that biodiesel from palm is a competitive substitute for conventional diesel in some scenarios (see Fig. 6.1 and Table 6.1). On the other hand, the estimated production costs for biodiesel from *Jatropha* were about two times higher than fossil diesel fuel (Fig. 6.2 and Table 6.2).

To make *Jatropha*-based biodiesel cost-competitive, the Peruvian government would therefore have to create subsidies or use tax revenues to keep the price of the B5 blend competitive with conventional diesel fuel. A similar case has been found for *Jatropha*-based biodiesel in Tanzania and India (Peters and Thielmann 2008). However, these results may make the government reluctant to support *Jatropha* initiatives in the future. Thus, only palm oil-based biodiesel appears cost-effective in Peru, which may explain why it is the current source of domestic supply.

There are some potentially negative aspects to palm oil that should be considered from a sustainability perspective. In some other countries, oil palm has been implicated as a major driver of deforestation (Carlson et al. 2012; Koh et al. 2011), which can destroy numerous ecosystem services and negate greenhouse gas (GHG) reductions achieved from fossil fuel substitution. In addition, palm oil is used for cooking

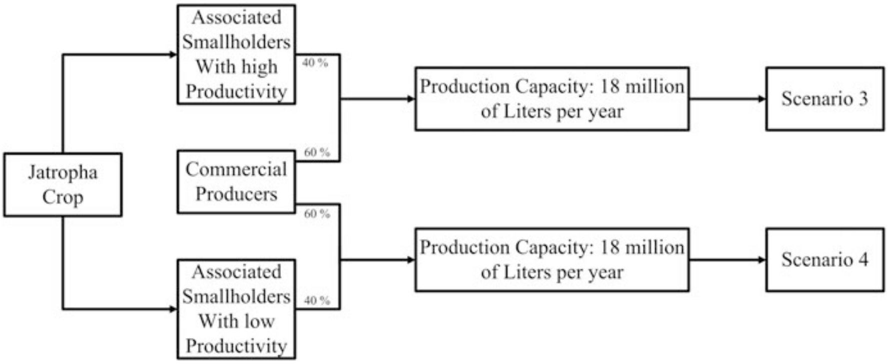

Fig. 6.2 Scenarios for biodiesel production from *Jatropha* supplied by associated smallholders with high and low productivities, as well as commercial producers (projections)

Table 6.2 Production costs of *Jatropha* biodiesel (projections)

	Scenario 3: associated smallholders with high productivity and commercial producers (US$/liter of biodiesel)	Scenario 4: associated smallholder with low productivity and commercial producers (US$/liter of biodiesel)
Total raw materials cost	0.6538	0.6823
Total utilities cost	0.0008	0.0008
Operating labor	0.0179	0.0179
Maintenance	0.0059	0.0059
Operating charges	0.0045	0.0045
Plant overhead	0.0119	0.0119
General and administrative cost	0.0556	0.0579
Capital depreciation	0.0844	0.0844
Total production costs	*0.8348*	*0.8656*

and food processing. In developing countries such as Peru, low-income families use this oil as an important source of calories. For example, according to the FAO, in Peru the per capita domestic consumption of palm oil for food is ~1.6 kg per person per year (FAO 2010a; Felix and Rosell 2010). Thus, an alternative use of palm oil for biodiesel production may create competition between food and fuel, pushing up food prices. To minimize this risk, the government could promote feedstocks like *Jatropha* and attempt to bring prices down so that biodiesel from *Jatropha* is competitive with conventional diesel. Alternatively, the government could promote the expansion of oil palm, which would increase supplies so that prices remain stable even as demand increases. Policies would need to be implemented to ensure that oil palm expansion does not lead to direct land-use change, which would contribute to GHG emissions and biodiversity loss. Care must also be taken to avoid land-tenure conflicts and other negative social impacts.

To increase the viability of biodiesel production from *Jatropha*, markets for co-products like glycerin and electricity produced from *Jatropha* residues could be developed. The Peruvian government supports this through Law No. 27360, which grants tax benefits to agro-industrial projects that sell coproducts up to 20 % of total project income (Congreso de la Repulica del Peru 2009). In addition, Law No. 1002 promotes the use of at least 5 % of energy generation from renewable sources, including biomass residues (Congreso de la Repulica del Peru 2008). These alternatives were considered, and impacts on the total production cost of biodiesel as credits by selling by-products were compared. The operative stages and additional cost of glycerin purification to pharmaceutical grade and biomass fired cogeneration systems using Jatropha cake as fuel, were estimated in previous studies (Cardona et al. 2011; Rincón and Cardona 2011).

The high costs of vegetable oils are normally attributed to intermediary expenses and crop production costs. However, our work has shown that these factors play a minimal role. Consequently, in order to reduce production costs and make *Jatropha*-based scenarios more competitive, production cost for smallholders should be given more focus. Following the example of palm oil-based scenarios, it is clear that in order to improve the profitability of *Jatropha*, the production conditions of smallholders must be improved, not only as part of government policies for rural development, but also as a profitable option for private investors. Associations of smallholders with the same production costs as commercial producers can significantly affect biodiesel production costs. The latter can be achieved with government incentives, which can enhance production conditions. As a result, *Jatropha*-based biodiesel production could develop in Peru under several future scenarios. In the short term, however, the oil palm industry in the country is likely to grow more rapidly and first-generation biodiesel is expected to be more stable (FAO 2010a; Felix and Rosell 2010).

6.3.2 Ethanol in Peru

Ethanol use is currently higher than biodiesel use in Peru. In 2011, the nation produced 122 million liters of ethanol (see Chap. 1). It is used both as a fuel blend with gasoline and as a gasoline enhancer. Relative to methyl tertiary butyl ether (MTBE), ethanol has greater octane booster properties, is nontoxic, and does not contaminate water sources. Nevertheless, ethanol production costs are higher than those of MTBE, and Reid vapor pressure is higher leading to greater volatilization, which can contribute to ozone and smog formation (Sánchez and Cardona 2008). Several countries since the 1990s have been mandating programs to require ethanol mixing with gasoline. Fuel ethanol production has thus increased because many countries seek to reduce oil imports, boost rural economies, and improve air quality (Bailis and Baka 2011).

In the case of Peru, fuel ethanol production is still in its infancy. Following the Supreme Decree No. 021-2007 by the Energy Ministry, which established the requirements for trading and distributing biofuels, the ethanol blend was required to be E7.8 for 2010 (Perú 2003). As in most tropical regions, Peru produces ethanol from sugarcane, but the government is also considering promoting the use of molasses, a by-product of sugar refining. Peru's sugar production is situated primarily in the valleys of the northern coastal regions of Piura, the primary ethanol region, as well as La Libertad, Lambayeque, and Lima. Caña Brava (owned by the Romero Group) was the first ethanol producer in Peru. Caña Brava has established 6,000 ha of sugarcane in Piura and built a processing plant with a capacity of 350,000 liters per day (Nolte 2012). Maple Ethanol and Maple Biocombustibles have also invested in ethanol production through the acquisition of 13,500 ha in Piura, 7,000 of which is devoted to sugarcane production for ethanol. Maple opened an ethanol refinery in early 2012 with a capacity similar to that of Caña Brava's. Ethanol production in Peru was expected to reach 240 million liters in 2012, substantially increasing the 2011 output (Nolte 2012).

There is potential for further increasing ethanol production from Peruvian sugarcane. Development of this industry is likely to be concentrated around sugarcane refineries in the north coastal areas and the center of the country. In total, there are 12 refineries with a potential to produce around 64 million liters of ethanol per year from molasses. Annual volumes of sugarcane processing amounts to between 6 and 8 million tonnes (including both commercial-scale and small-scale producers). Sugarcane production on the Peruvian coast has high productivity levels, averaging between 110 and 160 tonnes per hectare per year (FAO 2010a; Felix and Rosell 2010).

A 350,000-liter-per-day ethanol plant must have 20 ha of sugarcane production per day to sustain its operation (Nolte 2012). With an average sugar content of 17 %, 1 MT of sugarcane produces 170 kg of sugar, which can be converted to 110 l of ethanol. Taking this into account, sugarcane bagasse is used as a feedstock for steam, which is used to generate heat and electricity through a turbine. Electricity generation is an important component of ethanol projects, reflected in other South American countries such as Brazil and Colombia (see Chaps. 3 and 7). However, depending on the technology (e.g., gas vs. steam turbine), the generated electricity may or may not be capable of meeting the energy requirements of the same plant. Generally speaking, surplus electric power is generated and sold to the national grid. In the case of Peru, ethanol operations require about 8 MW, and the generated power is around 10 to 12 MW (Nolte 2012).

As a result of the growing ethanol industry, the government expects an increased deployment of 45,000 ha in arable land in the next several years (the potential is 200,000 ha). This will require between US$ 500 million and US$ 2 billion in investment, and will increase exports and employment by US$ 900,000 and from 20,000 to 40,000 people (Nolte 2012). This expected growth in demand for ethanol has also initiated discussions about alternative biofuel crops such as sweet sorghum. However, there are several concerns and issues associated with bringing this crop into a high production system similar to the one established for sugarcane (FAO 2010a; Felix and Rosell 2010).

Current production of sugarcane in the Amazonian region is relatively small compared with production levels of the Peruvian coast, and production in the Amazonian region is primarily intended for local sugar consumption. Even so, there is great interest by the government in the use of forests to promote sugarcane crops for production of hydrated ethanol fuel use, mainly for motorcycles (Nolte 2012). In response to this policy, we have included a scenario of hydrated ethanol production in the Amazonian region, which is described below.

Production costs of ethanol from sugarcane are between 0.27 and 0.51 US$/liter. For the case of ethanol from molasses, the cost can vary between 0.43 and 0.64 US$/liter, depending on the price of molasses (FAO 2010a; Felix and Rosell 2010). Currently, most of the sugarcane in Peru is used for sugar production; ethanol production is relatively new. Two approaches could emerge to meet this new demand: supply through the "purchase planters" (small producers), which is similar to existing arrangements for sugar production, or large-scale commercial production that avoids smallholder involvement.

Commercial sugarcane production on the Peruvian coast has slightly higher yields and lower costs (US$ 12.32 per tonne). Yields among small producers are slightly lower, which leads to higher costs per tonne. For small growers in the coast, assuming that they have access to seeds, technical assistance, financing, and other inputs, the estimated production cost is US$ 12.40 per tonne, including a modest profit margin. Production costs of commercial sugarcane in the Amazonian region are estimated at US$ 11.32 per tonne. In the case of small producers, the estimate was US$ 17.65 per tonne, including a profit margin for the small farmer or producer. The difference in production costs of sugarcane compared to coastal irrigation is not required and the labor cost is lower. Variation in productivity can reach small producers in the Amazonian region, which would potentially lower the price level that small producers can receive on the coast.

The additional income from the sale of coproducts is an option that can lower costs in ethanol processing. The major coproducts from the production of ethanol from sugarcane include vinasse, which can be used as an organic fertilizer, and bagasse, which can be used as feedstock in a cogeneration power plant (as previously mentioned). Use of these coproducts depends upon demand and price, and there is currently a market developed for vinasse in Peru. The use of bagasse in the cogeneration process can generate electricity and can also be used in the production of paper pulp, an underdeveloped sector in Peru.

6.4 Measuring the Sustainability of Liquid Biofuels

Currently there are several concerns about bioenergy sustainability around the world. In this way the Global Bioenergy Partnership (GBEP), in compliance with different national governments, institutes, and other partners, developed sustainability indicators for bioenergy (GBEP 2011; also see Chaps. 2 and 7 for additional discussion). The GBEP has a mission to promote the wider production and use of modern bioenergy, particularly in the developing world where traditional use of biomass is prevalent. There are 24 indicators, which represent the environmental, social, and economic pillars. These indicators were developed to provide policy makers and other stakeholders a set of analytical tools that can inform the development of national bioenergy policies and programs, and monitor the impact of these policies and programs.

In the Peruvian case, these sustainability indicators can be applied to future development, given the nascent stage of its biofuel industries. The Peruvian government can adopt these indicators to consider the lifecycle impacts of biofuel production over the main sustainability pillars (i.e., environmental, social, and economic). These indicators inform important issues such as GHG emissions (which may be higher, e.g., for biodiesel derived from palm oil if cultivation is accompanied by land-use change), food security, conservation, pollution, water use, rural economic development, land tenure, energy matrix, net energy ratio, productivity, logistics and distribution, and participation of bioenergy in GDP, among others (GBEP 2011; Dale et al. 2013). The methodologies can be adopted from countries that are farther along in applying the indicators.

6.5 Conclusions

The development of biofuels presents challenges and opportunities worldwide. It is very important to understand the relation between biofuels and agricultural markets. It is also important to note that these markets are constantly changing due to issues such as climate change, pests, trade, and oil prices, among others. For the case of Peru, the potential demand growth for biofuel products is a function of the projected income and the population increase, as in any other country. In addition, the availability of land for biofuel production depends on the average yield and productivity, and the payback time of the crop. Therefore, our discussion about the cost advantages of palm oil vs. *Jatropha* biodiesel should be considered in this broader context. Similarly, the future growth and development of sugarcane ethanol must be considered in light of sustainable development and other policy goals.

From a policy point of view, it is necessary to evaluate additional factors to improve smallholder's competitiveness and its participation in mixed biofuel scenarios. However, it must be taken into consideration that although less economical, the greater involvement of smallholders generates a social profit in the context of sustainable development. Thus, it may be necessary to promote government policies through laws and regulations on the private sector that incorporate social responsibility. Partnership between smallholders and commercial producers can have a positive effect on crop yields, because it provides the partners access to better agricultural technologies and conditions. Therefore, this association should be promoted in Peru to provide the conditions for real sustainable development.

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Chapter 7
Colombia

Theresa Selfa, Carmen Bain and Renata Moreno

> *Given the role of governance ... indicator selection depends on an assumed socio-political and legal context. Stable and transparent governance that is both legitimate and accountable is a prerequisite for energy security, and we argue similar conditions are required for a suite of indicators to provide reliable information about sustainability.*
>
> (Dale et al. 2013, p. 90)

Abstract Multistakeholder initiatives (MSI) are proliferating in many economic and environmental spheres. MSI for bioenergy are developing standards and metrics for measuring the sustainability of biofuels through specific criteria and indicators. This paper examines different sets of indicators proposed by two MSI for bioenergy, Bonsucro and the Global Bioenergy Partnership (GBEP), and the challenges in operationalizing them to measure environmental sustainability, in the context of the sugarcane ethanol industry in Colombia. Drawing on interviews with stakeholders in the sugarcane ethanol industry in Valle del Cauca, Colombia, plus participant observation of a recent GBEP meeting and interviews with participants at the GBEP meeting, we examine the challenges and limitations of indicators in promoting sustainability in biofuels systems.

7.1 Introduction

The liberalization of international trade, expansion of global value chains, intensification of neoliberal economic reforms, and the prevalence of neoliberal ideology have constrained the ability of the state to regulate the economic, social, and environmental

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spheres. This has led to the proliferation of private standards and audit procedures established by the private sector—including social movement organizations (SMO) and corporations—to govern the conduct of individuals and institutions (Busch 2011; Ponte et al. 2011). Sustainability issues, social benefits, and safeguards for public goods are increasingly governed through the use of private, voluntary standards and certification systems promulgated via multistakeholder initiatives (MSI).

In the current neoliberal era, the biofuels sector represents an interesting hybrid between state and market actors. While the state has played a central role in promoting and developing the biofuels sector, it has been reluctant to actively address social and environmental protections. As production and use of biofuels are expanding globally, attention is turning to understanding the role of governance of biofuels systems, as decision making and conduct are not determined through government regulations but increasingly shaped by nonstate actors (Ponte et al. 2011; Bailis and Baka 2011; Mol 2007; also see Chap. 2 in this volume).

In the biofuels sector, MSI, such as the Roundtable on Sustainable Biomaterials (RSB, formerly Roundtable on Sustainable Biofuels), Global Bioenergy Partnership (GBEP), the Roundtable on Responsible Soy (RTRS), the Roundtable on Sustainable Palm Oil (RSPO), and Bonsucro, the initiative that focuses on sustainability standards for sugarcane, are composed of combinations of state and nonstate actors, including environmental organizations, nongovernmental organizations (NGOs), and corporations. In these initiatives, sustainability standards are often formulated as principles, criteria, and indicators. Here, standards designed to measure environmental sustainability, such as reductions in global greenhouse gas (GHG) emissions are the most common, but other measures related to social and economic sustainability, such as security of land tenure, food security, and water rights, are also included in some frameworks (Djama et al. 2011). As also discussed in Chap. 2 of this book, some MSI are in the process of attempting to operationalize their biofuels sustainability indicators "in the field" and this paper addresses some of the challenges confronted in that process. Specifically, we look at two frameworks and sets of indicators proposed for promoting and measuring biofuels sustainability in Colombia: Bonsucro and GBEP. In this chapter, we explore the challenges related to MSI in Colombia through document analysis, in-depth interviews, and participant observation methods.

A recent review of bioenergy socioeconomic indicators by Dale et al. (2013) argues that transparent governance is assumed as a precondition for selection of a suite of indicators that will provide reliable information about bioenergy sustainability. Yet our research highlights incompatibilities with such assumptions and illustrates practical challenges in the application of sustainability indicators in the context of biofuels production in Colombia. Our case studies suggest that while criteria and indicators deployed by the GBEP and Bonsucro initiatives are premised on objective and science-based measures of sustainability, in practice they are shaped by history, local context, and politics. We find that, in Colombia, powerful local actors attempt to both modify science-based, objective indicators and withhold data needed for "benchmarking" indicators. As a result, these initiatives end up reinforcing inequitable socioeconomic relations, environmental outcomes, and resource distribution, rather than facilitating greater sustainability. We conclude by outlining some of the challenges in operationalizing sustainability indicators in the context of Colombia, and suggest limitations in their applicability globally.

In the next section, we describe the methods used in this research, followed by a discussion that outlines the government policies and mandates that have stimulated the growth of the biofuels industry internationally. We then describe the policy and environmental context in Colombia, which gave rise to sugarcane ethanol. Following these sections, we present two frameworks for measuring the sustainability of biofuels: GBEP, composed primarily of state actors and multilateral organizations, and Bonsucro, whose members include NGOs, sugarcane producers, and bioenergy companies, and discuss the challenges with operationalizing these measures in Colombia.

7.2 Methods

This chapter combines document analysis, exploratory interviews with 14 stakeholders in the sugarcane and ethanol industries, and participant observation methods. Government policy documents and documents on Bonsucro and GBEP were analyzed to understand the emergence and characteristics of these MSI in Colombia. Interviews were conducted in the Valle del Cauca region in southwest Colombia between June and August 2012 with informants who were chosen to represent the diversity of stakeholders in the industry. Stakeholders that were interviewed included small farmers and large sugarcane producers, sugarcane workers, union activists, local government officials, officials from sugar industry associations (producers and refineries), sugar refineries, and researchers. The interviews focused on understanding the role of sugar and ethanol industries in the development of the Valle del Cauca, impacts of these industries on current social and environmental conditions, and on the prospects and limitations for multistakeholder governance initiatives to mitigate the impacts. In addition, we draw on other data gathered through participant observation at a 2-day GBEP meeting in Bogota, Colombia, that was convened to report on the results of efforts to pilot test GBEP's indicators for sustainability, and through follow-up interviews with participants in that meeting.

7.3 Government Mandates for Biofuels Production

Despite the prevalence of neoliberal ideology and practice, government policies have played a major role in the development and expansion of the biofuels industry globally over the last decade, although mandates and incentives for sugarcane ethanol began in Brazil in the 1970s (Goldemberg 2013) (see Chap. 4 of this volume for more information). As of 2009, biofuel production mandates were in place in 24 nations spanning advanced industrialized (USA, Canada, and Germany), middle-income (Chile and China), and developing-country (Peru, Colombia, and Dominican

Republic) contexts (Bailis and Baka 2011). In general, government mandates have privileged corporate ownership and control of energy resources over local biofuels development that could enhance local "energy sovereignty" (Borras et al. 2010, p. 578).

In the mid-2000s, strong political support for renewable energy in the USA led to a suite of government policies, which in turn fueled the dramatic expansion in US biofuel production (for specific details on these policies see Lehrer 2010; Wallander et. al. 2011). Of particular significance was the 2005 Renewable Fuel Standard (RFS1) that established a guaranteed market for ethanol (National Research Council 2011). This was expanded with the 2007 Energy Independence and Security Act (EISA), which required the blending of 57 billion L/year of corn ethanol by 2015 and an additional 61 billion L/year of advanced biofuels by 2022 (National Research Council 2011). The US government developed some modest mandates for GHG emission reductions for biofuels relative to petroleum. For example, the 2009 Renewable Fuels Standard (RFS2) mandates a 20 % reduction in GHG emissions for conventional biofuels and a 50–60 % reduction for advanced or cellulosic biofuels (National Research Council 2011). In 2009, the European Union (EU) established the Renewable Energy Directive (RED), which mandates that 20 % of transportation fuels will come from renewable sources by 2020, and requires that an initial 35 % GHG reduction will increase to 50 % by 2017 (EU 2009). However, in light of the challenges in producing mandated volumes of advanced biofuels, targets have been scaled back both in the USA and EU (U.S. EPA 2013; Levidow 2013).

The mid-2000s also witnessed a dramatic increase in the production of biofuel feedstock in the global South to meet the growing demand for renewable energy domestically and especially in the global North. Sugarcane ethanol is particularly valued by the EU and the USA because it is considered an "advanced biofuel" under the US RFS2 and it also qualifies as providing greater GHG emission reductions as required by the EU RED. RED certification is a legal requirement for imports of biofuels into the EU, which has driven the expansion of private standards and certification schemes designed to ensure that biofuels exported to the EU meet the RED sustainability rules. Most of these schemes are being developed and implemented by private-sector actors or MSI (German et al. 2011).

7.4 Biofuels Policy in Colombia

Colombia has emerged as one of the larger producers of biofuels in Latin America and currently is producing both oil palm biodiesel and sugarcane ethanol. Biofuels have been promoted by the Colombian state with a narrative similar to that heard in many countries: to reduce carbon emissions, to reach energy self-sufficiency, and to boost agricultural and rural development. In addition, the growth of biofuels in Colombia is in response to increasing demand from the USA and EU to assist in meeting their renewable energy mandates by importing advanced biofuels.

The context for the growth of the Colombian biofuels industry makes the case study interesting as well. First, is the history of armed conflict in regions now promoting biofuels as alternative rural development strategies. Second, biofuels are being grown in regions with entrenched unequal land distribution patterns and a long history of sugarcane production and exports. Third, the recent expansion of neoliberal policies and initiatives, such as passage in 2011 of the Free Trade pact between Colombia and the USA, and the Colombian sugarcane industry's recent entry into Bonsucro shape the place of biofuels within national and international agendas. Fourth, Colombia was chosen as the Latin American site to pilot test the efficacy of the 24 sustainability indicators adopted by GBEP, the results of which will have regional implications.

The Colombian government has played a central role in the development of the biofuels sector. Government support for biofuels began with the Uribe Administration (2002–2010) that defined biofuel production as a major strategy for rural development. The goal was to establish a biofuel industry by extending and adapting the existing industries of sugar and palm oil. Government incentives included mandatory blends, tax exemptions, access to land, and special loans. A 2012 national government decree (#4892) declared a biofuels blend level required in vehicles of 10 %, with a range of 8–13 % for ethanol and 10 % for biodiesel. For 2013, the levels can be changed by the government in consultation with the Biofuels Commission if the targets cannot be met (Pinzon 2012). Currently, in the ethanol-producing southwest region of the country, a 10 % ethanol blend is mandated and in the rest of the country 8 %. Biodiesel has reached 10 % in the western part of the country and 7 % in the rest, including in Bogota, but the percent blended is expected to rise more quickly than ethanol because of the rapid expansion of palm oil plantations for biodiesel (Pinzon 2012).

Starting in 2002, the Colombian government granted tax exemptions for the blending of ethanol and biodiesel into fuels for domestic consumption (Act 788 of 2002 and Act 939 of December 2004). Data on the production and consumption of ethanol and biodiesel are shown in Tables 7.1 and 7.2. Biofuel refineries also were granted reduced income tax from 35 to 15 %, and they are exempt from value-added tax (VAT) and the global tax, both of which are assessed on petroleum. A 10-year tax exemption was also granted by the Colombian government in 2004 for new palm oil plantations. In addition, the Ministry of Energy regulates prices and blend levels for biofuels, which guarantees a minimum price for biofuels producers (Pinzon 2012). In 2007, the Ministry of Agriculture allocated 6.1 billion pesos[1] in nonreimbursable incentives and financed 20.5 billion pesos in soft loans through its Agro Ingreso Seguro (AIS) program for the establishment of approximately 9,200 ha of oil palm.[2] Likewise, 20 billion pesos in soft loans were allocated from the AIS program to two ethanol projects and two biodiesel projects, in addition to 4.5 billion pesos for an oil palm extraction plant (Alvarez 2008).

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[1] In 2007, US$ was equivalent to 2078.35 Colombian pesos.

[2] Officials from the Ministry of Agriculture were subject to penal sanctions due to misuse of funds from this program and corrupt practices in the allocation of resources (See El Espectador 2009).

Table 7.1 Ethanol production and consumption in Colombia. (Source: Pinzón (2012) and Fedebiocombustibles (2013a))

Fuel ethanol (million liters)								
Year	2006	2007	2008	2009	2010	2011	2012	2013
Production total	269	275	256	327	291	337	362	410
Consumption	265	270	247	338	292	351	368	400

Table 7.2 Biodiesel production and consumption. (Source: Fedebiocombustibles (2013b))

Biodiesel (tonnes)					
Year	2008	2009	2010	2011	2012
Production	–	169,411	337,713	443,037	489,991
Consumption	–	169,065	337,718	–	488,187

The expansion of biofuels was also assisted by international cooperation and funding, mainly from the USA, with support for palm planting as a strategy to consolidate territorial control and replace illicit crops, as well as to promote alternative development projects. In the regions of Bolivar, Meta, and Sucre, biofuel projects aimed to employ demobilized members of paramilitary groups as well as people displaced by violence. These efforts have been coordinated by the US Agency for International Development (USAID) (Mejía 2011). By 2012, approximately 40,741 ha of sugarcane were dedicated to ethanol production and 168,200 ha of palm oil for biodiesel (Fedebiocombustibles 2012a, b). With the dramatic expansion of palm oil, Colombia has emerged as the largest producer of both palm oil and palm-based biodiesel in Latin America and the second largest producer of ethanol, after Brazil (Ministerio de Minas 2012).[3]

Despite this expansion, Colombia has not yet met its national blend mandates, let alone its goal of becoming an exporter of ethanol and biodiesel. In response to the shortfalls, the government modified its target downward for both ethanol and biodiesel production (Pinzon 2012). Colombia's international competitiveness is constrained because its existing infrastructure and current business model used for the production of biodiesel and ethanol are not cost competitive with its most immediate competitors (Brazil in ethanol and Argentina in biodiesel) (Kojima 2011). In order to address these constraints, efforts are being made to increase production levels by expanding the area under cultivation, reducing costs, and orienting its business model toward international markets, which includes adopting international sustainability standards, such as Bonsucro. Support for these efforts is also coming from foreign governments, as well as from the Inter-American Development Bank, which has financed projects aiming at finding and correcting bottlenecks in biofuels production.

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[3] Nevertheless, it is important to point out that its production levels are dwarfed by Brazil for ethanol and by Argentina for soy biodiesel.

7.5 MSI Governance of Biofuels

A confluence of forces over the past several decades has led to a shift in the functions of government, the market, and civil society as well as the relationships between them. These forces include the dramatic expansion in global trade, the rise in neoliberal ideology, concerns about socially responsible corporate behavior in developing countries, and global environmental crises, such as climate change (Ponte et al. 2011; Bain et al. 2013). Within this context, the nation state has found itself less able—and less willing—to regulate the economic, social, and environmental realms and we find instead that global rule setting increasingly includes a range of "'post-sovereign', 'networked' and 'hybrid' governance" initiatives (Backstrand 2006, p. 290).

Governance initiatives have evolved considerably during this period. Early on, social movements and NGOs took the lead in developing rules intended to encourage socially responsible behavior among corporations. In addition, they worked on developing alternative markets, especially in the agri-food sector, by establishing their own standards and certifications for markets such as organic and fair trade. Businesses and business associations also took the lead in developing their own codes of conduct, guidelines, standards, and auditing systems, for example, Global-GAP, which were largely intended to govern behavior within their own global supply chains (Djama et al. 2011; Fransen and Kolk 2007).

Since 2000, legitimacy concerns about these efforts have led to a shift toward MSI. While the nature of these organizational forms vary, the general idea is that different groups representing business, civil society, and sometimes government work together to address a range of issues, including developing standards that are mutually beneficial (Cheyns 2011). Proponents argue that such collaborations fill a governance gap by addressing issues that states and multilateral institutions have failed to address, such as climate change and sustainable development (Backstrand 2006). MSI are seen as having specific qualities that increase their effectiveness, including an emphasis on dialogue and consensus building and the sharing of information and expertise between different sectors of society, as well as between business and governmental actors (Cheyns 2011; Fransen and Kolk 2007).

The rules for business behavior established by MSI tend to vary in terms of their strictness, specificity, reach, as well as their requirements for monitoring and compliance (e.g., whether they require verification of compliance by an independent, third party) based on who was involved in establishing them. Nevertheless, an important focus of MSI is the development of agreed-upon standards that allow economic, social, and environmental phenomena to be governed across value chains and international markets. The development of standards (or indicators) is important because they provide the rules for what to measure and how to measure. In doing so, the goal is to ensure a common metric among people and things regardless of what markets or countries they operate in (Bain et al. 2013).

A number of MSI have been developed to address concerns regarding negative socioeconomic and environmental effects of biofuel production, especially in developing countries (van Dam et al. 2008; Oosterveer and Mol 2010; Bailis and Baka

2011). Some of the major initiatives include the RSPO, the RTRS, the RSB, and Bonsucro. Each of these groups has developed standards on a range of critical issues for their member companies to meet, including land and labor rights and sustainability issues related to deforestation and the loss of biodiversity. Participating companies are expected to meet these standards, and compliance is demonstrated through an independent audit that leads to certification (Chao et al. 2012). By 2013, 14 such schemes for biofuels were approved by member states as having met the RED regulations for reducing GHG emissions, including the RTRS, RSB, and Bonsucro and several industry schemes, such as Greenergy (EU 2013). Other multistakeholder efforts, such as the GBEP whose members are predominantly states and multilateral organizations, have also developed indicators designed to promote sustainable bioenergy development. However, its effort is entirely voluntary and there is no compliance mechanism, such as third-party certification.

Research on the efficacy of implementing sustainability criteria, standards, and certification systems in the biofuels sector has begun, and preliminary findings suggest caution about the likelihood that these nonstate, market-driven systems can ensure that environmental and social sustainability are embedded in biofuels production and trade. Past case study research literature on agricultural and forest certification illustrate some of the challenges and shortcomings of these systems and help inform the analysis of biofuels governance (Friedmann and McNair 2008; Klooster 2006; Konefal and Hatanaka 2011).

In the subsequent sections, we examine the promises and challenges of MSI to promote sustainability in the biofuels sector, with case studies in Colombia. In particular, we will focus on Bonsucro, an initiative that has developed standards to improve the sustainability of sugarcane production, and the GBEP initiative, which aims to promote sustainability across the biofuels commodity chain. The next section discusses the background of these two initiatives.

7.6 Operationalizing Biofuels Sustainability Through MSI in Colombia: Bonsucro and GBEP

The primary global initiative in relation to sustainable sugarcane and ethanol production is Bonsucro, which was launched in 2005.[4] Bonsucro's membership includes NGOs (e.g., World Wildlife Fund (WWF) and Solidaridad), producers and production companies, and end-user companies and it became an associate member of the International Social and Environmental Accreditation and Labeling Alliance (ISEAL) in 2008. The brand Bonsucro was launched in 2010, and in June 2011 the certification began. Also in 2011, the Bonsucro Certification System was approved as a qualifying standard under the EU RED. Bonsucro's Standard provides single certification auditing of both sugar and ethanol streams, which allows a mill to switch between

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[4] Information on the background, memberships, principles, criteria, and indicators for Bonsucro are drawn from their website, Bonsucro (2013), http://www.bonsucro.com.

the two. The Standard focuses on five key areas related to the social and environmental impacts of sugarcane production, which are legal compliance, biodiversity and ecosystem impacts, human rights, production and processing, and continuous improvements (Bonsucro 2013).

GBEP was founded in 2006 by the G8 + 5 (Brazil, China, India, Mexico, and South Africa) with the objective to promote the development and commercialization of renewable energy.[5] Its members are 23 nation states and 14 international organizations and institutions, such as the European Commission, several United Nations (UN) organizations including the Food and Agriculture Organization (FAO), International Energy Agency, and the European Biomass Association. Associated (observer) members include an additional 25 states and international development organizations including the World Bank, regional development banks, and the European Environment Agency. In total, GBEP partners and observers include most of the world's countries that produce biomass energy feedstock. In terms of its organizational structure, GBEP has a steering committee that guides overall activities, a technical working group, and three task forces that focus on specific issues: Task Force on Sustainability; Task Force on GHG Methodologies; and Working Group on Capacity Building for Sustainable Bioenergy.

GBEP was founded to facilitate international cooperation in bioenergy and to support national and regional policymaking regarding bioenergy. In a GBEP white paper, one of the key roles identified for GBEP is to facilitate bioenergy integration into energy markets (Italian Ministry of Environment 2005). Our interviewees involved in GBEP, however, emphasized that they are not developing a standard or certification for bioenergy; the goal of GBEP is to increase the production and use of biofuels, and to develop criteria and indicators that would allow for the measurement of sustainability in the sector.

In 2011, GBEP published a set of 24 "practical, science based" voluntary indicators that address environmental, social, and economic sustainability related to bioenergy. The GBEP indicators were the result of a consensus-building effort among a broad range of national governments and international institutions to measure the sustainability of bioenergy. In order to evaluate their feasibility and as a tool for policymaking, it was determined that the GBEP indicators should be tested on the ground in several countries.

The next section presents our analysis of how Bonsucro and GBEP are approaching the measurement of sustainability of bioenergy systems in the context of sugarcane ethanol production in Colombia. We describe the historical development of land use in the Valle del Cauca, after which we present contemporary case studies. The case studies focus particularly on how water use and water quality in bioenergy systems are being measured via Bonsucro and GBEP indicators and the limitations of these approaches for addressing sustainability of bioenergy systems in the Colombian context. Water access and quality emerged as one of the most controversial sustainability issues related to sugarcane production in the Valle del Cauca

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[5] The background discussion of GBEP has been drawn from documents on their website, http://www.globalbioenergy.org/.

region. Therefore, the next sections examine how water sustainability is being defined and measured in the GPEB and Bonsucro standards in Colombia.

7.6.1 Implementing Sustainability Standards in Colombia

Initiatives for sustainable biofuel production raise some important considerations concerning their implications in the Colombian context characterized by highly inequitable land and natural resource distribution, and the collusion between political and economic elites to maintain the status quo. Historically, government policies and market arrangements have privileged large-scale agriculture and agribusiness (Marin et al. 2011). Today, half the land (52 %) is owned by just 1.15 % of the population, while half of all rural families (1.3 million people) have no land at all (Smith and Vivekananda 2008; Padgett and Otis 2012). The result is a country of extreme inequality whereby 33 % of Colombians live in poverty and 10 % live in extreme poverty. In the rural areas, 47 % live in poverty and 23 % live in extreme poverty (DANE 2011). In the Valle del Cauca (see Fig. 7.1), the center of sugarcane production, 61 % of the land is controlled by just 5 % of registered landowners (De Roux et al. 2008 cited by Marin et al. 2011).

Initial research suggests that biofuel policies are reinforcing the inequitable distribution of land by favoring the entrenched large-scale capitalist agriculture over small-scale agriculture in Colombia (Marin et al. 2011). Studies show that it is primarily large-scale producers and landowners who have access to the necessary capital, technology, and agricultural inputs, which allow them to expand biomass production for biofuels (Mejía 2011). In the Valle del Cauca, sugarcane production grew 20 % from 186,500 to 223,905 ha between 2001 and 2011, often at the expense of other cash crops (Fedebiocombustibles 2012a). Between 2008 and 2009, for example, 5,292 ha of land (11.62 %) planted in cotton, rice, beans, corn, and soy was replaced with sugarcane (Gobernación del Valle del Cauca 2012). According to the Colombian Geographic Institute Agustin Codazzi (IGAC), the Gini index for the lands of Valle del Cauca presented a slight increase during the period 2000–2009, rising from about 0.819 to 0.828. The gap between the Gini of the lands[6] and of the owners[7] is among the highest in the country; the high concentration of landownership in the Valle del Cauca region results from both the large size of landholdings and the concentration of landownership, especially in high-quality lands (IGAC 2012). Municipalities in Valle del Cauca where sugarcane is the primary activity, such as Palmira, Cerrito, and Candelaria, also have the highest Gini indexes of the region (Gini of lands between 0.858 and 0.916 and Gini of owners between 0.891 and 0.959) (IGAC 2012).

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[6] The Gini of lands is estimated using the size of the lots contained in the cadastre (land official records).

[7] The Gini of owners is calculated by adding the area and appraisal of the properties of individuals that appear under the same name in the cadastre (land official records).

Fig. 7.1 Main sugarcane-growing region in Colombia. (Source: Toasa 2009)

The sugarcane industry in Colombia is in the process of implementing Bonsucro certification. To date, Asocaña,[8] the association that represents the sugar mills and ethanol plants, has conducted preaudits of its mills and trained 40 in-house auditors with the expectations that 40 % of its sugarcane will be certified by 2013. The association of small sugarcane producers, Procaña, is collaborating with Asocaña and Bonsucro to facilitate implementation and is working with NGOs to help them train its farmers on Bonsucro principles. From the perspective of our interviewees, Bonsucro is necessary to ensure that the industry could access EU markets. In addition, for other interviewees, certification is viewed as essential for demonstrating the industry's commitment to social and environmental sustainability, which participants believe will help to avoid future conflicts with local communities over issues such

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[8] The sugar mills directly own a substantial amount of land in the Valle del Cauca.

as water shortages and health effects related to water contamination and the burning of sugarcane. As one participant explained:

> Our intention [with certification] goes beyond opening new markets; it is more about social responsibility through a standard that allows us to have a better produced cane. [Certification] makes it easy for us to show that the sugar sector is actually committed to sustainability. (Interview C14)

7.6.2 *Measuring Sustainability in Sugarcane Ethanol: Water Use and Quality*

In the Valle del Cauca, sugar mills have appropriated water from rivers and aquifers, and more than 3,000 km^3 of potable water are used per year from more than 600 underground wells to irrigate the cane plantations.[9] Currently, the valley has salinization and drainage problems, and water contamination related to agriculture is a serious problem (Perez et al. 2011). The municipalities of Palmira, Candelaria, and Cerrito, the three main areas planted with sugarcane in the Valle del Cauca, have the highest rates of environmental conflict (Cortés 2010). In part, these conflicts are related to water issues, especially the contamination of water sources and water shortages for small-scale producers and household use.

A recent study conducted on the use of water by sugarcane and ethanol industries in Valle del Cauca provides an overview of the extent of water quality and availability problems in the region (Perez et al. 2011). Five critical issues related to water use by sugarcane and ethanol producers were identified in the study:

1. An increase of 23 % was observed in the amount of water used by agriculture in the Valle del Cauca over the period 1980–2009, most of which is attributed to the increase in sugarcane production.
2. There was unequal distribution of water concession in the Valle del Cauca in 2009, as sugarcane production had 64 % of concessions for surface water compared to 26 % for other human uses; 7 % for other agriculture; 2 % for industry; and 1 % for other uses. Even more dramatic, 88 % of water concessions for underground water went to sugarcane compared to 2 % for human uses, 2 % for other agriculture, 6 % for industrial, and 2 % for other uses.
3. Lower water rates were paid by the sugarcane industry relative to other users.
4. The sugar and ethanol industries are responsible for high rates of water contamination, especially pesticides and fertilizers. In addition, the sharp rise in the production of ethanol in the last few years has led to a steep increase in the production of vinasse as a by-product from distillation. While small amounts of vinasse can be effectively integrated as a fertilizer into crop production, high rates of concentrations are leading to the contamination of soil and surface water, especially with heavy metals.

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[9] Accion Colectiva Popular. Information available at: http://www.corpodice.cocogum.org/Archivos/Accion%20Colectiva%20Popular/Accion%20Colectiva%20Popular.html.

5. The overall levels of nutrient pollution of the Cauca River, especially nitrogen and phosphorous, are quite high. Estimates of the contribution of pesticides, nitrogen, and phosphorous from municipal versus sugarcane sources show that 76 % come from sugarcane, while 24 % come from municipal sources.

Both the disproportionate use of water and the contribution to contamination of water by the sugar and ethanol industries are clearly shown in the Perez et al. (2011) study. While sugarcane production has been contributing to most of these water quality and quantity problems for decades, the shift into ethanol production, stimulated by government policies and facilitated by the government environmental agency, the Cauca Valley Corporation (CVC), has led to a dramatic increase in water use and contamination since 2006. We now examine how these issues are addressed in Bonsucro and GBEP.

7.6.3 Case Study 1: Bonsucro

Environmental issues related to sugarcane production and processing are addressed in two Bonsucro principles: "Principle 4: Actively manage biodiversity and ecosystem services" and "Principle 5: Continuously improve key areas of business." The first of these environmental criteria is designed to assess the impact of sugarcane on biodiversity and ecosystems services, which are specified through the following indicators: "ensuring sugarcane production does not infringe upon areas of high conservation/biodiversity value, including wetlands and riparian areas; ensuring the quality of runoff water from sugarcane production is sufficient to support aquatic life." Other criteria set limits to the amount of nitrogen and phosphorous fertilizers and pesticides applied to sugarcane, quantified as phosphate equivalent. In terms of how these indicators are measured, in Bonsucro, nitrogen and phosphate equivalents are used as a proxy of the "risk" of eutrophication. That is, the amount of nitrogen and phosphorous applied on the field is reported but not measured in downstream water to assess contamination. This indirect measure of water contamination is problematic because it relies on producers to accurately measure and report on the quantity of fertilizer applied, rather than requiring action from the mills. In addition, it does not account for the fact that water contamination is caused by more than just the quantity of inputs applied but on other factors, such as soil type, slope, weather, and proximity to water bodies. However, in light of the study by Perez et al. (2011), it seems apparent that the application of inputs to sugarcane is not regulated or monitored and has already led to significant water contamination.

The criteria for "continuous improvement in key areas of business" include a number of environmental components, such as continuously improving soil and water resources, reducing emissions and effluents, and energy efficiency in the production of sugarcane ethanol (Bonsucro 2011). Here, we focus on how the improvement of water resources is proposed to be evaluated through specific indicators, namely, net water consumed per unit of product, which is defined as water captured or borrowed for use in irrigation and in processing, less water returned from mill to water source.[10]

As with all its standards, Bonsucro's standards for water use are designed to be applied to all parts of the commodity chain, from the field to sugar to ethanol, and to be applied equally across producing nations. However, in interviews with producers and representatives from industry associations, we heard repeatedly that the standards for water are too stringent for Colombian sugarcane and ethanol producers to meet, and that industry members are looking for ways to modify the standards to better fit their own situation. Interviewees also commented on how the development of technology for water use and water efficiency for large producers has been a key area where the Colombian state has invested for their benefit. Other interviewees highlighted that large agricultural interests have been privileged over small producers and households who have increasingly lacked a sufficient quantity of water for agriculture and adequate quality of potable water for community and household use. We illustrate these points through the interview data below.

A representative from Asocaña explained some of the challenges the Colombian sugar industry faces with Bonsucro certification with respect to water use. He argued that the sugar industry is very diverse globally in terms of its environmental endowments, which makes it challenging for Colombia to conform to Bonsucro's requirements. He explained:

> The world sugar industry is very diverse. The conditions in India are not the same as the conditions in Brazil or Colombia. The water requirements are different. Different from others we (in Colombia) produce during the whole year, and the standard falls short in accounting for those differences. This is one of the difficulties we have had in relation to the maximum limits that the standard establishes for some variables .... We have had a hard time trying to adapt to this. (Interview C6)

Because of these challenges, Asocaña decided to appeal to Bonsucro for modification of the standard, arguing that because Colombia needs to irrigate sugarcane and because they produce all year, the allocation of allowable water use needs to be increased.

> We have submitted to Bonsucro some letters asking them to consider the possibility that in the new version of the standard they can take into account more of the specificity of each industry. What they tried was to take the experiences of the whole industry and to create one standard for everyone, but it is very difficult to compare Colombia with India, for example in water consumption ... To try to unify a standard for both of us is very difficult. This is one of the biggest problems we have faced, to try to fulfill a standard that doesn't apply to my specificity. (Interview C6)

Bonsucro stakes its credibility on objectivity and the equal application of standards across location, space, and time. However, in our case study we see how politics and local socioecological conditions intervene and how the sugar industry is attempting to shape how standards may be applied and perhaps even modified to suit local demands.

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[10] The standard set is 20 kg of water per kg of sugar in the sugar mill, and for ethanol, 30 kg per kg of ethanol and < 130 kg per kg of cane (Bonsucro 2011).

Many interviewees stressed how expert knowledge and substantial financial investment from the Colombian state had given the sugar sector access to water, and has facilitated technology to be able to apply water in the most precise manner possible. The discourse of apolitical and impartial use of expert knowledge and water monitoring by sugarcane producers belies the collusion between the CVC and sugar sector, which has facilitated the disproportionate use of water by the industry relative to other users and ignored the contamination of water, a public good, by large producers.

As an industry representative explained:

> . . . we monitor [water use] all the time and we have data to demonstrate that we are complying [with limits]. . . . as a sugar industry we have very good management of the water resource because we are intense in the use of the resource. We invest a lot of money in taking care of watersheds and water tables . . . . Our business [relies on] water, if we run out of water, everything will get complicated for us, our business would get ruined. . . . We also have a Round Table of Water, which convenes all the experts and the heads of the water management areas of all the sugar mills to create guidelines and strategies to better use the resource. (Interview C14)

Representatives from both Asocaña and Procaña explained how the industry was using metering and specialized irrigation systems that are able to detect soil moisture with such precision that they are able to reduce water use by 50 %. Financing for this research and for the irrigation system came from the Colombian government and the CVC has also facilitated water use for the benefit of the sugar sector. Sugarcane producers have benefitted greatly from the research and they argue that the government should devote more resources to this research.

> . . . each sugar mill is assigned a maximum flowrate, they have to pay a usage fee, the CVC is stimulating the use of meters so the sugar mills are charged just for the water they actually use and not the maximum flowrate as it is done at the present. (Interview C4)

However, according to Rodríguez (2009), Colombia's first Minister for the Environment, the water usage fee was decreased significantly at the beginning of President Uribe's first term and the pollution tax has not been updated, causing both instruments to lose their effectiveness. Rodríguez (2009) suggests that this situation was the result of a decision to favor the agricultural sector and make the use of water practically free. In contrast to the interviews with sugarcane producers, an interview with an agronomist provided a completely opposite analysis of water use and the social and environmental profile of the industry. He was critical of excessive water use by the sugar industry and the resulting water pollution that affected potable water for surrounding communities. He indicated that while there are ostensibly restrictions on water use, they are not enforced by the CVC.

> The municipalities which depend on underground water suffer in the dry seasons from water shortages because the water is being robbed by the sugar industry and with license by the CVC. Candelaria, Pradera, many towns are affected by the lack of water during El Nio. The wells are very expensive to pump so they prefer to use surface waters, but there is not enough water for them and for the surrounding populations. 2004 and 2008 were very serious years in terms of lack of water. . . . There are [restrictions on water use] but . . . the water management in Valle del Cauca is corrupt, CVC is co-opted by the sugar mills. (Interview C5)

He criticized the CVC's lack of transparency about water access and use and argues that the ethanol market is a justification for excessive and unsustainable pumping of water resources:

> I have the impression that ethanol was necessary to justify pumping because it is very expensive. In Brazil 95 % of sugar cane is produced using rain water not irrigation. (Interview C5)

We also interviewed other residents in rural communities in Valle del Cauca where small-scale farming was driven out by land concentration and by expansion of the sugar industry. They described the difficulties they now face in accessing water for household use because of a lack of potable water from surface waters or from wells. These residents stated that they are forced to buy water for household use. They suggested that as the sugarcane growers have taken advantage of irrigation systems to maximize the efficiency of water use, they are diverting water away from other community users.

The case of sugarcane and ethanol production in the Valle del Cauca provides some interesting challenges for the application of Bonsucro as an objective, science-based standard to measure and improve the sustainability of biofuels. Both principles of "ensuring the quality of runoff water can support aquatic life" and "improving soil and water resources" are nominally positive in terms of improving environmental conditions. However, these principles seem quite limited in their application within the Colombian context, where a long-standing, entrenched system of unequal distribution of water and land resources, supported by government policies, persists. Although they want to participate in the Bonsucro certification for expanded market opportunities, the sugarcane industry is attempting to modify the standard to suit their interests, both in the interpretation of how to measure water quality and in its efforts to increase water quantity for sugarcane ethanol in Colombia.

7.6.4 Case Study 2: Pilot Testing GBEP Indicators in Colombia

The 24 GBEP sustainability indicators for bioenergy that were agreed upon through an international consensus process are currently being pilot tested in several national contexts to establish their feasibility and applicability as a tool for policymaking. Colombia and Indonesia applied for and were chosen as pilot study sites for the application of GBEP indicators. The German government provided funding for the pilot project, which was managed by FAO, to test the indicators and build the capacity of these two countries to apply the indicators. Interviews with participants in the GBEP indicator pilot project in Colombia revealed many challenges in their operationalization.[11] Many of the shortcomings with the GBEP process mirror the challenges noted with respect to applying Bonsucro's principles in the context of Colombia's unequal land and resource distribution landscape, especially in relation to the power of the sugarcane industry.

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[11] This discussion of the content of interviews with GBEP participants is more generalized, as GBEP participants asked not to be directly quoted.

Within the GBEP framework, there are similar indicators to measure water use and quality. Indicator 5 from GBEP focuses on water use and efficiency. The indicator is defined by:

> (5.1) Water withdrawn from nationally determined watershed(s) for the production and processing of bioenergy feedstocks, expressed:
> (5.1a) as the percentage of total actual renewable water resources (TARWR), and
> (5.1b) as the percentage of total annual water withdrawals (TAWW), disaggregated into renewable and nonrenewable water sources;

Drawing from the UN definition, GBEP proposes to assess "water stress" within a watershed or region producing biofuels as a measure calculated as the percentage of total annual water withdrawals (TAWW) in relation to total actual renewable water resources (TARWR). A ratio of 20–40 % TAWW to TARWR is considered medium to high water stress and over 40 % is high water stress. However, GBEP documents also state that where crops such as sugarcane are being produced for food as well as fuel crops, a distinction regarding water use will need to be made, albeit with great difficulty, "based on the fraction of agricultural output that is used for bioenergy production" (FAO 2011, p. 63). The GBEP documents recognize limitations with these indicators of water use and efficiency; one limitation with the indicators is that this only measures water withdrawals, often using global estimates, and not actual water use; therefore, it does not account for water use efficiency. Another limitation is that many countries, especially developing countries, have difficulties measuring TARWR and TAWW due to lack of data and uniform measurement standards. Numerous international efforts are underway to improve data quality. Given the water shortages for household use experienced by communities in the Valle Del Cauca highlighted in our interviews, and the unequal distribution of water resources between the sugar industry and all other users described above, communities in the region do appear to qualify as "water stressed," although it is clearly difficult to separate water use for sugarcane for food versus bioenergy.

Indicator 6 in GBEP relates to water quality and seeks to measure pollutants related to bioenergy feedstock production and processing. The indicators of water quality are defined in relation to:

> (6.1) Pollutant loadings to waterways and bodies of water attributable to fertilizer and pesticide application for bioenergy feedstock production, and expressed as a percentage of pollutant loadings from total agricultural production in the watershed;
> (6.2) Pollutant loadings to waterways and bodies of water attributable to bioenergy processing effluents, and expressed as a percentage of pollutant loadings from total agricultural processing effluents in the watershed;

Pollutant loadings are to be measured by the following indicator:

> (6.1) Annual nitrogen (N) and phosphorus (P) loadings from fertilizer and pesticide active ingredient loadings attributable to bioenergy feedstock production (per watershed area) (FAO, 2011:71).

The indicator measures pollutant loadings to waterways attributable to fertilizer and pesticide use for bioenergy feedstock production as a percentage of pollutant loadings from total agricultural production and for feedstock processing. This indicator is very similar in content and intent to Bonsucro Principle 4, as discussed above. However, as detailed below, our interviews highlighted how the sugar industry in Colombia has withheld data about water use and water quality, which makes it very challenging to verify the GBEP indicators on biofuels impacts on water.

The GBEP workshop, which was convened to report on the outcomes of pilot testing the sustainability indicators in Colombia, revealed some of the challenges in trying to apply these measures in the Colombian context. The workshop presentations repeatedly cited a lack of available data to test the efficacy of the indicators, and our interviews with participants from the workshop suggested that a part of the explanation for the lack of data was the intransigence of the sugarcane industry to provide the data, and the inability of the Colombian government to compel the industry to comply. Participants in the GBEP workshop stated that the sugar industry was coordinated in their efforts to not provide necessary data. For example, sugar industry representatives did not want to provide data on pesticide use in sugar production, which is one of the GBEP indicators of water quality.

In addition, our interviews also suggested that many stakeholders associated with the sugarcane industry were already invested in the Bonsucro certification process and therefore were uninterested in providing necessary data for the GBEP process, which they understood to be just another system for measuring biofuels sustainability. Sugar industry representatives did not appear to have a stake in GBEP because, unlike Bonsucro certification, GBEP is not a standard and does not promise expanded access to the EU market. Therefore, they saw it as both redundant and pointless.

Interviews highlighted that the sugarcane and ethanol sectors have well-funded private research agencies that work on feedstock improvements, and also collect social, economic, and environmental data related to the sugar industry. This resulted in a centralization and monopolization of the data related to this sector, which meant that, in practice, the industry associations were virtually the only source for some information about sugar and ethanol production. The control over data access and quality poses multiple problems for international projects like GBEP that seek to objectively measure sustainability through indicators. In the GBEP case, the sugar industry insisted that they should have control over the estimation of the indicators because of their expertise and autonomy. The sugar industry's role is quite problematic and raises the question of how to gather data to measure sustainability when data are held by the very sectors whose public image may be negatively affected by the results of objective measurements. This undermines the credibility of initiatives such as GBEP as being objective, science-based, and apolitical.

Finally, the prominence of the sugar industry in Colombia necessitated their participation in GBEP, but also constrained which other actors were invited and willing to participate in the process. Fearing the withdrawal of the sugar industry, critical civil society groups, including union groups, peasants, and social organizations, were not even consulted as part of the data collection process for GBEP. Unlike the Indonesia pilot site, where there was substantial input from NGOs and other organizations, the role of civil society in Colombia is quite limited overall, which translated into a lack of ability to compel compliance with providing data for GBEP. Our interviews highlighted challenges for a process such as GBEP to gather meaningful data for indicators to measure sustainability.

7.7 Conclusions

The case study of MSI for biofuels clearly illustrates the challenges of operationalizing a standard for sustainability in the context of a country like Colombia. While many stakeholders may be involved in constructing the global standards that are intended to be objective, value neutral, and science based, in practice we see local politics and power relations playing a key role in how these standards are translated on the ground. Recent scholarship on standards has shown how MSI attempt to gain legitimacy through stakeholder representativeness and trustworthiness, but that standards often reflect unequal balances of power of stakeholders (Partzsch 2011; Cheyns 2011; Ponte and Gibbon 2005; Elgert 2012).

This chapter builds on other recent literature that looks at how global standards are translated into local environments. Klooster (2011) found that standards and certification, specifically Forestry Stewardship Certification, have been deployed instrumentally by Mexican indigenous communities to foster organizational networking, conservation, and economic benefits. Djama et al. (2011) apply a governmentality approach to focus on how standards such as RSPO are designed to fulfill managerial criteria (i.e., auditing for third-party certification) more than to effectively promote sustainability. Research examining third-party certification practice for RSPO in Indonesia shows how civil society groups used RSPO as a platform to fight for indigenous land rights, but that the auditing process itself devalued indigenous forms of evidence for compliance in relation to scientific and technical evidence and, as a result, existing power relations were reinforced. Bain and Hatanaka (2010) also argued that techno-scientific values and discourse embedded in third-party certification often exclude many stakeholders who cannot conform to these discourses.

Our case studies illustrate similar issues and constraints in the operationalization of Bonsucro and GBEP in the Colombian context. In the case of GBEP, despite the interest of the Colombian government in participating as a pilot-test case, the sugarcane industry undermined the process. Powerful actors were able to control who participated in the pilot testing, who had access to necessary data, and they resisted addressing how sugarcane for ethanol exacerbates the region's "water stress." With Bonsucro, the industry is attempting to modify the standards for water use to suit local conditions. In both cases, other actors are excluded or not consulted, which favors the ability of the industry to manipulate the process and the data to protect their own interests. Powerful actors have disproportionate access to land and water resources, and neither GBEP nor Bonsucro initiatives appear capable of disrupting these inequalities. As a certification initiative, Bonsucro promises expanded market access for sugarcane ethanol and is more valued in Colombia than GBEP. Neither GBEP nor Bonsucro is being operationalized on the ground in an objective manner, but both are clearly influenced by politics and power. While framed as global initiatives to promote sustainability in biofuels, in practice both initiatives are reinforcing local power relations and inequitable access to land and natural resources.

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Chapter 8
Guatemala

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Abstract The Central American isthmus is a region that has to date been largely overlooked in the biofuel debate, despite several countries currently developing biofuel policies and programs, including Costa Rica, Guatemala, Honduras, and Nicaragua. This chapter provides an introduction to the biofuels sector in Central America, before focusing on Guatemala, which has been identified as the strongest potential leader in Central America for the production, trade, and consumption of biofuels. This potential is primarily due to high yields of sugarcane and oil palm, although at present only ethanol is being produced on a large scale; most of this production is currently exported. Furthermore, Guatemala has no national policy to promote a domestic market and it is unlikely that one will be developed in the short-to-medium term. This has consequences for the way in which the sector is developing in Guatemala and the sustainability issues associated with the production of the principal feedstocks. This chapter concludes that biofuels in Guatemala represent an industrial strategy rather than an energy policy, a sector driven by private interests with strategic concerns for sustainability.

8.1 Introduction

The increase in oil prices and a short supply of fossil fuels are forcing Central American nations to support and start exploring alternative sources of energy production, with many policymakers in the region looking to the example of Brazilian biofuel production (see Chaps. 3 and 4). The energy challenges facing many countries in the isthmus are significant; in 2008, an estimated 6 million people did not have access to electricity, while around 20 million relied on firewood to satisfy their most basic

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energy needs (CEPAL 2008). In addition to pursuing electrification and cooking fuel programs, many Central American states are also in the process of developing laws and regulations to govern the production and use of biofuels.

Different feedstocks to produce biofuels are already cultivated in the region, including sugarcane (*Saccharum officinarum* L.), jatropha (*Jatropha curcas*) and oil palm (*Elaeis guineensis*). Other less known or less productive feedstocks, such as castor oil and sorghum, are also under review. With regard to more advanced technologies some Central American countries, including Honduras and Guatemala, are researching the use of fish waste and microalgae for biodiesel production, respectively (Universidad Galileo 2012; Gomez 2012).

Nevertheless, while only Costa Rica and Panama have laws and regulations to promote the use of biofuels, the potential for sustainable and regulated biofuel production in the region is questionable. Guatemala is the only country currently producing fuel ethanol on a large scale, due to its well-established and efficient sugarcane sector. However, this interest is a relatively recent development and is driven by industry rather than being a politically driven energy or climate change policy. Whatever the driver, both industry and government need to ensure that future production is sustainable and, therefore, a policy framework which incorporates sustainability must be developed. Without such a framework, there is a risk that the negative impacts of production will outweigh the potential benefits.

The overall aim of this chapter is to introduce the current biofuels situation in Guatemala, the only Central American country that is currently producing biofuels on an industrial scale; the chapter then reviews the sustainability issues associated with biofuel production in Guatemala. The remainder of the chapter is structured as follows: Section 8.2 provides a general review of biofuels in Central America in order to understand the position of Guatemala in relation to its neighbors. Section 8.3 introduces the political economy of Guatemala, highlighting land use and the current demand for oil. Section 8.4 reviews Guatemala's nascent biofuel sector, focusing on the policy context and introducing the key feedstocks, while section 8.5 discusses the environmental, social, and economic sustainability implications of Guatemalan biofuel production. The final section draws conclusions on the Guatemalan biofuels sector.

8.2 Biofuels in Central America

The Central American isthmus is a region that has largely been overlooked in studies of bioenergy and biofuel potential. This is despite all countries making wide use of traditional bioenergy and all being in the process of developing legal frameworks to promote the production and use of biofuels. The drivers of biofuels vary according to the priorities of the individual state; for example, while climate change is an important driver of biofuels in Costa Rica, in Guatemala biofuels have been driven by the sugar industry for which ethanol represents an additional export product. A driver that is common to all states is the need to reduce dependence on imported fossil fuels, particularly petroleum. This is of key importance in a region where oil imports totaled US$ 9,321 million or 16 % of the total value of exports of goods and services (CEPAL 2011). There are many barriers to the uptake of biofuels including cost, compatibility with existing infrastructure, and inhibitory policy environments. The creation of domestic demand will therefore be essential if biofuels are to play a future role in the region's energy mix. However, no state has yet developed a domestic market for biofuels, although Costa Rica is the most advanced in this respect having mandated blending requirements for ethanol and diesel.

Despite the lack of domestic biofuels markets, nearly all countries are producing biofuels for export markets, primarily to Europe (IDB 2010). While governments are the key actors for designing the legal and regulatory frameworks within which biofuels will be promoted and used, they are not always the primary movers in the Central American biofuels industry. It has largely been the private sector, rather than the state, that has driven the development of the biofuel sector within Central America. In Guatemala, for example, growth in fuel ethanol exports has been led exclusively by the sugarcane industry. A biofuel sector driven by the private sector, and therefore global markets, will look very different from one created by state actors. This has profound implications for the way in which the industry develops in terms of which feedstocks are used, how the feedstock is produced, who produces the biofuel, which markets are targeted, who stands to benefit, and who stands to lose from increased production and trade in biofuels.

As part of a globalized world economy, many Central American countries are already experiencing land-use changes driven by shifts in the world price of agricultural commodities. Price instabilities and market oscillations have caused the price of traditional agricultural commodities to fall and agricultural producers have sought alternative markets and crops. In Honduras, uncompetitive banana plantations are being converted to oil palm at a rapid pace (La Prensa 2011); in Guatemala, sugarcane and oil palm are expanding into nontraditional cultivation areas (Alonso Fradejas et al. 2008); and across the region, governments and private actors are interested in jatropha, particularly for its potential to grow on so-called 'marginal' lands. While these changes are not wholly due to increasing global demand for biofuels, biofuels offer a new market for agricultural crops and their by-products.

A report by the Inter-American Development Bank (IDB 2006) identified challenges to developing a biofuels industry in Latin America and the Caribbean, grouping them into three categories. The first category referred to technical barriers such as the introduction of new technologies, both agricultural and mechanical, or to new technical approaches. The second, policy barriers, involved uncertain or inhibitory policy environments. A third category, financial barriers, included those that limit access to financial capital at different stages in the biofuel chain. A further challenge applied specifically to the countries of Central America and the Caribbean, classified as 'small market countries' due to their small domestic fuel markets and small agricultural production capacity. The IDB (2006) concluded that these countries lack a sufficient market size to successfully initiate a biofuels market on their own; the solution, it is argued, is to work with neighboring countries to achieve sufficient economies of scale. Greater regional integration has also been posited for other sectors to overcome the small market barrier; for example, the Proyecto Sistema de

Interconexión Eléctrica para los Países de América Central (SIEPAC) was conceived to integrate regional electricity markets (Lecaros et al. 2010).

The six Central American states signed a regional agreement in 2007, the Central American Sustainable Energy Strategy 2020 (Estrategia Energética Sustentable Centroamericana 2020), which included articles on the use of biofuels (CEPAL and SICA 2007). One of the Strategy's objectives was to reduce the consumption of fossil fuels in the transport sector by 15 % by 2020. This would be achieved through legal blending requirements, which would require a 10 % gasoline blend with ethanol (E10) and a 5 % diesel blend with biodiesel (B5). However, incentivizing the production and domestic use of biofuels will require specific legislation and, as yet, only Costa Rica had made any progress towards developing such requirements. To facilitate this process, the Secretariat for Central American Integration is negotiating the establishment of regional standards for biofuels. These standards would facilitate trade within the region, as well as exports to the European Union (EU), the USA, and Japan. Various other agencies and countries have been promoting the development of a clear regulatory framework for biofuels in the region, including the Economic Council for Latin America and the Caribbean (CEPAL), the IDB, the Organization of American States (OAS), and the Brazilian, US and Colombian governments (CEPAL 2007, 2009). Colombia, for example, through the Plan Mesoamerica has provided the capital (both financial and knowledge) for three biofuel-processing plants in El Salvador, Honduras, and Guatemala. The plants would have an installed capacity of 10,000 l/day (CEPAL 2009). The first two are already inaugurated, but as of early 2013 no progress has been made on the Guatemalan plant.

In summary, Central America is responding to the increasing global demand for biofuels. Although the countries of the region are relatively small, there is broad interest in developing a biofuels industry, both for export and domestic markets. The limited land available in many of these countries, however, raises many issues associated with the production and use of biofuels, which include land use, food security, and institutional capacity.

8.3 The Guatemalan Context

With a land area of 108,889 km^2 and a population of 14.7 million people, Guatemala is the most populous nation in Central America (INE 2011a). Guatemala has an incredible diversity of climates and ecosystems, primarily due to a chain of mountains and volcanoes that passes through the country from the northwest to the southeast. This range defines the various geographic and climatic regions of Guatemala: the fertile Pacific coastal plain and piedmont, the western and eastern highlands, the Atlantic coastal plain, and the Petén rainforest (Handy 1994). Three-quarters of the population, and most of the cities, are concentrated along this volcanic chain, especially on the Pacific side. The country's economic base has historically been dependent on agricultural exports (coffee, sugar, cotton, banana, and beef), although neoliberal reforms in the 1980s and 1990s led to diversification of the economy, particularly into manufacturing and tourism. The agricultural sector remains important to the economy, accounting for 15 % of the gross domestic product (GDP) (CABI 2011).

Like most Central American countries, Guatemala experienced a turbulent twentieth century and arguably experienced the region's bloodiest conflict. The Guatemalan civil war lasted 36 years, claimed more than 200,000 lives, saw the massacre of entire communities, and led to the displacement of more than 1 million people (REMHI 1998; CEH 1999). Guatemala is not a poor country—the World Bank classifies it as Lower Middle Income (2012)—yet it has the lowest Human Development Index in Latin America after Haiti (UNDP 2012). Guatemala also has the second lowest tax base (10.5 %) in the Western Hemisphere (after Haiti), which means that state institutions are chronically underfunded (Sanchez 2009). It has consistently been one of the most unequal countries in the world in terms of income distribution; more than half the population lives below the poverty line and, of these, 13 % live in extreme poverty (INE 2011b; World Bank 2012). Three-quarters of Guatemala's indigenous people are poor, double that of the nonindigenous population (Shapiro 2006); one in two children under the age of five suffer from chronic malnutrition, rising to 80 % in indigenous areas (UNICEF 2009). Until recently, the population of Guatemala was predominantly rural; in 2011, 50 % of the population was urban, and this is expected to increase to 55 % by 2020 (UNDESA 2011). In rural Guatemala, agricultural censuses have shown that more than half of the agricultural plots are not large enough for subsistence farming (INE 2004; Taylor 2005). In 2003, just 2 % of producers (with an average of 194 ha) controlled 57 % of arable land, while 87 % of producers (with an average of 1.2 ha) occupied just 16 % of arable land (INE 2004). Furthermore, the average size of holdings below 1.4 ha decreased from 0.7 ha in 1964 to 0.19 ha in the 1990s (Taylor 2005). The highly skewed distribution of land was one of the root causes of Guatemala's civil conflict.

8.3.1 Land Use in Guatemala

According to the Food and Agriculture Organization of the United Nations (FAOStat 2013), the share of agricultural and arable land in Guatemala has increased since 1960 and there has been a concurrent reduction in forested area. Arable land increased from 1.1 Mha in 1961 to 1.5 Mha in 2011 while the forest area fell from 4.7 Mha in 1990 to 3.61 Mha in 2011 (Fig. 8.1). The drivers of deforestation are multiple and include cattle rearing, small-, medium-, and large-scale agriculture (the latter tied to the production of monocultures), forest fires, illegal logging, and narcotrafficking (IARNA 2012).

The main crops in Guatemala are sugarcane, bananas, and coffee (FAOStat 2013). Figure 8.2 shows the top 12 commodities produced in Guatemala in 2011 according to international price per commodity and production in million tonnes. In terms of quantity, sugarcane is the second most important commodity, but the most important by price. Oil palm is ranked eleventh, with a production of 248 billion tonnes in 2011.

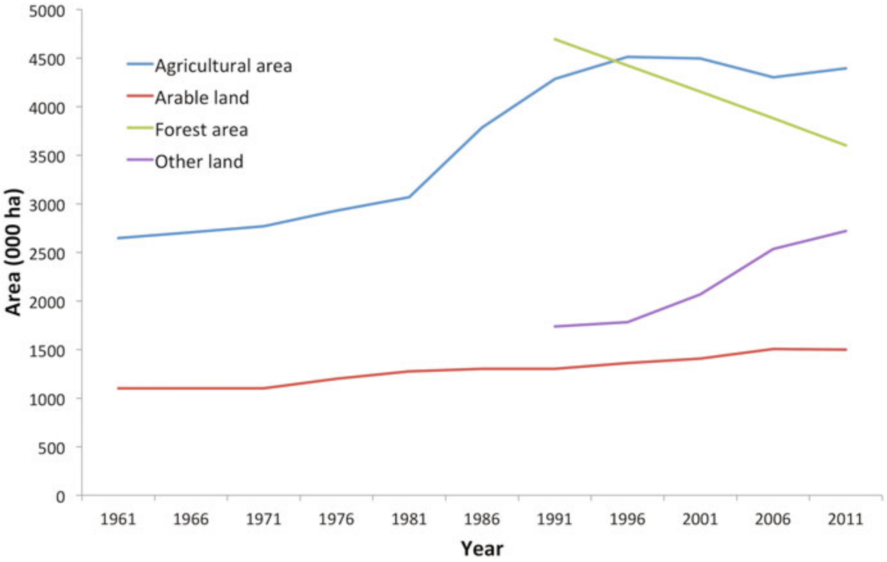

Fig. 8.1 Land-use change in Guatemala, 1960–2012. (Source: FAOStat 2013)

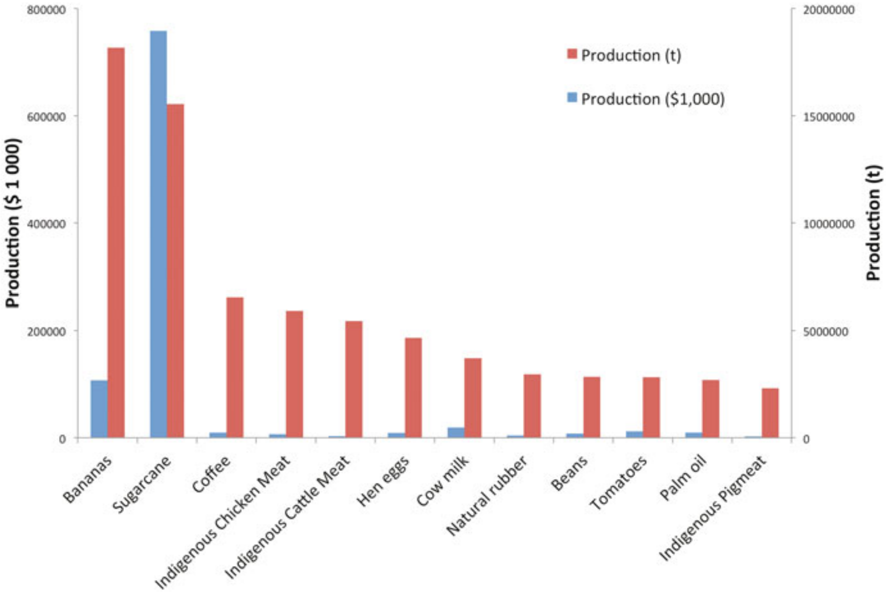

Fig. 8.2 Top commodity production in Guatemala, 2011. (Source: FAOStat 2013)

Permanent crops, such as banana and oil palm, are common, although slightly more land is used for the cultivation of annual crops. Sugarcane cultivation constitutes about 22 % of the area under annual crops (although sugarcane is a semi-perennial

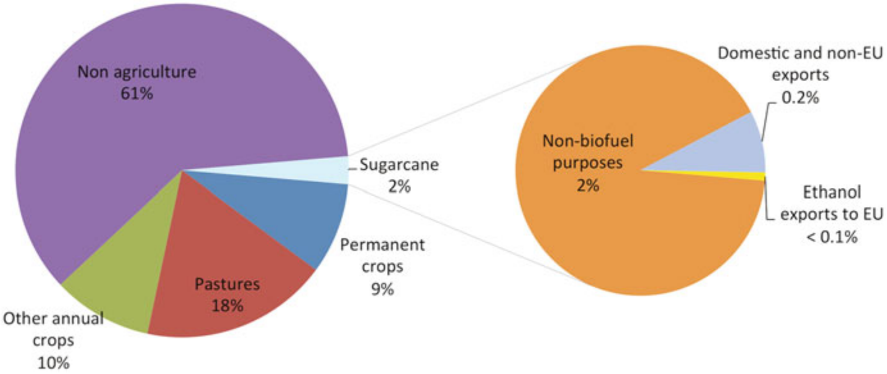

Fig. 8.3 Agricultural land use (kha) in Guatemala in 2008, focused on sugarcane production and ethanol use. (Source: Hamelinck et al. 2011)

Table 8.1 Fuel consumption and projected biofuel demand. (Source: adapted from MEM 2011 and CENGICAÑA 2011b)

Fuel/biofuel blend	Demand (million liters/year)			
	Fuel consumption (2009)	Projected biofuel demand	Production capacity (2011)	Surplus production
E10	1,270	127	240	+ 113
B2	1,591	32	6.6	– 25.2

crop), making it important in Guatemala's agriculture, while ethanol is an important co-product (Hamelinck et al. 2011). Figure 8.3 shows the agricultural land use in 2008 and the estimated area for ethanol production and use.

8.3.2 *Oil Consumption and Demand*

Guatemala is an oil producer; however, this activity is very small scale (an estimated 736,000 tonnes were produced in 2009, compared to Venezuela's 150 billion tonnes) (IEA 2013). Since the country has no oil-refining capacity, the majority of petroleum production is exported and Guatemala is a net importer of petroleum products (CEPAL 2011). In 2010, the value of petroleum imports was US$ 2.23 billion, with most imports used in the transport sector (CEPAL 2011). Guatemala's vehicular fleet totaled 2 million vehicles in 2010, around 75 % used gasoline and the remainder diesel, including heavy transport such as buses, pickups, trucks, and containers (Hart Energy 2010a). The vehicle fleet has an average age of 13 years, with models registered prior to the year 2000 accounting for almost 60 % of vehicles (Hart Energy 2010b). In 1998, Guatemala's petroleum market was liberalized in order to keep the price of transportation fuels low; government policy remains one of nonintervention in the market (UNCTAD 2007). In 2009, gasoline consumption reached 1.27 billion liters, 44 % of vehicular consumption, while diesel reached 1.59 billion liters, accounting for 56 % of the transport fuel market (Hart Energy 2010a). Table 8.1 shows these figures as well as the projected demand that a 10 % ethanol blend with gasoline (E10) and 2 % biodiesel blend with diesel (B2) would require.

Having outlined the current political and economic context within which biofuels are situated, the following section describes the Guatemalan biofuels sector in more detail, focusing on current policy framework and the principal potential feedstocks, namely sugarcane, oil palm, and jatropha.

8.4 A Nascent Biofuels Sector

The United States Department of Agriculture (USDA) regards Guatemala as the strongest potential leader in Central America for the production, trade, and consumption of biofuels due to high yields of sugarcane (ethanol) and oil palm (biodiesel) (USDA 2009; Tay 2012). The USDA (Tay 2012) estimates that to meet a domestic requirement for E10 would require 145 million liters per year, which could be easily met by the sugarcane industry. A 10 % biodiesel/diesel blend would, however, be more difficult to meet due to the embryonic status of the biodiesel industry. At present, there is no domestic market for biofuels and successive attempts to establish a mandate have failed. In addition to various government ministries, the principal domestic actors involved in the biofuels sector are fuel suppliers (both national and multinational), agricultural associations, and nongovernmental organizations (NGOs). Guatemala is included in the US-Brazil Biofuels Initiative and has been the recipient of funding from international organizations, including the OAS and IDB, seeking to promote the domestic use of biofuels. However, the weak nature of the Guatemalan state has had implications for the way in which the biofuel sector has developed. Biofuels have developed in a policy and regulatory vacuum and it has been left to certain domestic and external actors to promote their use and the direction of development. As a result, the vast majority of biofuels currently produced in Guatemala are exported and can be viewed as an industrial strategy, rather than an energy policy i.e., the sector has been incentivized by a desire to obtain greater value from the coproducts of sugar production.

8.4.1 A Biofuels Policy for Guatemala

At present, there is no domestic market for biofuels in Guatemala nor is there legislation to promote their use. However, there have been two previous attempts to develop a biofuels law. The first, Decree 17/85, or Ley del Alcohol Carburante (Law of Fuel Grade Alcohol), was published in 1985 in response to increasing petrol prices and low international prices for sugar (Congreso de Guatemala 1985). The law proposed the substitution of petroleum products with energy produced from renewable domestic sources, which would encourage investment in agribusiness and create employment opportunities. It established an E5 mix (i.e., 5 % fuel ethanol in the gasoline mix) in order to guarantee a domestic market with defined prices and fixed quotas. The Ministry of Energy and Mines (MEM) would have responsibility for controlling production, commercialization, purity, and quality of the ethanol. Under Article 34, ethanol producers were subject to a quarterly tax payment, equivalent to 2.5 % of alcohol production, which had to be paid in advance. The annual sales price would be fixed by a technical committee, which would include representatives from MEM, the ministries of finance and the economy, as well as ethanol producers. No single refinery would be permitted to supply more than 20 % of domestic demand, except under certain (unspecified) conditions. Under Article 31, ethanol producers would be exempt from import taxes and custom duties on machinery, equipment, supplies, and additives associated with the production of fuel alcohol. However, the decree failed for a number of reasons including increasing sugar prices, failure to agree on the sales price of alcohol, opposition from the hydrocarbon industry, and the relative stabilization of international petroleum prices.

Since 1985, further efforts to develop a national biofuels policy have faltered due to opposition from petroleum importers and lack of buy-in from key stakeholders. For example, a draft bill—the Ley de Oxigenación de Combustibles con Etanol Carburante (Oxygenation of Fuel Grade Ethanol Law)—was proposed in 2006, which aimed to standardize the sector and create a mandatory blending requirement, thus creating an internal demand for biofuels. However, the law is still with Congress and is seemingly in limbo and unlikely to be approved in the near future. In 2007, the state set up a National Biofuels Commission (Comisión de Biocombustibles) driven by concerns about reducing the use of fossil fuels, increasing the use of renewable energy, and capitalizing on potential export markets. The aim of the Commission was to develop guidelines for a future biofuels policy. The Commission was comprised of representatives from MEM, the Ministry of Environment and Natural Resources, the Ministry of Agriculture, and the Ministry of the Economy. However, a lack of time and resources has rendered the Commission ineffectual and it is the private sector that has led the development of the biofuels sector in Guatemala (Lefevre and Ramirez 2010).

The last couple of years have once more witnessed renewed interest in promoting biofuels, this time driven largely by external actors, principally the OAS and the US-Brazil Biofuels Initiative. In 2010, the OAS financed a consultancy to draw up a proposal for a new Ley de Biocombustibles para Guatemala (Biofuels Law for Guatemala) (Hart Energy 2010a). Despite this, the inauguration of a new president and a lack of political will have once more halted progress and, at the time of writing, the initiative is on hold.

Despite the lack of a national policy for biofuels, Guatemala is currently producing fuel ethanol from sugarcane on a large scale. In 2010–2011, all of the fuel ethanol produced in the country was exported (CENGICAÑA 2011b). Production of biodiesel is not yet significant, although there is some interest in promoting its use and production from oil palm. The use of jatropha as a biodiesel feedstock is also being investigated, particularly at a small scale, by private and nonprofit organizations. However, early trials, which have used unimproved seeds, have not been encouraging (Private sector interview, February 2012). There are therefore three biofuel models in Guatemala: large-scale ethanol from sugarcane; large-scale biodiesel from oil palm; and small-scale biodiesel from several feedstocks. These models are neither exhaustive, nor are all of them currently running. The subsequent sections discuss each of these models in turn.

8.4.2 Ethanol and the Guatemalan Sugarcane Industry

Sugarcane cultivation has a long history in Guatemala, having been cultivated since the sixteenth century. Today, Guatemala is the fourth largest exporter of sugarcane products in the world, representing 3 % of total world exports, and is second in Latin America (ASAZGUA 2011). Guatemala's success as a sugarcane producer is attributed to several factors, including the Pacific coast's fertile volcanic soils, favorable weather conditions, and a world-leading research center. The sugarcane industry is principally located in five departments on Guatemala's Pacific coast (Fig. 8.4). This allows for easy access to the country's principal port, Puerto Quetzal, and EXPOGRANEL, the loading terminal for sugar exports.

There is only limited opportunity for sugarcane to expand on the Pacific coast due to the climatic conditions and competition from other agro-industries, including oil palm, banana, and rubber. As a result, in 2007 one of the sugar mills relocated eastwards to the departments of Alta Verapaz and Izabal, favored for their proximity to the Atlantic coast. The executive director of Asociación de Azucareros de Guatemala (ASAZGUA), an industry body, was quoted as saying, "the only limit that the sugar cane industry has encountered to increased production is the amount of land available" (cited in SAVIA 2009). The mills themselves produce 80 % of the sugarcane, with the remainder provided by independent producers, most of whom are large landowners (Hart Energy 2010b).

The industry is important nationally, representing 21 % of agricultural exports, 10 % of total exports, and 3 % of the national GDP (ASAZGUA 2011; CENGICAÑA 2011a). As one of the country's key industries, the sector has significant political and economic influence (Solano 2008). At present, there are 13 sugar mills in Guatemala. The sector is vertically integrated and highly concentrated; it has become more concentrated as the mills have sought to both concentrate and extend their operations. Pantaleon is one of the largest sugarcane mills in Latin America, having acquired three others within Guatemala (Concepción in 1984, Monte Rosa in 1998, and El Baúl in 2000) as well as holdings in Nicaragua and Honduras and an alliance with the Manuelita Group (Colombia) and UNIALCO (Brazil) for sugar and ethanol production in Brazil.

The area planted with sugarcane has increased steadily since the 1980s (see Fig. 8.5). It has increased from 78,000 ha in 1980–1981 to 232,000 ha in 2010–2011 (CENGICAÑA 2011a), a tripling in harvested area. Sugarcane yields have increased by almost 20 % over this period, an achievement attributed to the research of CENGICAÑA, a private research center funded by Guatemala's sugar mills.

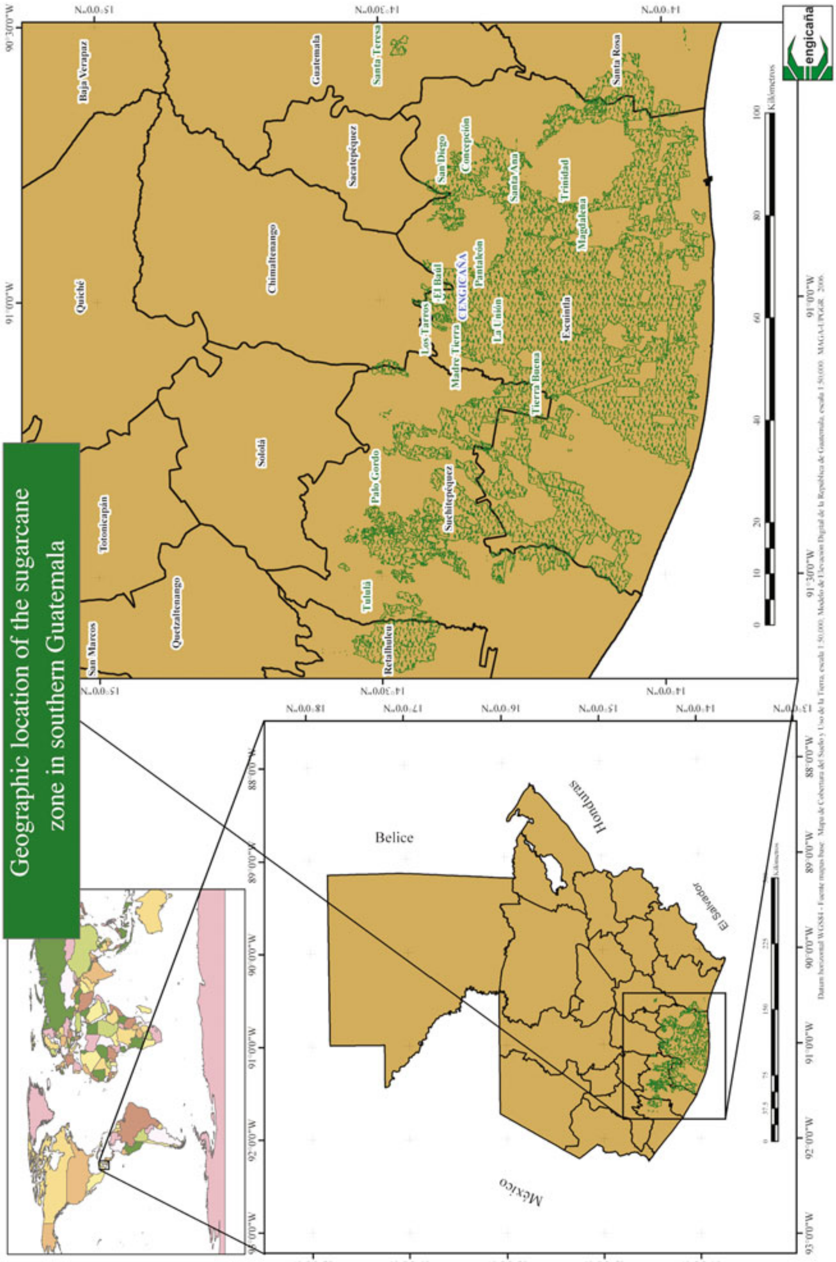

Fig. 8.4 Geographical location of sugarcane production in Guatemala, 2008. (Source: CENGICAÑA 2008)

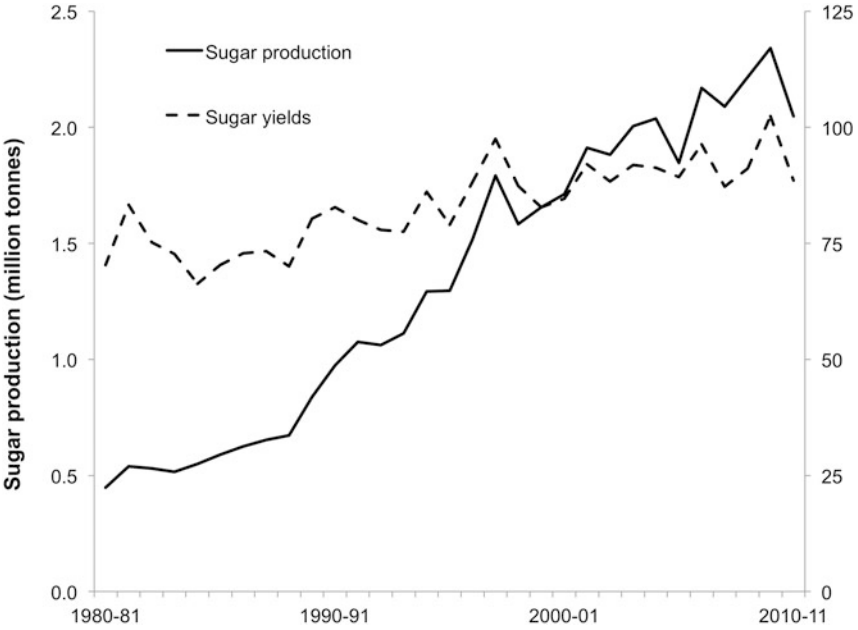

Fig. 8.5 Evolution of sugarcane production in Guatemala, 1980/1981 to 2010/2011. (Source: CENGICAÑA 2011a)

The USDA (Tay 2012) reports that the total potential area that could be planted with sugarcane is 350,000 hectares, potentially yielding up to 30 million tonnes of sugarcane. In 2010–2011, the sector had a combined milling capacity of 130,000 t/day and 2 million tonnes per crop year (CENGICAÑA 2011a). In 2009–2010, sugarcane yields reached 102.4 tonnes per ha (Fig. 8.5), making Guatemala the second most efficient sugarcane producer in Latin America after Peru (FAOStats 2013); however, unfavorable climatic conditions during 2010–2011 caused yields to fall to 88.52 tonnes per hectare.

As commercial companies, it is up to the mills to decide which end products to produce—whether unrefined or refined sugar, fuel or potable ethanol—and this decision will be based on internal and external market prices. In addition to the production of sugar and other derivatives, many of the refineries also produce electricity from bagasse (CENGICAÑA 2009; CEPAL 2012).

The majority (70 %) of the sugar produced in Guatemala is exported; key export markets include South Korea, Mexico, and the USA. The remainder is consumed domestically (ASAZGUA 2011); the annual per capita consumption of sugar is almost 53 kg (USDA 2009). In 2011, exports of raw sugar represented 59 %, with refined sugar accounting for 41 %; however, the industry is increasingly focusing on exports of refined sugar, a higher value-added product. Domestic consumption is split between 28 % industrial and 72 % human consumption; the soft drink industry is the major industrial consumer of sugar in Guatemala. All sugar sold domestically

Table 8.2 Ethanol production in Guatemala, 2011/2012. (Source: CENGICAÑA 2011b)

Distillery (refinery)	Production (l/day)	Estimated annual production (l/year)	Type of alcohol produced	Year operational
Mag Alcohol, S.A. (Magdalena)	300,000	69,000,000	Neutro, REN, HT	2007
Bio Etanol, S.A. (Pantaleon)	150,000	24,000,000	Fuel ethanol	2006
	360,000	57,600,000		2011
Palo Gordo, S.A. (Palo Gordo)	75,000	11,250,000	REN, HT	1984
Destiladora de Alcoholes y Rones, S.A. (Tulula)	250,000	62,500,000	Potable, REN, HT	2006
	50,000	12,500,000	Fuel ethanol	2010
Total	1,185,000	236,850,000		

must be enriched with Vitamin A and the industry is reported to spend US$ 3.5 million a year in fortification (USDA 2009).

The sugarcane sector has been producing ethanol from molasses (a by-product of sugar production) for about 20 years, but on a small-scale; large-scale distilleries have only been in operation since 2006. At present, five of the 13 mills produce ethanol, while others are expected to add alcohol distilleries in the future (see Table 8.2). Nearly all of the 1.18 million liters produced per day is exported, principally to the EU, the USA, and Mexico.

As of 2013, only two refineries (Pantaleon and Tulula) have the capacity to produce fuel ethanol, although other distilleries in Guatemala produce potable and industrial ethanol. In Guatemala, ethanol is produced from molasses, which was originally considered a waste or low-value by-product until the industry added fermentation and distillation capacity. The sugarcane industry is keen to highlight that it does not reduce production for traditional (domestic or export) markets and ethanol production has always been driven by economics. The availability of molasses may prove to be a barrier to the production of fuel ethanol. According to Hamelinck et al. (2011), 9 % of the total area under sugarcane was used for the production of ethanol and 1 % was dedicated to fuel ethanol for the European market. The sugarcane industry could easily meet the domestic demand for a 10 % blend, although many of the mills would need to invest in distillation and dehydration facilities (USDA 2009).

8.4.3 Biodiesel

In contrast to ethanol, Guatemala only produces small quantities of biodiesel. There are several small-scale biodiesel plants, which run on a variety of feedstocks, including jatropha, used cooking oil (UCO), and tallow. No oil palm is used to produce biodiesel. Estimates of biodiesel production capacity range from 15,000 to 25,000 liters per day (Tay 2012; Hart Energy 2010a; ACR 2011). The United Nations Conference on Trade and Development (UNCTAD 2007) argues that while this production is not significant, it presents an important economic opportunity for small users, communities, and low-tech producers.

Table 8.3 Biodiesel production capacity, 2010. (Source: ACR 2011)

Company	Installed capacity[a] (l/day)	Feedstock
Biocombustibles de Guatemala[a]	6,800	Jatropha, UCO
Combustibles Ecologicos	2,273	UCO
Comunidad Nueva Alianza	227	Jatropha, UCO
Empacadora Toledo	6,800	UCO
Fuerza Verde	227	UCO
Guatebiodiesel	6,800	Jatropha, UCO
Helios	1,300	Jatropha, UCO
TecnoServe	1,100	Jatropha, UCO
Total	25,527	

[a] Not all of these plants are still operational, which may account for the range in annual production cited above. For example, Biocombustibles de Guatemala declared bankruptcy in 2010 and is no longer in operation

Table 8.3 shows that recycled oils are the principal biodiesel feedstock, much of which comes from restaurants and the food industry. Private companies, including Pollo Campero (the largest fast-food chain in Latin America), have also invested in biodiesel production capacity, the products of which are used in company fleets (Private sector interview, March 2012.). The USDA (Tay 2012) estimates that the long-term potential for biodiesel based on oil palm in Guatemala is close to 370,000 liters per day. Despite this potential, Guatemala does not currently produce, consume, or export biodiesel from palm oil. The USDA suggests that the biggest barrier to the promotion of a domestic biodiesel market is that the present law does not allow for the blending of “biofuels with diesel” (Tay 2012, p. 9). In addition, the existence of other, more profitable, markets for feedstocks represents a considerable barrier. The following sections describe two potential feedstocks—palm oil and jatropha—in more detail.

8.4.3.1 Oil Palm

The USDA (Tay 2012) states that the Guatemalan oil palm industry has ‘significant’ potential for biodiesel production, due to its high yields of oil palm. It highlights the efficiency of Guatemalan oil palm production, with yields of 7 tonnes/ha compared to the global average of 3–4 tonnes/ha. Compared to other agro-industries in the country, the oil palm sector is relatively new, with the first plantations being established in the 1980s. Since then, the cultivated area has increased from around 3,000 ha in 1990 to 93,500 ha in 2010 (IARNA 2012; Tay 2012). A study by the Ministry of Agriculture estimated that there are potentially half a million hectares suitable for oil palm plantations, with the crop currently occupying around 20 % of this potential (cited in MEM 2011). As with the sugarcane sector, the oil palm sector is concentrated; although there are 40 companies dedicated to the cultivation of oil palm, the sector is dominated by just five companies. The owners of these companies belong to Guatemala’s traditional landed elite who, like those in the sugar sector, has considerable influence over policy and the economy (Solano 2008). Currently, all palm oil produced in Guatemala is sold to the edible oils market. While the Guatemalan Palm Oil Association (GREPALMA) has expressed an interest in promoting the use and production of biodiesel, at present edible oil markets are both more profitable and more certain than fuel markets (UNCTAD 2007); consequently, 'not one drop of palm oil' is currently being used to produce biodiesel (Private sector interview, March 2012). As stated, oil palm continues to be more valuable for edible oils than for biodiesel; however, there might be an opportunity for competitively produced biodiesel from some palm oil by-products, such as palm fatty acid distillate (Chongkhong et al. 2007).

8.4.3.2 Jatropha curcas

Central America is the center of origin for jatropha, which is known locally as piñon or tempate. It has traditionally been used as a living hedge, since it is unpalatable to livestock. Within Guatemala, there is some private and public interest in jatropha, particularly given its potential to grow on degraded and 'marginal' land. Indeed, both private and public organizations have undertaken field trials for the cultivation and processing of jatropha. A leading energy crop company, SG Biofuels, has 87 ha on Guatemala's Pacific coast where it is field-testing hybrid varieties of jatropha. In collaboration with the not-for-profit Technoserve, SG Biofuels established small-scale jatropha production with local communities; however, none of these use the improved cultivars that the company has recently begun to commercialize.

The state, several NGOs, and universities are interested in the capacity of this feedstock to provide additional livelihood benefits for subsistence farmers. For example, the University of San Carlos had been funded to investigate the intercropping of jatropha with food crops along the Corridor Seco (dry corridor), which is home to some of Guatemala's poorest people (Academic interview, November 2010). There are currently around 1,000 ha planted with jatropha (ACR 2011), and estimates of the land available for its cultivation vary from 206,000 ha to 623,000 ha, much of which is classified as marginal or degraded land (UNCTAD 2007). Much of this expansion would likely occur in underdeveloped areas, making competition with other crops unlikely (Hamelinck et al. 2011).

Initial expectations for jatropha have, however, been reduced and agricultural trials have suffered setbacks, as also has been the case in Mexico, Peru, and elsewhere (see Chaps. 6 and 9). For example, one private investor, Biocombustibles de Guatemala, had around 600 ha of jatropha in 10 plots around Guatemala. The largest of these plantations, located on the Pacific coast, was virtually destroyed by Hurricane Agatha in 2010 and the company declared bankruptcy later that year (Private sector interview, March 2012). However, the plantation also used seeds without improved varieties. Montes et al. (2012) caution that jatropha is essentially still a wild species that has yet to benefit from crop improvement programs and that the crop agronomy is poorly understood. Uncertain performance and economic viability have made it difficult for promoters of jatropha to encourage farmers to grow the crop, while an uncertain value chain has led some organizations to focus on other uses, including for biomass and domestic use (UNCTAD 2007) .

8.5 Sustainability Issues

In terms of the sustainability of the Guatemalan biofuels sector, several social, environmental, and economic issues have been identified as important and are discussed in the following sections. Many of the concerns about the sustainability of biofuels are related to the mode of agricultural production of the two principal potential feedstocks—sugarcane and oil palm—which are cultivated in large-scale, industrial monocultures.

8.5.1 Social Sustainability and Equity

The issues of land use and access lie at the heart of all debate about the sustainability of biofuels in Guatemala. The expansion of monocultures has been the subject of fierce criticism by activists who argue that the current expansion dynamics—particularly of oil palm— are exacerbating the country's already highly skewed land distribution. The average farm size in Guatemala is 0.18 ha, less than the 1.4 ha that the United Nations stipulates is required for subsistence (Taylor 2005). By contrast, the average palm plantation is 631 ha and the average sugar plantation is 13.3 ha (CABI 2011). The sugarcane and oil palm sectors have been criticized for their models of expansion and the subsequent, largely negative, impacts on local communities (e.g., ActionAid 2008, 2012; Alonso Fradejas et al. 2008; Hernandez 2011; Rosenthal 2013); land concentration, dispossession, and forced eviction of rural and indigenous communities have been documented. This has led to the loss of food production areas, particularly the traditional cultivation of milpa (a mix of corn and beans), with clear consequences for food security in a country that has the fourth highest rate of chronic malnutrition in the world (World Food Program 2012). As subsistence farmers lose the ability to feed themselves and their families, they become increasingly dependent on monetary income with consequences for their diets and for food and economic security. An article in *The New York Times* in January 2013 brought international attention to the negative impacts of global demand for biofuels in Guatemala. The article pointed to growing competition for land and rising food prices, specifically corn prices, which meant that "the average Guatemalan is now hungrier because of biofuel development" (Rosenthal 2013).

An event that captured the attention of the international community was the relocation of the Guadalupe sugarcane refinery (now called Chabil Utzaj) from the Pacific coast to the Polochic Valley in 2006. The Polochic Valley has a long history of conflict and land disputes and also borders the Sierra de las Minas biosphere reserve. Since the arrival of the refinery, NGOs have documented a worrying concentration of land through the eviction of tenant farmers and the displacement of traditional cropping systems (ActionAid 2008; Mongorria and Gamboa 2010; Bird 2011; Oxfam 2011). Fourteen indigenous communities living on contested land in the Valley were forcibly evicted by the refinery's private security forces, the police, and the army in March 2011. The evictions resulted in one death and multiple injuries. Families from these communities now live precariously, often staying with family members, and without access to land or to justice. However, it should be noted that, although the relocation of the refinery to the Polochic Valley has been blamed on international demand for biofuels, the refinery has no ethanol production capacity.

In terms of employment, the sugarcane and oil palm sectors are important employers in Guatemala. The sugarcane industry has 60,000 permanent employees and 350,000 employed either directly or indirectly during the zafra (harvest), which runs from November to May; of these, 33,000 work as sugarcane cutters (ASAZGUA 2011). The oil palm sector is similarly important, generating 17,300 direct and 45,000 indirect jobs (GREPALMA 2012). However, many critics question the types of employment generated by these agricultural sectors, where the majority of the workforce is temporary, poorly skilled, and badly remunerated (Hernandez 2011; ActionAid 2012). In 2012, the minimum wage was Q 68 (US$ 8.40) for an 8-hour day, yet a study by ActionAid (2012) revealed that many oil palm companies paid their temporary employees just Q 50–56 per day. Similar criticisms have been leveled against the sugarcane sector, which pays its workers according to tonnes harvested. The average worker harvests around 5 tonnes per day for which they will be paid Q 14–18 per tonne, depending on the sugar mill, an average of Q 70 per day, just slightly more than the minimum wage. The sugarcane industry is keen to emphasize the additional benefits that all workers receive, which include healthcare benefits, food, accommodation, and other benefits, such as savings accounts (ASAZGUA 2011). While most refineries have a policy of not employing women and children to work in the sugar fields, a recent investigation discovered children under the age of 14 working in a sugarcane plantation owned by the president of the Cámara del Agro (Arce and Rodriguez Pellecer 2012).

8.5.2 *Environmental Sustainability*

The environmental pressures exerted by sugarcane and oil palm plantations have also raised concerns including deforestation, biodiversity loss, soil erosion, excessive water use, water pollution, and the emissions of greenhouse gases (GHGs) (Fitzherbert et al. 2008). However, a key constraint in understanding the environmental sustainability of biofuels is a paucity of scientific evidence specific to the Guatemalan context. For example, the only study of the GHG emissions of sugarcane production uses default data and, as an industry publication, is for internal use only (Private sector interview, Nov 2011). In addition to the typical factors that influence the carbon balance of agricultural products (i.e., agricultural inputs and land-use change), there are two country-specific factors that are likely to influence the carbon balance of fuel ethanol produced in Guatemala: firstly, the majority (87 %) of the sugarcane is burned prior to harvesting in order to facilitate the manual harvest of the crop; the remainder is harvested mechanically (CENGICAÑA 2011c). The second factor is the cogeneration of bagasse, which during the harvest supplies Guatemala with around 15 % of its electricity needs (CENGICAÑA 2009; CEPAL 2012).

Recognizing the importance of climate change, particularly regarding water resources, in 2011 the sugarcane sector founded the Instituto Privado de Investigación sobre Cambio Climático. In addition, the sector has been working with multinational corporations, including Coca-Cola, to improve the environmental sustainability of sugar production (Bovernick et al. 2010; Coca-Cola 2011). Many refineries are International Organization for Standardization (ISO) certified, while the ethanol produced by Destiladora de Alcoholes y Rones Sociedad Anónima (Guatemala), DARSA, and Pantaleon is certified by the International Sustainability and Carbon Certification (ISCC) scheme (discussed in more detail in Chap. 2 of this volume).

The relative newness of the oil palm sector means that there are few studies of the environmental impacts of production, and much of the criticism leveled at the sector has focused on social issues. However, the sector emphasizes that the models of production that are currently implemented contribute to soil conservation, while the crop itself replicates forest conditions, providing soil cover which both minimizes the erosive effects of rainfall and provides organic matter to the crops (GREPALMA 2012). This contrasts with scientific studies, which have found that species richness is lower in oil palm plantations than in forests for many species (Fitzherbert et al. 2008). Even so, five oil palm growers in the country have already been certified by the Roundtable on Sustainable Palm Oil (see Chap. 2 for more details).

A related issue of concern for the environmental sustainability of the Guatemalan biofuels sector is that of deforestation. Forest cover in Guatemala has fallen from 64 % in 1950 to 34 % in 2010; between 2006 and 2010, the net annual deforestation rate was 1 %, equivalent to a net loss of 38,597 ha per year (IARNA 2012). Much of this deforestation is taking place in the northern department of Petén, which until recently contained one of the largest remaining areas of tropical forest in Mesoamerica (Shriar 2011); it is also a region that has experienced rapid expansion of oil palm production. Of the 93,513 ha cultivated with oil palm in 2010, more than a quarter has taken place at the expense of forests; 93 % of this in Petén (IARNA 2012). Furthermore, 23,000 ha, or 24.6 %, of oil palm plantations are found within protected areas; 74 % of these have been established since 2006 (IARNA 2012). Direct deforestation is less of a concern for the sugarcane industry, which has long been concentrated on the Pacific coast, with the result that its expansion has largely occurred at the expense of pasture and competing cash crops, including cotton, bananas, and maize (Hamelinck et al. 2011). Whether there are indirect impacts as these crops are displaced to other areas has not been determined, although there is anecdotal evidence that the relocation of the Chabil Utzaj refinery to the Polochic Valley has indirectly contributed to the loss of natural habitats as peasant farmers have invaded the Sierra de Las Minas biosphere reserve in order to produce basic grains (NGO interview, December 2010).

Business-as-usual agricultural practices in Guatemala are estimated to cause soil losses of almost 300 million m^3/year, contributing to the sedimentation of waterways and high levels of eutrophication (Bovarnick et al. 2010). The contamination of waterways has been an issue for the sugarcane sector, which disposed of untreated production waste and wastewater in rivers and streams; however, stricter environmental policies have ensured this practice has been discontinued. Water use is an issue for the sector, particularly because sugarcane is a water-intensive crop, which requires 1,782 liters of water to produce 1 kg of refined sugar (Mekonnen and Hoekstra 2011). In Guatemala, 60 % of the crop is irrigated, with the remainder rain-fed (Hamelinck et al. 2011). A large quantity of water is used in various stages of the production process and it is estimated that the production of sugar and ethanol requires 15 liters of water per minute, per tonne of sugarcane (Alonso Fradejas et al. 2008). Along the Pacific coast, water is diverted from lakes and rivers to irrigate agricultural plantations; this practice has left local communities without access to water during the dry season, while during the rainy season the diversion of watercourses leads to increased incidence of flooding (SAVIA 2009). The oil palm sector has been similarly criticized for excessive water consumption (SAVIA 2009), although GREPALMA (2012) argues that the water demand is similar to that of any crop. The sector argues that because more than half of oil palm plantations are located in areas of high rainfall, which require no irrigation, water consumption is minimal while, as a tree crop, oil palm plays an important role in the water cycle, increasing precipitation in areas where it is cultivated (GREPALMA 2012).

8.5.3 Economic Sustainability

The production of ethanol in Guatemala—whether potable, industrial, or fuel—represents an industrial strategy, rather than an energy or climate policy. As a result, the economic sustainability of the sector is dependent upon international market prices. Despite a US$ 3 million investment in a dehydration plant, DARSA has not produced fuel ethanol since late 2010 due to the low international market prices for this product (Private sector interview, Mar 2012). At present, the significant investment required to construct the ethanol and dehydration plant has proved prohibitive for other refineries, although it is expected that other refineries will eventually diversify into ethanol production, either for export or for domestic use (Private sector interview, Dec 2011). Similarly, at present no palm oil producer is producing biodiesel due to the far higher prices obtained from food markets. The principal market for fuel ethanol is the EU, although there are some exports to other countries in the Central-American region and to Mexico.

8.6 Conclusions

As the only country in Central America currently producing biofuels on a large scale, Guatemala provides an interesting case study to explore some of the sustainability considerations that may affect production in the region.

The promotion of fuel ethanol in Guatemala has emerged from industry and it represents an added product for export, along with sugar. Thus, unlike in other countries presented in this book, the nascent Guatemalan biofuel sector has been driven by industry rather than by policy. This has had consequences for the way that the sector has developed; biofuels are not promoted for their potential energy security, climate, or rural development benefits. Rather, fuel ethanol has developed in line with an industrial strategy to diversify the product portfolio of the sugar sector and take advantage of growing export markets. Furthermore, since the Guatemalan state provides no economic or policy support for the production and use of biofuels, the economic sustainability of the sector is entirely dependent on international market prices. A fall in the price of fuel ethanol led DARSA to cease production. While ethanol is important to the economics of a sugar mill, it is a minor contributor to the profitability of the sector. Therefore, addressing sustainability issues with regard to the need for sustainable biofuel production alone will be limited in its effectiveness. Improving the sustainability of sugarcane production through demand for sustainable sugar and ethanol (and electricity) will be a more effective approach.

There is a dearth of scientific evidence on the environmental impacts of biofuel-feedstock production in the Guatemalan context, particularly the GHG emissions. Furthermore, given the pressure on forests within the country, the expansion of oil palm onto forested land is a worrying trend and more research is required in this context. However, given the limited resources of the state, and the low priority afforded to environmental issues, much of this is likely to come from the private sector. Such research may or may not be made available for others to review and is likely to gloss over the potential negative impacts of production. The social impacts of biofuels are also of critical concern, since feedstock production appears to lead to further land concentration, forced evictions, and poor working conditions. However, addressing the sustainability of biofuels alone will have only limited impact in Guatemala. Instead, efforts should focus on improving the production of the feedstocks themselves in order to embed principles of sustainability within the agricultural sector and further apply sustainability standards (see Chap. 2).

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Chapter 9
Mexico

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Abstract Liquid biofuels have the potential to substitute for petroleum in Mexico's transport systems, thereby mitigating greenhouse gas (GHG) emissions and promoting rural development. However, although the Mexican government constructed a legal and regulatory framework for their introduction, it has so far failed to develop the specific policies, programs, and market conditions that would ensure biofuel production and commercialization. As a result, Mexico is the only major country in Latin America without a commercial biofuel industry thus far. In particular, no mandates for mixing biofuels with fossil fuels have been established and the high gasoline and diesel subsidies are only being slowly reduced, not removed. A general lack of agricultural knowledge about some of the feedstocks, leading to unrealistic yield expectations and insufficient production, has been another contributing factor to the closure of various biofuel projects. Finally, far more technical, environmental, economic, and social knowledge is required in order for the country to define the most appropriate biofuel feedstocks that are capable of contributing to the mitigation of GHG emissions without causing negative effects on rural development and overall sustainability. At present, the development of ethanol from sugarcane appears to be the most promising option but many hurdles remain before it can be successfully developed into a biofuel industry.

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9.1 Introduction

During Mexican President Felipe Calderón's term of office (2006–2012), biofuel experts went from optimistic to gloomy about this industry's future in Mexico. With the country's proximity to the USA and rising international biofuel expectations, it was widely thought that by promulgating the 2008 Law for the Promotion and Development of Bioenergy the Mexican government would successfully open up investment and market opportunities for biofuels (Chavez 2012). Five years after passage of the Bioenergy Law, however, Mexico has no commercial biofuel industry. In contrast to what the government planned, there are currently no plants producing ethanol for the transport sector and most of the biodiesel projects have been canceled or are on hold (Romero-Hernández et al. 2011). Biofuel investors lay the blame for this situation principally on fossil fuel subsidies and a lack of financial incentives from the Mexican government for the bioeconomy (Torres 2011; Global Medios 2011) but deeper structural, political, and contextual problems have also played a role.

Mexico has important natural resources, including fossil fuels, metals (such as silver, gold, and copper), water, and a large range of ecosystems and species, making it one of the most biodiverse countries in the world (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad 1998). However, with only 12.6 % of its mountainous terrain considered arable land, the country is obliged to import large quantities of food, particularly maize, its staple food crop, to feed its growing and increasingly urban population of more than 115 million people (Index Mundi 2013). Although Mexico's economy is expanding (4 % growth in 2012), the pace is not fast enough to keep up with demand for better quality jobs, infrastructure, and improved educational and health services. Moreover, during the last decade, disturbing levels of drug-related violence in many parts of the country have hindered the government's efforts to meet the country's challenges (BBC News 2012).

According to the Human Development Index (UNDP 2013), Mexico ranks 61st in the world and falls into the second group of nations labeled as "highly developed countries." The same index reports the country's per capita income (adjusted for purchasing power parity) as US$ 2,947, less than one-third of that of the USA. However, this figure hides the highly inequitable distribution of wealth (one of the largest in Latin America) and the large percentage of people (over 46 %) who live in poverty (CONEVAL 2010). Mexico's high infant mortality rate of 16.7 deaths per 1,000 live births is a reflection of this, though many other countries in the region have similarly high rates.

Despite this poverty, Mexico has been well endowed with natural resources, particularly petroleum. There is little doubt about the pivotal role of petroleum in transforming societies, driving economic growth and power, raising living standards, and causing environmental deterioration. Western civilization's dependence on it is such that it is hard to imagine life without it. Yet the world has probably peaked in conventional petroleum production (Heinberg 2008) and most countries today are deeply concerned about where they will get their future energy from to satisfy the increasing demand. Although Mexico is the eighth largest oil producer in the world (CNBC 2013), its state-owned oil company Petróleos Mexicanos, better known as PEMEX (which provides the government with around 30 % of its income), has lagged behind in investment and technology so that the country is obliged to import increasing amounts of fuel (SENER 2013a). The total cost of oil imports is now nearing the country's income from crude oil and threatening the health of public finances (Arzate and Rueda 2013). In 2006, at the start of Calderón's presidential term, international oil prices were high and rising, but underinvestment in the energy sector meant that Mexico's proven reserves were almost stagnant and its crude oil production was declining (Hargreaves 2012), which has continued ever since. At the same time, there was mounting international concern about the severe consequences of climate change and its potential to cause devastating change (Parry et al. 2007). Some countries were beginning to exploit new opportunities in the so-called green economy by developing biofuels as clean energy options. It became clear that if Mexico was to benefit from the biofuel trend, there was an urgent need to develop new energy policies that could diversify the country's energy mix, help reduce greenhouse gas (GHG) emissions and revitalize its rural economy.

An analysis of various bioenergy scenarios for Mexico based on life cycle and sustainability assessments of different technologies found that, in 2008, only 8 % of Mexico's primary energy needs were being met through the use of bioenergy, and this was primarily in the form of fuelwood for subsistence needs such as residential cooking and space heating (SEMARNAT-INE and UNAM-CIEco 2008). However, other analyses estimate that the country has the potential resources to increase this figure to 40 % of its 2011 primary energy production, using existing technologies to move beyond subsistence applications (SENER 2011, 2013a), if the right policies, programs, and mechanisms are put in place. SEMARNAT's 2008 study concluded that the country's potential for ethanol production from sugarcane and grain sorghum was high and that it would be theoretically possible to replace almost all the petroleum used by cars in the private sector with biofuels (or 36 % of 2011's total gasoline consumption), thus significantly reducing GHG emissions. The same analysis also claimed that *Jatropha curcas* (hereafter *Jatropha*) could make a notable contribution to biodiesel production. Included at the end of the report was a list of biofuel projects in different parts of the country, which together represented a potential investment of over US$ 1.5 billion.

What follows provides a description of the regulatory and institutional framework developed in Mexico between 2007 and 2012 to promote the introduction of biofuels into the economy. The chapter will analyze the factors that have so far prevented the industry from taking off and provide examples of local projects that were caught between official rhetoric and scientific ignorance and thus failed to develop as expected. Finally, it is noted that, although sugarcane currently appears to be the most promising biofuel feedstock, developing a ethanol industry in Mexico still faces enormous challenges.

9.2 Regulatory Framework for Energy Resources

Based on studies (such as those mentioned in Sect. 9.1) and keen to display its environmentally friendly credentials on the world stage, Felipe Calderón's government set about generating policies that would favor the production and use of biofuels (Presidencia de Calderón 2007). Mexico's regulatory framework consists of three interconnected structural layers: (1) the constitution, (2) statutory laws, and (3) the rules and regulations that accompany these laws and provide more specific information regarding their limitations, scope, and sanctions (Romero-Hernández et al. 2011).

With respect to biofuels, the most important constitutional article is number 27, which establishes the state as the original owner of all land and water within the country's boundaries. It does, however, make provision for the state to transfer its ownership to the private sector. Of particular relevance for biofuels is the fact that this article also defines the state as the original owner of all natural resources, minerals, solid fuels, and all liquid and gaseous hydrocarbons. This is the legal basis that grants PEMEX monopoly control over the country's fossil fuels, and makes it possible for the government to fix subsidized gasoline prices at the pump, helping to deter competition from other energy sources. In spite of considerable interest to privatize PEMEX, especially from Calderón's own political party, so far this has not been possible.

Mexico's new President, Enrique Peña Nieto, elected to a 6-year term in 2012, has declared that his administration will give priority to structural economic reform, increasing competitiveness and some degree of market liberalization, though not full privatization of the energy sector (Thomson 2012). If this is achieved it will no doubt have profound regulatory and energy policy repercussions, but at the time of writing, only general ideas regarding energy reform have been discussed in the press, almost all of which hinge around the central debate of whether PEMEX should be privatized or not (Reforma 2013). Just before leaving office, Calderón made various announcements about significant new oil finds (DeFraia 2012) and shale gas discoveries (Platts 2012) that have suddenly made the country's hydrocarbon future look potentially much brighter again (Navarro 2012). A minority of voices, arising largely from environmental advocates like Greenpeace, have called for more investment in renewable energy. However, this group makes no mention of biofuels in its latest report (Greenpeace 2013), in part because of a lack of national consensus about sustainability indicators. Currently, private participation in biofuels production in Mexico is permitted on a small scale without special permits, but large-scale operations must undergo extensive permitting.

9.2.1 Public Biofuel Policies

Mexico's public policies, aligned with the constitution and the country's regulatory structure, are developed every 6 years by the incoming president's team and presented in the National Development Plan (Plan Nacional de Desarrollo, PND), which defines the general objectives and strategies. For the first time in the 2007–2012 Plan, a mandate was included to develop renewable energy sources and to establish the legal framework for the promotion, regulation, and use of biofuels (Presidencia de Calderón 2007). Each of the Ministries involved in the field—Energy (Secretaria de Energía, SENER), Agriculture, Livestock, Rural Development, Fisheries and Food (Secretaría de Agricultura, Gandería, Desarrollo Rural, Pesca y Alimentacion, SAGARPA), and the Environment (Secretaria de Medio Ambiente y Recursos Naturales, SEMARNAT)—were mandated to define objectives and strategies to achieve these goals in their policy documents and programs. Thus, SENER brought out its sector program (Programa Sectorial de Energía) in which it established the need to carry out studies showing the desirability and feasibility of introducing biofuels in transportation and the importance for information and technology exchange.

The agricultural sector policy document of SAGARPA (*Programa Sectorial de Desarrollo Agropecuario y Pesquero*) established the objective of increasing farmers' income and improving rural economies through value-added processes and promoting biofuel production. It identified several relevant species for this (based principally on their climatic and biophysical suitability) including sugarcane and sorghum, with the proviso that biofuel production should not interfere with food security or affect biodiversity (which effectively excluded maize as a feedstock). A goal was established to plant 300,000 ha with biofuel feedstock by 2012. Finally, the Ministry of the Environment's sector program (Programa Sectorial de Medio Ambiente y Recursos Naturales) set the objective of reducing harmful GHG emissions by coordinating with other ministries and participating in the development of biofuel promotion programs.

9.2.2 Law for the Promotion and Development of Bioenergy

The Bioenergy Law (Ley de Promoción y Desarrollo de los Bioenergéticos 2008), the first of its kind in Mexico, came into force in 2008. In accordance with the higher-level policy documents already mentioned, it established the general aim of reducing fossil fuel dependency, lowering GHG emissions in the cities, and boosting sustainable development in the countryside. More specifically, it consisted of five stated objectives:

- Promote the production of feedstocks for bioenergy from agricultural activities, forestry, algae, and biotechnological enzymatic processes in rural Mexico, without jeopardizing food security or sovereignty
- Develop the production, marketing, and efficient use of biofuels to contribute to stimulating the rural sector and generating rural employment
- Promote regional development in marginalized areas
- Reduce GHGs using international instruments
- Coordinate the activities of federal, state, and municipal authorities

Because of the complex interactions between the different ministries involved in the implementation of bioenergy policy, the law established a coordinating body, the Interministerial Commission on Bioenergy Development (Comisión Intersecretarial para el Desarrollo de los Bioenergéticos) to oversee and articulate all the different activities of production, storage, transportation, distribution, commercialization, and use. Its strategy document (Estrategia Intersecretarial de los Bioenergéticos) defines various courses of action including:

- Encouraging the availability of information and business opportunities
- Promoting research and technological development and research networks
- Generating market certainty; creating conditions for matching supply and demand in a fair environment and interacting with foreign biofuel markets
- Enhancing production capacity and improving competitiveness

9.2.3 Bioenergy Programs

At the program level, where specific mechanisms and instruments should be put in place to translate policy into action, two key bioenergy documents were released: Sustainable Production of Feedstocks for Bioenergy and Scientific and Technological Development Program (Programa de Producción Sustentable de Insumos para Bioenergéticos y de Desarrollo Científico y Tecnológico, SAGARPA 2008) and the Bioenergy Introduction Program (Programa de Introducción de Bioenergéticos en Mexico, SENER 2009).

An analysis of these documents provides a fascinating picture of how the Mexican authorities envisioned that the biofuel industry would develop from 2007–2012. As is blatantly clear today, however, much of what was planned did not materialize or was only initiated.

Both the biofuel programs had the same vision, i.e., in 2012 the biofuel chain of production and consumption would be competitive and profitable in Mexico, providing an example of organization and productive integration. High-quality bioenergy would be supplied to the domestic market, in accordance with established standards and the country's productive capacity would be large enough to export biofuels as well as to meet internal demand. Finally, the programs envisioned that bioenergy would become a driver for scientific and technological research and development (R&D). By 2012, the application of advanced technologies in Mexico would have overcome concerns about food security, loss of biodiversity, pollution, land use change, and the availability of water.

The most important criteria used to select potential biofuel feedstocks (SENER et al. 2006) were the suitability of different species to certain climatic and biophysical conditions. But another very important criterion (written into the Bioenergy Law; see footnote 1) was the exclusion of maize as a feedstock, unless the country has a surplus, which is highly unlikely in the near future since Mexico has not been self-sufficient in maize production since the 1960s. The special status given to maize

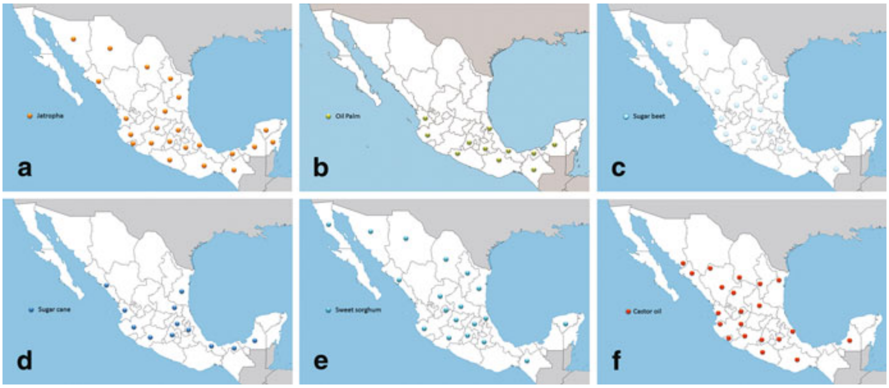

Fig. 9.1 Maps of Mexico showing the states that were identified by Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP) as being suitable for the production of six proposed biofuel feedstocks: **a** *Jatropha*, **b** oil palm, **c** sugar beet; **d** sugar cane, **e** sweet sorghum, and **f** castor oil. (The maps were redrawn by Miguel Ángel Herrera Alamillo based on information from SAGARPA 2008)

is not only derived from the fact that it is Mexico's basic food crop, it is also because the crop is sacred to Mexico's indigenous societies and because the country, being its center of origin and one of its centers of domestication, feels a special responsibility for its conservation. Taking these criteria into consideration, SAGARPA included the following crops in its list of most promising biofuel feedstocks: sugar cane, sweet sorghum, and sugar beet for ethanol, and *Jatropha,* castor oil, and oil palm for biodiesel. A map, included in the program, indicated the locations considered suitable for biofuel feedstock production, which covered a large part of the country (see Fig. 9.1a–f).

The activities that were contemplated in this program also included the development of technical guides for feedstock cultivation, socioeconomic studies, and proposals for future agricultural policies. However, it should be noted that even today Mexico lacks the necessary agricultural knowledge and experience required to develop and commercialize four of these crops (sugar beet, sweet sorghum, castor, and *Jatropha*) and no country-specific studies exist regarding their GHG mitigation potential, their water requirements, and their possible effects on biodiversity.

No indications were provided in the program regarding deforestation, although several general references were made to the importance of sustainability in biofuel production. Some specific information was given regarding financial incentives. For example, the National Forestry Commission (CONAFOR) included *Jatropha* in its ProArbol Program, providing a subsidy of 7,300 pesos (approximately USD 600) per hectare at that time for the establishment of commercial plantations using this species. Moreover, under SARGARPA's social industrial investment projects, investors could apply for up to US$ 6 million in grants (SAGARPA 2008).

The Ministry of Energy's Biofuel Introduction Program was released in 2010 to lend further support for the development of an integrated biofuel supply chain. It specifically included the promotion of R&D in the clean energy field and generating business opportunities. The program even included a start-up plan for the use of ethanol as a gasoline oxygenate (at 6 % volume) in gasoline consumed in three major cities (Mexico City, Monterrey, and Guadalajara). The initial production target was to be 176 million liters, reaching 802 million in 2012 (SENER 2009). It was estimated that the program would require 300,000 ha for the production of feedstock and would cost around US$ 25 million.

Because the first tender for the purchase of ethanol to meet the Biofuel Introduction Program was canceled, due to the low price set by PEMEX (the sole buyer), the government had to redefine the strategies, objectives, and scope of the Biofuel Introduction Program. As a result, the Anhydrous Ethanol Introduction Program (AEIP) was created (SENER 2011) with the objective of using sugarcane-based ethanol instead of methyl tertiary butyl ether (MTBE), which Mexico largely imports and had already been phased out in the USA due to environmental concerns (Solomon et al. 2007). New goals were set, including mixing between 50 and 100 million liters of ethanol in 2012, rising to a maximum of 230 million liters in 2016. In 2012, PEMEX launched a new bid to accomplish the AEIP; however, it too was cancelled due to the low price that PEMEX was willing to pay its domestic producers, 50 % lower, in fact, than producers were requesting (Chavez 2012). In contrast to Malaysia and Indonesia, Mexico has not responded to improved export opportunities, as it cannot compete with other ethanol exporters such as Brazil (Schoneveld et al 2010). The new government, under President Enrique Peña Nieto, recently brought out its National Development Plan for the period 2013–2018 and, in reference to renewable energy, it states that appropriate targets will be established for the gradual introduction of biofuels (starting with ethanol) in the transport sector and that the government will work on the identification and dissemination of technological packages, including the selection of crops for biofuel production and information on how to produce them (SENER 2013b).

9.2.4 Bioenergy Research and Development Projects

In 2012, the Mexican Network of Bioenergy released a database and final report (Riegelhaupt et al. 2012) on research, development, and technology transfer projects carried out in Mexico in the field of bioenergy between 2004 and 2011. In total, 688 projects were registered. Between 2004 and 2007, on average, 46 projects were approved per year, and in the period from 2008 to 2011 the number of approved projects jumped to 125 per year. It is probable that the approval of the Bioenergy Law and the creation of special funds within the Ministries of Agriculture and Energy to sponsor R&D were largely responsible for this increase. The report found that 94 % of the projects were focused on technological themes related to bioenergy, whereas only 6 % concentrated on generating knowledge corresponding to environmental, economic, and social aspects.

With regard to the level of technology studied, most of the early projects focused on first-generation bioenergy, but a small number of later projects included second-and third-generation technologies including the use of residues and nonfood crops as well as algae and other microorganisms with the potential for transgenic cultivars (Riegelhaupt et al. 2012). Some 50 different types of inputs were analyzed in the projects, including crops, forestry, and waste products (general, agro-industrial, and urban wastes). Amongst the sugar-rich crops, the most commonly researched ones were sugarcane, agaves, and sweet sorghum for ethanol production and amongst the oil-rich ones *Jatropha,* soya, and oil palm for biodiesel.

9.3 Financial Incentives

In contrast to the investments in the petroleum sector, which Mexican law restricts for its own citizens, foreigners can invest in biofuel production. From 2007 to 2010, considerable interest was generated amongst foreign investors about biofuel prospects in the country. However, their initial enthusiasm declined greatly as weak points in Mexico's overall strategy became apparent. Although the policy documents were clear at a general level, they lacked details that investors require in order to make long-term commitments. In particular, no specific requirements for blending biofuels with fossil fuels were established. In addition, no targets for private investment were set, and, most importantly from the investors' point of view, no financial incentives were offered at the commercialization stage to make biofuel prices competitive with those of fossil fuels, which have long-enjoyed high subsidies in Mexico. Although these subsidies have gradually been reduced, it was calculated that in 2008 they cost the country some US$ 17 billion (Scott Andretta 2011).

As a result of these perceived weaknesses, many investors either canceled their projects or put them on hold. The following sections will review the status of the main projects and plans for biodiesel and ethanol development, respectively.

9.4 Biodiesel

Latin America's first industrial-scale production of biodiesel took place in Mexico, in a plant built by Biocombustibles Internacionales S.A. de C.V. (Grupo Energeticos, ENERGEX) with a capacity of producing 1.5 million liters/month. It operated between 2004 and 2011 and produced biodiesel from animal fat. In 2009, the company won a tender to supply PEMEX with low sulfur content biodiesel, which it did until the early part of 2010 when PEMEX abruptly decided to change over to an imported additive and stopped its purchases from Biocombustibles Internacionales. In spite of writing to the Ministry of Energy requesting that the Bioenergy Law be applied and that PEMEX be made to purchase biofuels, nothing came of their efforts. Without PEMEX's purchases, the company was forced to reconvert its biodiesel plant (at considerable cost) for the purposes of producing fuel oil for use in furnaces and boilers and asphalt (Torres 2011).

9.4.1 Jatropha Biodiesel

In 2007, *Jatropha* (Figs. 9.2 and 9.3) was considered by many to offer excellent opportunities for biodiesel production in tropical and semi-tropical areas and was selected as the main feedstock for various Mexican biofuel initiatives, including three projects developed by private companies in the state of Yucatan and for "Chiapas Bioenergético," the much publicized, government-backed program in the southern state of Chiapas. After referring to the cultivation problems of *Jatropha,* some biofuel projects in these two regions are discussed below as examples of the problems that these initiatives confronted and how they developed (it is not intended to be an exhaustive analysis of all the failed *Jatropha* projects in Mexico).

As is now widely recognized (Jonsgchaap et al. 2007), some of the main difficulties encountered in all the *Jatropha* projects stemmed from the crop itself. A native shrub of Mexico and Central America, *Jatropha* in rural areas has often been used for making soap, traditional medicine, and hedges. It was frequently chosen as the most suitable feedstock on the basis of claims that it was hardy, fast growing, drought resistant, had high oil content and was adapted to a wide range of climatic conditions (Jonsgchaap et al. 2007). Openshaw (2000) referred to it as a "poor man's biofuel" because of its ability to grow on wasteland. The UK biofuel company D1 Oils promoted it in Swaziland saying "it will not compete with food crops for good agricultural land" (FOE 2009).

It is now well known that many of these early claims were overstated, or are only true under specific conditions (Kant and Wu 2011). After the evaluations of scientific data and field experiences, what has become clear is that *Jatropha* is a wild plant that has not been domesticated and that, at present, high-yielding varieties with all the desirable traits for given agro-ecological conditions are not yet commercially available (Divakara et al. 2010). There is consensus that *Jatropha* has promise as a biofuel feedstock but that much more research is needed before *Jatropha's* genetic potential can be fully exploited (Jongschaap et al. 2007; Divakara et al. 2010).

The rush to plant *Jatropha,* predicated on insufficient scientific knowledge, has inevitably led to a series of disappointments and failures in Mexico as well as in many other parts of the world (Matlack 2012). In their evaluation of claims and facts about *Jatropha,* Jongschaap et al. (2007) emphasize that "…the popularity of jatropha as an oil producing crop has been based on the incorrect combination of positive characteristics which are not necessarily present in all *Jatropha* accessions, and have certainly not been proven beyond doubt in combination with its oil content." Some of the many characteristics that have been mentioned as objectives for research include the proportion of male to female flowers (which may be as high as 30:1), resistance to pests and disease, and its use of water and its oil yield (Galaz-Avalos et al. 2012). There is now little doubt amongst the scientific community that the selection and multiplication of elite germplasm will be the key to the success of future *Jatropha* cultivation for biodiesel (Matlack 2012).

9.4.1.1 Chiapas Bioenergético

Ignorant of the difficulties that *Jatropha* presents, in 2007 the governor of Chiapas, Juan Sabines-Guerrero, created a commission charged with developing and promoting the use of bioenergy in the state through joint public and private investments and environmental education for a more sustainable future.

CONAFOR contributed to this effort by including *Jatropha* in its ProArbol program that provides financial and technical assistance to landowners of all types to conserve and sustainably manage the country's forest resources (by classifying it as a tree, CONAFOR was able to keep control of it rather than the Ministry of Agriculture). The Forestry Commission also made available a subsidy to establish commercial *Jatropha* plantations (classified as reforestation), thus making farmers and companies who embarked on this activity eligible for to receive around US$ 600 per hectare (7,398 Mexican pesos per hectare in 2009, rising to 7,700 Mexican pesos in 2012).

When the planting of *Jatropha* began in 2008, CONAFOR focused its attention on marginalized rural communities (Skutsch et al. 2011). Thus in Chiapas, small farmers were convinced to participate in the initiative by the subsidies, which covered their start-up costs and by 2010 they had planted around 10,000 ha (El Universal 2010). Technical advice was provided by researchers from the National Institute for Forestry, Agricultural and Fisheries Research (INIFAP), which also invested some 10 million pesos in a laboratory to study the biology and genetics of *Jatropha* and higuerilla (castor oil) plants. A germplasm bank with more than 400 accessions of the plants, mostly from Chiapas and Central America, was established by the researchers. At the same time, a biodiesel plant to process the *Jatropha* seed was constructed in Tapachula. The plan was for the biodiesel to be used in urban buses in both Tapachula and Tuxtla Gutierrez, first mixed at a low percentage with fossil fuels but gradually increasing to 100 %.

On visiting the biodiesel installations in Chiapas in October 2012, however, reporters from the newspaper *Reforma* found a very different situation from that portrayed by Chiapas' state government at the beginning of Juan Sabines-Guerrero's term of office. Indeed, evidence indicated that the whole biodiesel initiative was a sham (Reforma 2012). They observed that the industrial plant was in disrepair and that the four stationary tanks were empty. They were told (by an anonymous source) that when the urban transport system in Tapachula was inaugurated, biodiesel was brought in from the central part of Mexico and that, even in 2012, only a few transport units used a 5 % mix of biodiesel. The same investigation revealed that the first commercial flight in Mexico in 2011, supposedly using biokerosene derived from *Jatropha* oil, had also been a farce. Finally, it was said that when Governor Sabines realized that he had no biodiesel from *Jatropha,* he tried to produce it from waste cooking oil, collected from restaurants. However, this project also failed because the biodiesel distillery, built in Puerto Chiapas, was not designed to process oil with large quantities of impurities.

Fig. 9.2 *Jatropha curcas* plants in Dr. Ricardo Quiroga's experimental plantation in Chiapas. (Photo courtesy of Victor Loyola-Vargas, reprinted with permission)

Fig. 9.3 The development of fruits in *Jatropha curcas* plants 3 weeks after pollination. (Photo courtesy of Victor Loyola-Vargas, reprinted with permission)

9.4.1.2 Jatropha plantations for biodiesel in Yucatan

In Yucatan, the target areas defined by the authorities for *Jatropha* cultivation were concentrated in the northeastern municipality of Tizimin on both *ejidal* (communal) and private land. Much of the area is or had been used for extensive cattle ranching with some areas set aside for traditional swidden agriculture (*milpa*) based on the production of maize, beans, and squash for home consumption. There are still patches of secondary forest in the landscape, partly where cattle ranches have been abandoned and partly due to the fallow stage of the swidden system. Establishing *Jatropha* plantations requires removing this secondary vegetation. From the start, small farmers in Yucatan showed almost no interest in the *Jatropha* promotion campaigns, mostly due to unfamiliarity with the crop, uncertainty about the payments, and lack of a clear market. As a result, CONAFOR worked principally with three companies that decided to invest in *Jatropha* production for biodiesel: Global Clean Energy Holdings, based in California, Kuosol, a joint subsidiary of Mexican Keken and Spanish Repsol and LODEMO, a Yucatecan corporation (Evia 2013; Solé 2013; Perez 2013).

9.4.1.3 Global Clean Energy Holdings

Global Clean Energy Holdings (GCEH)[1] is a renewable energy company focused on the production and commercialization of non-food-based feedstocks for biofuels (New York Times 2013). In 2008, it announced that it had formed a joint venture to buy land in Mexico and develop it for biofuel feedstock production. The company acquired three old farms (totaling just over 6,000 ha) in the municipality of Tizimin, Yucatan and, taking advantage of the subsidies provided by the Mexican government (both CONAFOR and the Ministry of Agriculture), GCEH proceeded to plant *Jatropha* on slightly more than half of the area, with the aim of producing biodiesel. Some 500 people from local communities were employed on the farm, while managerial and technical staff and scientific advisors were brought in from different parts of Mexico and abroad (SCS Global Services 2012).

Despite a promising beginning, by 2010 GCEH saw the need to develop a nonprofit research organization in order to produce high-yielding commercial varieties of *Jatropha*. According to its declarations, the company was convinced that only by using soil and plant science, genetics and agricultural technologies to maximize *Jatropha's* yield potential and minimize inputs would it be able to develop its business. A field station was developed in Mexico to carry out the tests required by the scientists who were leading the genetic component of the research.

However, in spite of all the investment, by 2012 it was evident to neighboring farmers that not all was well in GCEH's *Jatropha* plantations, which appeared to be affected by pests and diseases. In December 2012, the company laid off 200 workers saying that it was undergoing a restructuring process. In March 2013, another 200

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[1] See GCEH's home page and letters to its shareholders (2010–2013) for more information about the company at: http://www.gceholdings.com/.

workers were made redundant (Diario de Yucatan 2013) and company personnel confirmed that the *Jatropha* plantations were “on hold” while the company decided whether to continue or not, depending on if it managed to solve its production problems in the coming months (Evia 2013).

Interestingly, in November 2012 GCEH became the first company based in North America and the only biodiesel feedstock producer to achieve certification through the Roundtable on Sustainable Biofuels (RSB; now called Roundtable on Biomaterials) (GCEH 2012; see also Chap. 2). This is ironic, given the difficulty in establishing the Yucatan plantation as well as the mass firings that occurred between December 2012 and March 2013. The RSB certificate states that none of the local stakeholders that were contacted had any concerns about the GCEH projects; on the contrary, they supported them because they had brought badly needed employment opportunities to the nearby communities, social programs such as free breakfasts for children, and support for local baseball clubs. The prior land use (abandoned cattle ranches) had offered no such opportunities or support for local people. The report by the certifying company found that GCEH had no financial restrictions and had a competent human resource management team (SCS Global Services 2012). The salaries paid to the workers were 195 % of the regional minimum wage and were generally higher than what the workers had received in previous employment; food security improved as a result (SCS Global Services 2012). In addition to local people seeing *Jatropha* as a medicinal tree, having the company in the area resulted in their learning about its environmental benefits as a potential source of biofuel. Thus, it is difficult to reconcile this positive account with the negative portrayal reported by several media outlets as well as the large-scale layoffs.

9.4.1.4 Kuosol

Unlike GCEH and LODEMO (which bought better-quality agricultural land near Tizimin), Kuosol chose to plant *Jatropha* on 1,500 ha near its intensive pig production unit, a few kilometers from Muna, in the central part of Yucatan, to take advantage of residual water from the biodigesters for irrigation purposes (El Economista 2010; Keken 2012). However, after five years of developing its *Jatropha* plantations Keken and Repsol dissolved Kuosol at the beginning of 2013 and closed down the *Jatropha* project completely, selling off what assets they could (Solé 2013). The reasons given for their failure with *Jatropha* were that the seed yields from the plantations were too low, sometimes they did not even reach 1 ton per hectare, which was far below the estimated amount necessary for the project to be economically viable. The company attributed the low yield to poor soil and agricultural conditions, poor agricultural management and the use of poor, highly variable genetic planting material. It appears that the original project had been based on unreliable data that had not been tested before the project was initiated (Solé 2013).

9.4.1.5 LODEMO

With its headquarters in Merida, the capital of Yucatan, the LODEMO Corporation is well established in the commercialization and distribution of fuel for transport in southeastern Mexico. In 2007, it created the subsidiary Biocom to position itself in the biofuel sector and set up Agroindustria Alternativa del Sureste with the ambitious project of developing 20,000 ha of *Jatropha* plantations for the production of biodiesel. By blending biodiesel into its fossil fuels, the company hoped to simultaneously get a foothold in the alternative energy sector, mitigate GHG emissions, and improve its environmental image (LODEMO 2013). It bought 2,570 ha of farmland in the municipality of Tizimin and by 2011 had established 2,000 ha of plantations. At the same time it established a germplasm bank and set up several academic collaborations with local research institutions in order to generate genetically improved planting material and carry out chemical analyses to test the quality of the biodiesel produced. In spite of some setbacks with its *Jatropha* plantations, LODEMO continues to work on its plantations and, at the time of writing, remains committed to its long-term aim of blending biodiesel with its conventional diesel. Being well positioned in the distribution and commercialization of fossil fuel, LODEMO clearly has an advantage over other companies hoping to develop biodiesel from *Jatropha*. However, even LODEMO has reduced the size and pace of its projects (Perez 2013).

9.5 Ethanol

Currently, Mexican experts agree that sugarcane has the greatest potential as a biofuel feedstock for the production of ethanol. This is because the country already produces nonfuel ethanol as a subproduct of sugarcane milling and Mexico has substantial experience with the sugarcane industry, which contributes some US$ 3 billion to its economy. Eighteen of its 57 sugar mills have ethanol distilling capabilities, but of these only eight are currently producing ethanol for the beverage and pharmaceutical industries (Chavez 2012). Over recent years, strong fluctuations in the price of sugar have prompted some producers to explore schemes for fuel ethanol production. One such plant is the Central Energética de Atoyac, located in the state of Veracruz (Alcoholera de Zapopan 2013).

In SEMARNAT's prospective study on bioenergy (SEMARNAT-INE and UNAM-CIEco 2008) it was estimated that an additional 2.9 million hectares of land could be planted with sugarcane without negatively affecting agricultural land, forests, or protected areas. It has since been calculated that the sugarcane produced would potentially make it possible to replace 22 % of Mexico's 2011 gasoline consumption. Sugarcane has the advantage of cogenerating electricity from bagasse, so that if the necessary investments are made, it is technically possible for the distilleries to become producers of electricity for the national grid as well as ethanol producers. It has been estimated by Garcia et al. (2011) that the production of ethanol from sugarcane's direct juice has the potential to mitigate GHG emissions by 56 % and, if it comes from molasses, by 40 %. They also stated that the energy return on investment for ethanol from direct sugarcane juice and molasses is superior to that reported for corn ethanol in the USA.

In spite of this, before the production of fuel ethanol from sugarcane can become a reality in Mexico, many complex obstacles have to be overcome. Amongst these some of the most important are: low agricultural yields, low farm incomes, small and fragmented production units (on average around 3 ha per farmer), insufficient use of fertilizers, and cultural resistance to technological change and organization (Aguilar-Rivera 2013).

Moreover, in recent years' experience, trying to invest in biofuels in Mexico has left many doubts and scars. For example, Destilmex, a plant in the northern state of Sinaloa, was built specially to produce fuel ethanol, at a cost of US$ 60 million but later it had to be dismantled. Eduardo de la Vega, the company's chief executive officer originally intended to operate it on maize, as he considered sugarcane to be too expensive. However, when the Bioenergy Law was passed in 2008 and maize was excluded as a biofuel feedstock (unless the country had a surplus) he changed to the idea of sorghum. A combination of high production costs and bad harvests due to freezing temperatures in the north of the country resulted in him announcing, in July 2011, that Destilmex would be dismantled (Global Medios 2011).

9.6 Summary and Conclusions

This chapter has provided an analysis of the context and principal factors that have influenced Mexico's efforts to develop biofuels over the last several years. It was argued that the introduction of liquid biofuels could potentially make a significant contribution to Mexico's energy security, particularly in view of the fact that the country is facing difficulties in replacing its oil reserves and, although it exports oil, is obliged to spend increasing amounts of money on importing gasoline to meet the growing demand. It was also pointed out that biofuels could help reduce GHG emissions and could play a role in promoting economic development in impoverished rural areas.

In 2008, Mexico developed a legal and regulatory framework for the production and use of biofuels in the transport sector. However, it conspicuously failed to generate the right economic conditions to create sufficient biofuel supply and demand to allow the industry to develop and thus bring to fruition the full benefits of a diversified energy matrix, such as exists in Brazil. As a result, there is no commercial biofuel industry in Mexico as of 2013.

On the demand side, no specific mandates for mixing biofuels with fossil fuels were ever published and only in a few cases, at the state level, were economic subsidies provided to the investors. At the same time, substantial subsidies were being provided to fossil fuels, making it extremely difficult for biofuels to compete. At present they are still more expensive to produce than their fossil energy competitors and industry claims that the only way to make their production feasible is through subsidies. As of yet, President Peña Nieto's government has made no clear statements on this issue.

On the supply side, the selection of feedstocks was based on criteria related to the crops' suitability to biophysical conditions and food security. However, in most cases, the technical knowledge needed to grow and commercialize the crops successfully (on a large enough scale to satisfy the potential demand from a biofuel industry) is still lacking and research progress is very slow. Although *Jatropha* was considered by many to be a promising biodiesel feedstock, the evidence presented in the failed projects points to an overly optimistic assessment at the outset and a fundamental lack of scientific knowledge. GHG mitigation potential of many of Mexico's possible feedstocks is another area where insufficient data exists and, moreover, almost no studies have explored their possible impacts on other sustainability issues such as the use of water, biodiversity conservation and social and economic welfare.

The feedstock that seems to have the greatest promise to meet expectations in the short term is sugarcane. Knowledge and experience growing the crop have been gained from Mexico's longstanding sugar industry and technical studies referring to its GHG mitigation potential have been carried out. Nevertheless, serious social, economic, technological, and political hurdles, as well as general issues about sustainability, still stand in the way of the country developing a successful ethanol-based biofuel industry.

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Chapter 10
The Caribbean

Carlos E. Ludena

Abstract This chapter analyzes the potential and current status of ethanol and biodiesel production in Caribbean countries. It first assesses the potential for biofuel production, given actual feedstock availability in these countries, and potential biofuel mandates. It then analyzes the current situation of biofuel production, and the impacts that trade policies, such as the Caribbean Basin Initiative, have had on investments in biofuels in the last several years. The largest biofuel sectors in the region are for sugarcane-based ethanol production in Jamaica, Cuba, and Trinidad and Tobago. The chapter surveys the status of nine individual countries and territories, and reviews the current situation of biofuel production, based on the latest available information from published literature and media press releases.

10.1 Introduction

Interest in biofuel production in Caribbean countries has risen in the last few years for several reasons. First, almost all countries in the region rely on imports to supply their liquid fuel needs. Due to this high dependency on foreign sources of fuels for transport, most governments in the region started looking into alternative domestic sources such as biofuels. At the same time, economic circumstances for important local economic sectors have set the conditions to meet local fuel demand, which may also provide new opportunities for these sectors.

The rest of this chapter is structured as follows. Section 10.2 analyzes the technical potential of biofuel production regarding one of the scarcest resources in the Caribbean, which is agricultural land, including an analysis of the technical feasibility to meet 10 % ethanol or 10 % biodiesel (E10/B10) blends for local demand. Section 10.3 describes the current investment environment for biofuels. Section 10.4 describes the special circumstances of the Caribbean and examines how ethanol production has been affected by trade, especially through the Caribbean Basin Initiative (CBI). We then present Sect. 10.5, which discusses biofuel production and prospects

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in the Bahamas, Barbados, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico, Trinidad and Tobago, and the US Virgin Islands. Finally, Sect. 10.6 concludes the chapter with a short overview of the future of biofuel production in the Caribbean.

10.2 Technical Potential for Biofuel Production in the Caribbean

We begin by analyzing the potential for expanding production of biofuel crops in the Caribbean, using the United Nations Food and Agriculture Organization (FAO) global agro-ecological assessment for agriculture (FAO/IIASA 2005; Raso et al. 2007). The agro-ecological assessment estimates the suitable areas of production for several crops, including cassava, maize, oil palm, sorghum, soybean, sugar beet, sugarcane, sunflower, and wheat.[1] For the analysis of Caribbean countries[2], we focus on oil palm and soybeans for biodiesel production and on sugarcane, maize, sorghum, and cassava for ethanol production, given current or potential production of the region. From the FAO/IIASA data, there are several levels of suitability for crop production under different technological levels (rain-fed intermediate inputs, rain-fed-irrigated mixed input, and rain-fed-irrigated intermediate input). We focus on rain-fed production with intermediate inputs, as this is likely the most common production system, since irrigation levels are low in the region. We estimated the potential suitable area available for crop cultivation (expansion area) as the difference between the current production area (average harvested area between 2008 and 2011) and the suitable area from the FAO/IIASA database (Table 10.1).[3]

Among crops with potential for biodiesel production, palm oil and soybeans have suitable areas of production in Cuba, Dominican Republic, Haiti, and Jamaica, according to the FAO/IIASA (2005) database. Out of these four countries, only the Dominican Republic currently produces oil palm. On average, the total harvested area was 13,425 ha between 2008 and 2011, out of 304,000 ha suitable for production. For soybeans, Cuba, the Dominican Republic, and Haiti have suitable and very suitable areas of production, but none of these countries currently plant this crop.

For ethanol production, sugarcane is the most common crop in the Caribbean. Out of 21 countries in the region, 11 countries plant that crop. However, the majority of production is concentrated in a few countries. Out of the total average area harvested between 2008 and 2011, Cuba represented almost three-quarters of the planted area (73 %), followed by the Dominican Republic (15 %), Jamaica (5 %), Haiti (3 %),

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[1] *Jatropha curcas* is not included in the analysis because the FAO does not currently record data on production of this crop, nor is it included in the FAO/IIASA database.

[2] The Caribbean countries for which FAO/IIASA data are available include Bahamas, Cuba, Dominican Republic, Haiti, and Jamaica. FAO data show that there is no production of oil palm fruit, soybeans, sugar cane, maize, sorghum, or cassava in Anguilla, Aruba, British Virgin Islands, Netherlands Antilles, Saint Kitts and Nevis, and Turks and Caicos Islands. For those countries present in the FAO database, but not in FAO/IIASA, we present only the average harvested areas for the period 2008–2011.

[3] The estimates of potential expansion are mutually exclusive between crops, as suitable areas of production for certain crops may overlap, not only among biofuel crops, but for other food crops too.

Table 10.1 Average harvested area between 2008–2011 and potential expansion area for crop production in Caribbean countries (10^3 ha). (Source: FAO 2013; FAO/IIASA 2005)

Countries[a]	Average harvested area in 2008–2011 (10^3 ha)						Suitable area available for crop cultivation (10^3 ha) under intermediate input level rain-fed production					
	Oil palm fruit	Soy beans	Sugarcane	Maize	Sorghum	Cassava	Oil palm fruit	Soybeans	Sugarcane	Maize	Sorghum	Cassava
Antigua and Barbuda				0.0		0.0						
Bahamas[b]			2.3	0.2		0.0			711.7	−0.2		278.0
Barbados			6.2	0.1		0.0			6.2			
Cayman Islands						0.0						
Cuba[b]			438.1	175.5	0.2	66.6	217.0	868.0	1,470.9	826.5	170.8	3,002.4
Dominica			0.2	0.1		0.1			−0.2			
Dominican Republic[b]	13.4		87.2	21.6	0.7	21.0	290.6	24.0	413.8	3.4	23.3	388.1
Grenada			0.2	0.4		0.0			−0.2			
Guadeloupe			11.6			0.1			−11.6			
Haiti[b]			18.5	370.0	137.9	129.9	44.0	38.0	53.5	−331.0	−84.9	67.1
Jamaica[b]			27.1	1.9		0.9	57.0		44.9	−1.9		−0.9
Martinique			4.0			0.1						
Montserrat				0.0								
Puerto Rico				0.3		0.1						
Saint Lucia						0.5						
St. Vincent & the Gr.			0.8	0.2		0.1						
Trinidad and Tobago				1.2		0.1						
Total Caribbean	13.4		596.2	571.5	138.8	219.5	608.6	930	2,689	496.8	109.2	3,734.7

[a] FAO did not have any information for crop production of the crops analyzed for the following countries: Anguilla, Aruba, British Virgin Islands, Netherlands Antilles, Saint Kitts and Nevis, and Turks and Caicos Islands

[b] Countries for which FAO/IIASA had data on suitable cropland for crops analyzed

and Guadeloupe (2 %). The top four countries represent 96 % of the region's total planted area of sugarcane. Given the current levels of land use, out of these top four producers, the Dominican Republic could expand the most, with almost 4.7 times the current area used. Jamaica and Haiti are more limited, given that the suitable area for sugarcane production in these two countries is smaller.

Most of the countries in the region plant maize. The largest cultivators include Haiti, Cuba, the Dominican Republic, and Jamaica, in that order. However, it seems that production conditions have been exceeded for some countries, as indicated by the negative entries in the right-hand side of Table 10.1. This is especially true in Haiti, where the area used for maize production seems to have surpassed the suitable area by 331,000 ha. The same is the case for Jamaica (1,900 ha) and Bahamas (200 ha). Cuba, on the other hand, has a large area to potentially expand maize production.[4] For sorghum, only three countries plant the crop, with Haiti planting almost all the area in the Caribbean. However, it seems that plantings in Haiti have exceeded suitable areas by 84,900 ha. On the other hand, there is potential to expand production in Cuba and the Dominican Republic. Finally, for cassava, the data indicate that there is little potential to expand production, except in the case of Jamaica.

The findings in Table 10.1 show that technically, given the soil conditions and input levels assumed, there is potential for expansion into suitable areas for production of several crops. To assess the real need for local production of ethanol and biodiesel, however, we need to compare the areas required with a potential size of the market given specific blends of ethanol and biodiesel in gasoline and diesel, respectively. For that purpose, we will analyze the required land for expansion of crop production to meet food production needs and the additional requirement of land use, given the actual land under production, current crop yields, and a blend mix of E10 and B10 in each country. The results of this analysis, for both ethanol and biodiesel, are presented in Table 10.2.

In general terms, the crop that would require the least additional expansion in the subregion to cover the additional feedstock demand of an E10 blending mandate would be sugar cane. The country best suited for that purpose would be Cuba, with only a 3 % expansion of current land. This would be achievable for this country, given that the current land area under production is below historic production levels. Other countries, e.g., the Dominican Republic, Haiti and Guadeloupe, would need to increase their current production area around 30 % to meet E10, while Barbados would need to increase by 50 % and Jamaica by 60 %.[5] Overall, the region would need to increase by 14 % the current area under sugarcane production (around 80,200 ha) to meet a 10 % fuel blend.

In the case of maize, land requirements surpass those of sugarcane for all countries. Given the advantage of sugarcane for production of ethanol, it would be technically

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[4] However, any land use for biofuel production seems unlikely, given the current policies in place as explained later in this chapter.

[5] Organization of American States and Winrock International (2011) note that there are 47,000 ha of suitable land available for sugar cane production to supply all domestic demand (sugar, molasses, and rum production), including an E10 blend of gasoline. This amount of land is comparable to what has been estimated here, which is around 42,000 ha (the current 27,000 ha plus the additional 15,000 for the E10 blend).

Table 10.2 Additional land area required to cover local biofuel needs at an E10/B10 fuel mix (ha) and relative size of expansion to current area under production to cover additional area. (Source: Author's own estimations, based on average 2008–2011 crop yields and area harvested, FAO 2013; ethanol and biodiesel yields from crops, various sources; and 2008–2010 average country fuel consumption, EIA 2013 and World Bank 2013)

Countries	Additional land area required to cover biofuel needs at E10/B10 (hectares)					Number of times current area under needs to increase to cover biofuel needs at E10/B10				
	Sugarcane	Maize	Sorghum	Cassava	Oil palm fruit	Sugarcane	Maize	Sorghum	Cassava	Oil palm fruit
Antigua and Barbuda		6,602		3,451			160.0		203.0	
Bahamas	8,339	16,328		6,058		3.6	103.3		291.9	
Barbados	3,177	11,639		2,177		0.5	115.5		101.3	
Cayman Islands				3,787					1262.2	
Cuba	13,196	47,702	59,744	22,945		0.03	0.3	331.5	0.3	
Dominica	1,037	2,871		796		4.3	22.7		6.8	
Dominican Republic	26,979	200,493	180,255	55,812	41,701	0.3	9.3	250.1	2.7	3.1
Grenada	1,013	10,825		1,631		6.3	30.8		72.5	
Guadeloupe	3,575			6,373		0.3			48.7	
Haiti	5,114	82,491	85,085	22,419		0.3	0.2	0.6	0.2	
Jamaica	15,213	137,226		12,872		0.6	72.8		14.1	
Martinique	3,605			21,408		0.9			259.5	
Montserrat		563					35.2			
Puerto Rico		449,684		135,078			1411.9		1909.2	
Saint Lucia				9,312					19.7	
St. Vincent & the Gr.	1,085	1,541		1,294		1.3	7.9		9.2	
Trinidad and Tobago		55,232		17,617			46.2		137.4	
Total Caribbean	82,333	1,023,197	325,084	323,030	41,701	0.1	1.8	2.3	1.5	3.1

and economically unfeasible to use maize as a feedstock for ethanol. Overall, more than 1,000,000 ha in maize would be required in the Caribbean to produce ethanol, which is not feasible or sustainable for the region. For sorghum, Haiti would need to increase its current area under production by 60 %, which as shown in Table 10.1, would surpass the suitable land area available for sorghum in that country. In the case of cassava, Haiti and Cuba would need to increase by 20 and 30 % respectively, which are the lowest of all countries in the region. However, the amount of land would still be two to four times larger than the amount of land required to produce ethanol from sugarcane.

For biodiesel, the Dominican Republic would need to increase the cultivated area of palm oil by 42,000 ha, a 310 % increase in current area under production. This is much larger than the additional area required to meet a 10 % blend of ethanol and seems unlikely to go forward.

This section has shown the technical feasibility of ethanol and biodiesel production from existing crops. In general terms, the analysis shows that sugarcane-based ethanol production might be the more viable and sustainable way to meet the needs in the region. Sugarcane production has been historically one of the main agricultural crops produced in most of the Caribbean islands. However, production has declined for most countries in the last two decades for a combination of reasons, such as reduced preferential tariff treatments from major sugar importers, increased costs, and decline in yields, among other factors. Relative to 1991, the area harvested in 2011 decreased by 48 % in Barbados, 65 % in Cuba, 53 % in the Dominican Republic, 56 % in Haiti, and 38 % in Jamaica (FAO 2013). The amount of land required to produce an E10 blend from sugarcane-based ethanol would be far less than what historical levels have been for some of these countries, without competing with land use for food production. Sugarcane ethanol production would also take advantage of the existing infrastructure that most countries have.

The previous analysis, based on FAO data, has some limitations. One limitation is that it does not account for new crops such as *Jatropha*, which might have a larger potential than existing crops for the production of biodiesel. Later on in this chapter, we will discuss biodiesel production in the Caribbean from *Jatropha*, including the testing and analysis of the feasibility of biodiesel production from this crop. Another limitation is that we do not examine the country's food balance of each crop to analyze the domestic use patterns of biofuel feedstock, and the use of by-products such as molasses in the case of sugarcane-based ethanol.

10.3 Investment Environment for Biofuel Production

Based on the analysis in the previous sections, we will now go into more detail on the current situation of biofuel production in Caribbean countries and its sustainability. Although there has been progress in the region regarding biofuels and renewable energy projects in general, Caribbean countries still lag behind other countries in the region. MIF-BNEF (2012) assessed the conditions for investment in renewable energy projects in Latin America and the Caribbean, including biofuels. The report ranked the Caribbean countries considered (the Bahamas, Barbados, the Dominican Republic, Jamaica, and Trinidad and Tobago) in the bottom half out of 26 countries total. The best-positioned countries were the Dominican Republic and Jamaica, ranked 15th and 16th, respectively. Barbados, Bahamas, Haiti, and Trinidad and Tobago, in that order, ranked close to the bottom.

In the case of the Dominican Republic, the country is the top ranked among Caribbean countries given that it has eight types of clean energy policies, including biofuels. For Jamaica, the report shows an investment of US$ 20 million in 2006, because of the installation of an ethanol dehydration facility, which we will discuss later on in the chapter. For Trinidad and Tobago, the only major investment in renewable energy is the construction in 2008 of a US$ 222.5 million ethanol dehydration plant. Given the countries' energy matrices, it is unlikely that a large share of energy supply will come from renewable sources in the short and medium term. Finally, for the Bahamas, Barbados, and Haiti, there are no registered activities with biofuels. The report shows that there are no distributors, blenders, engineering companies, feedstock suppliers, or retail producers in any of those countries.

A necessary condition for biofuel development is the existence of a conducive legal framework. Rothkopf (2009) analyzed four Caribbean countries and found that the Dominican Republic and Jamaica were the more advanced. The Dominican Republic enacted the Renewable Energies Incentive Law 57-07 in 2007, with expected blends of E10 and B5. Jamaica, in turn, created objectives of E10 (2008–2010), E15 by 2015, B2 (2006–2008), and B5 for the period 2009–2015. However, the interim goals were not met, as we will discuss later on. In addition, Puerto Rico enacted Law 153 in July 2011 (Lexjuris 2011) to support a biofuel market. We will describe some of these policies and their impact in more detail later in the chapter, when we discuss the specific countries under analysis.

10.4 The Caribbean Basin Initiative: Trade and Impact on Biofuel Production in the Caribbean

One important factor that has affected biofuel production and investment in the Caribbean is the Caribbean Basin Economic Recovery Act (CBERA), most commonly known as the Caribbean Basin Initiative (CBI).[6] Under the CBI, the United States effectively eliminated tariffs on imports of some forms of ethanol from the Caribbean and Central America (under CAFTA-DR). Specifically, the CBI granted preferential treatment to imports produced from foreign feedstock that were equal to up to 7 % of the previous year's US demand (Worldwatch Institute 2007). Under this mechanism, Caribbean and Central American countries were granted specific

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[6] The CBERA covers Antigua and Barbuda, Aruba, the Bahamas, Barbados, Belize, British Virgin Islands, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Panama, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago.

allocations within the 7 % quota to export ethanol to the USA. At the same time, there was a US$ 0.14-per-liter tariff on non-CBI country imports, such as from Brazil. The tariffs offset an economic incentive of US$ 0.13/l for the use of ethanol in gasoline (Yacobucci 2008).

In practice, what happened is that the Caribbean became a hub to transfer Brazilian ethanol into the USA. Brazil supplied hydrous alcohol that was then dehydrated into fuel ethanol in Caribbean and Central American countries. Depending on the relative cost of Brazilian ethanol, in some years it could be imported directly, as was the case in the spring of 2006. The two CBI countries that benefited the most are Jamaica and Trinidad and Tobago, which have installed dehydration plants to export ethanol to the USA (as discussed later on in the chapter).

The import tariff expired in December 2011, which removed the Caribbean countries' advantage, because Brazil can import their own ethanol more cheaply than ethanol that passes through CBI countries. There has been a lobbying effort from CBI countries and business interests in those countries to reinstate the tariff on non-CBI countries (Jamaica Gleaner 2012).

It can be argued that CBI imports into the USA promoted the economic development of these economies, even though those countries were not using local feedstock. It is likely that investments in biofuel projects in these countries, particularly ethanol dehydration, would not have happened otherwise.

It is also worth noting that several Caribbean countries including the Dominican Republic, Haiti, and St. Kitts and Nevis are part of the set of target countries under a Memorandum of Understanding (MOU) between USA and Brazil to advance cooperation on biofuels and the CBI to develop domestic biofuels industries. These countries will benefit from the development of feasibility studies and USA–Brazil cooperation for the development of biofuels. MOU partners include the Inter-American Development Bank (IDB), United Nations Foundation (UNF), and Organization of American States (OAS). For instance, the IDB has assisted with studies and evaluations of National Biofuels Programs in the Dominican Republic (also sponsored by Apex-Brazil) and Haiti (Vieira de Carvalho 2012).[7]

10.5 Country-Level Biofuel Production

This section briefly describes the current status of the production of biofuels in countries in the region. The review includes the Bahamas, Barbados, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico, Trinidad and Tobago and the US Virgin Islands. The inclusion of these countries and territories is based on available verifiable and reliable information, focusing on those initiatives and projects that have come to fruition or that are currently under way.

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[7] The IDB has also developed a Sustainability Scorecard for Biofuels (www.iadb.org/biofuelsscorecard) to evaluate projects on various aspects of sustainability such as crop management and social impacts.

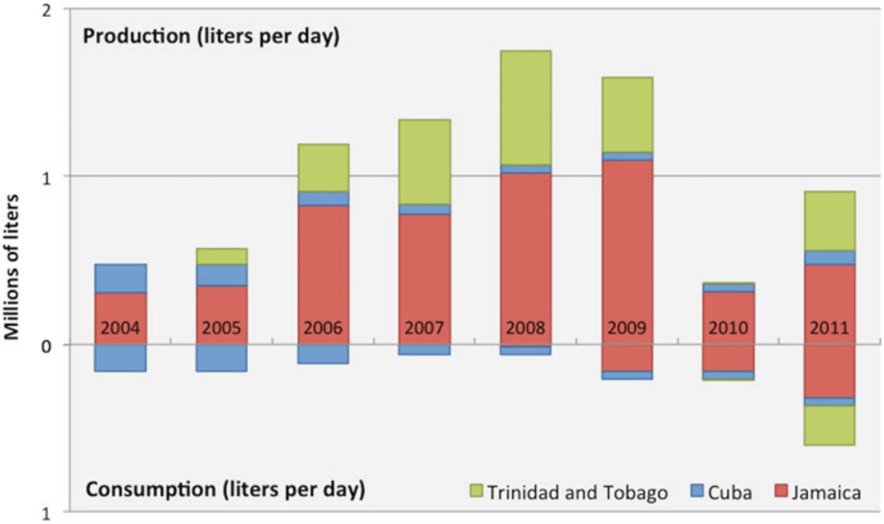

Fig. 10.1 Ethanol production and consumption in the Caribbean, 2004–2011 (thousands of liters). (Source: EIA 2013)

The only four countries with information regarding current production and consumption of biofuels in the Caribbean are Cuba, Jamaica, Trinidad and Tobago, and Barbados.[8] Of these four countries, the first three produced ethanol, with only Barbados producing biodiesel. Figure 10.1 shows the production and consumption of ethanol for Cuba, Jamaica, and Trinidad and Tobago. Jamaica is the largest producer in the region, with almost all its production through 2009 tied to the export of ethanol to the USA under the CBI. During that period, the highest production was reached in 2009, dropping sharply in 2010 after and rising slightly by 2011. As we will discuss later when we focus on Jamaica, the decline in production was caused by a shortage of raw material and drop in ethanol prices. However, domestic ethanol consumption in Jamaica has increased since 2008, reaching almost two-thirds of total production by 2011. Increased local demand is driven by local blending into the fuel mix as a cost-saving measure and to replace a less eco-friendly additive.

In Trinidad and Tobago, a similar production pattern as for Jamaica seems to have been followed, with increased ethanol production between 2005 and 2008 from 33 million to 247 million liters, but which declined by 34 % in 2009 to 162 million liters and stopped altogether in 2010. By 2011, production did recover, probably to meet domestic demand, as it is in that year that domestic consumption appears in Trinidad and Tobago for the first time in a significant way with a total of 116 million liters. Ethanol production in Cuba is entirely for domestic consumption (as they are not part of the CBI), with only 2011 production surpassing consumption. Finally, Barbados was the only Caribbean country that produced biodiesel for domestic consumption, but only in very small quantities (around 58,000 liters per year) (EIA 2013).

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[8] The US Virgin Islands produced ethanol only between 2007 and 2009; we present that information later on in the chapter.

10.5.1 The Bahamas

A waste-to-biodiesel project that uses waste cooking oil for biodiesel production has been planned in the Bahamas since 2010. The project, from Bahamas Waste, produces biodiesel for waste disposal trucks. According to the company's website, the biodiesel plant could produce up to 3.78 million liters of biodiesel per year. By November 2012, the company had produced 378,000 liters of B50 biodiesel, with approximately three-quarters of the truck fleet running on a biodiesel blend (Todd 2012).

10.5.2 Barbados

Steps for biofuel production are still in the early stages in Barbados. As noted in the Daily Nation (2011) by the chairman of the Barbados Sugar Industry Limited (BSIL) and Barbados Cane Industry Corporation (BCIC), the use of sugar mills for the production of ethanol is a viable way to revive an industry that has declined in the last few years. At the time, the Barbados National Oil Company (BNOC) and BCIC had already entered a joint venture partnership to develop the renewable energy sector in Barbados through the development of an ethanol plant to meet a blending target of E10 (BNOC 2010). However, by 2013, most of the activities have focused on bagasse cogeneration (Jamaica Gleaner 2013). There have also been some joint ventures regarding research-related activities, such as the agreement to fund research between the University of the West Indies Cave Hill and BioJet International, a supply chain integrator in the field of renewable jet fuel (University of the West Indies 2010).

For biodiesel, by 2007 the Ministry of Energy and the Environment was planning to mandate a B2 blend by 2012 and B10 by 2025 (Goddard 2007). By 2010, the BNOC had entered discussions with interested parties to test the viability of a B20 blend using waste cooking oil as a feedstock (BNOC 2010). Overall, as discussed previously, Barbados is the only country in the Caribbean that registers production of biodiesel in international statistics, having increased its production from around 48 liters per day in 2006 to 160 liters per day in 2011 (EIA 2013).

10.5.3 Cuba

Cuba was among the top three producers of sugarcane in the world from 1950 to the late 1980s. This lasted until 1991, when the Soviet Union collapsed and Cuba's exports to this country and its sugar industry collapsed as well. By 2007, sugarcane production was only one-eighth of its peak production in 1990 (Fischer et al. 2008). Cuba's sugarcane production declined from a little more than 1 million hectares in 2000 to 330,000 ha in 2007 (FAO 2013), a decline that forced the closing of more than half of the nation's sugar mills. Since then, it has slowly increased the area under cultivation to 506,000 ha in 2011, taking advantage of higher global sugar prices and increased demand. In addition, between 2006 and 2007, Cuba modernized existing alcohol production facilities (Cuba Standard 2012).

The Cuban Government established the Program for the Development of National Renewable Source of Energy in 1993 (González 2010). The general mandate from the government has been that biofuel production cannot compete with food production on resource use (land and other resources), given the possible implications for food security and prices. However, according to Gonzalez (2010), there have been studies that have evaluated the possibility of ethanol fuel blends up to 8 % (E8). In addition, that there is no consumption of fuel oil for sugar production, as all the energy comes from cogeneration from bagasse burning.

Given the general mandate by the government, most of the focus on biofuels in Cuba has concentrated on crops such as *Jatropha*, a crop that does not compete directly with food.[9] In 2012, it was reported by the news agency EFE (2012) that the first two biodiesel plants opened in Cuba: one in the province of Guantanamo, supplied by 130 ha of *Jatropha* under a project with the Swiss Agency of International Development (COSUDE) and the second plant was sited in the province of Sancti Spiritus, supplied by 110 ha of *Jatropha*, with three more planned biodiesel plants in the province of Matanzas (IANS 2012).

For ethanol production from nonfood competing feedstock, Havana Energy announced in December 2012 an investment of US$ 50 million in a Ciro Redondo sugar mill for the production of ethanol from the marabu weed (*Dichrostachys cinerea*), which is an invasive species on idle farmland in Cuba (Sequin 2012). As discussed earlier in this section, Cuba's ethanol production is mainly geared towards domestic consumption.

10.5.4 Dominican Republic

The Dominican Republic has the strongest regulatory framework in the region for the production of biofuels. Law 57-07, enacted in 2007, provides various incentives until 2020 for the production of renewable energies in general, including biofuels. The law's main components consist of a series of fiscal incentives, such as the removal of import taxes on all equipment, machinery and accessories imported for the production of renewable energy sources (article 8), exemption from income taxes for 10 years (article 9), and tax exemptions on foreign financing (article 10). There are also exceptions on export tariffs as long as the feedstock used is domestically produced. Producers that agree to supply the domestic market can export their surplus production (article 26).

Regulations under Law 57-07 have been in effect since May 2008 (CNE 2008). The regulations explicitly prohibit land used for human or animal feed to be used for biofuels feedstock (article 129). The National Energy Commission (CNE in Spanish) is in charge of supervising the law and its regulations and implementation. The National Institute on Innovation of Biotechnology and Industry (IIBI in Spanish) is in charge of developing national quality standards. The blend level will be established gradually by the CNE in coordination with the Industry and Trade Secretariat.

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[9] However, as noted in other chapters, *Jatropha* may compete with food crops for land.

Biofuels will be exempted from taxes until the blend reaches 20 % (CNE 2008). As mentioned by Francisco Gomez (NIST 2012), this is an authorization, not a mandate, for blending up to 20 % of biodiesel (B20) with diesel since 31 January 2010, with an initial blending level of 5 %.

Given the strong support system, some of the studies in the Dominican Republic have focused on the value chain of biofuels. OAS (2009) found that major needs at the time included the development of quality-control certification for fuel mixes and improved logistics for ethanol production, blending, and distribution.

The production of ethanol for local consumption requires investments in sugar mills, refineries, and in gasoline stations for retail sale (OAS 2009). According to the OAS, the investment required per gasoline station could range between US$ 250 and US$ 1,500, depending on the conditions and age of the stations. It was estimated that greenhouse gas emission reductions in 2010 were 5–6 %, with a projection of 14 % reductions by 2020 under a blend of E25 (OAS 2009). The study found that there were no major barriers to achieve an E10 blend, concluding that land used for sugar production would not impact food production. The IDB has been supporting the assessment of these gaps, under a Bioenergy Support Program for the development of sugarcane-based biorefinery (Gómez 2012).

Another feedstock that has been considered for ethanol production is sorghum. RJS Group is testing seven varieties and three hybrids for their potential for ethanol production and cogeneration. It is expected that a total of 40,000–45,000 ha will be planted under this project (Gómez 2012).

There are currently no large-scale *Jatropha* projects in the Dominican Republic.[10] There have been some pilot projects such the Globasol and Fundacion Sur Futuro project in Azua (110 km west of Santo Domingo), which have been testing the feasibility of *Jatropha* production under direct seeding conditions with several different irrigation and fertilizer conditions (NIST 2012; Gómez 2011, 2012). Globasol currently has a concession to develop a biodiesel project from *Jatropha* and the castor oil plant (*Ricinus communis*) with an estimated planted area of 37,000 ha and annual production of 68 million liters. The same company has also been importing biodiesel to test a mix of 2 % (B2) (Gómez 2012). There is another project in the province of Montecristi, where 400 ha have been planted using imported *Jatropha* seeds from Brazil (PHS Group 2011). Norte Biodiesel was granted a concession to study the feasibility of increasing its biodiesel production up to 1.7 million liters per year (Gómez 2012).

As noted by Francisco Gomez in NIST (2012), there are some challenges for the development of a local ethanol industry in the Dominican Republic, including: (i) the oligopolistic nature of the sugar industry, which lacks funding to modernize its facilities; (ii) high sugar prices; (iii) lack of development of a local market; and (iv) lack of integrated distribution channels. For biodiesel, the problems identified include:

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[10] Most statistics of production of *Jatropha* are either not available or not very unreliable. *Jatropha* Book (2013), a social networking website for *Jatropha* developers and researchers, notes the Dominican Republic has 10,000 ha under production at the time of writing. However, the reader should take this information with caution, as the statistics have not been independently verified.

(i) knowledge management of feedstock (i.e., *Jatropha*); (ii) lack of varieties suited for local conditions; (iii) lack of mandate; and (iv) multiple markets for feedstock and use of recycled oil.

10.5.5 Haiti

Under the Brazil–USA MOU to support National Biofuels Programs, the IDB, in partnership with the Getulio Vargas Foundation, has supported the implementation of a National Biofuel Program Feasibility Study for Haiti to analyze the potential for biofuel production in the country (Vieira de Carvalho 2009). This analysis has identified possible projects for ethanol and biodiesel production according to different fuel mix scenarios, based on feedstock and the suitability of production in Haiti. The feedstocks evaluated have been sugarcane, oil palm, *Jatropha* and castor bean. The studies have identified the potential for ethanol production from sugarcane, with a total of 10,000 ha, focused on small farmers (average farm size is 4 ha). For biodiesel, the studies have identified biodiesel production based on castor and oil palm, with 5,000 ha for each case. There are two pilot projects linked with each case. For palm oil, the pilot project would work with 50 families to plant 100 ha of palm oil near Les Cayes and install a processing plant with a total cost of US$ 1.5 million (Vieira de Carvalho 2009).[11]

10.5.6 Jamaica

The National Biofuels Policy of Jamaica is part of two broader policies: the overarching National Energy Policy 2009–2030 and the National Development Plan Vision 2030. These call for increased share of renewables in the energy mix to 20 % by 2030 to reduce the dependence of Jamaica on imported oil, which currently constitutes 91 % of the country's energy demand (Ministry of Energy and Mining of Jamaica 2010). In November 2009, an E10 mandate was implemented, effectively creating a domestic market for ethanol. The Jamaican government has set a Country Strategy for the Adaptation of the Sugar Industry 2006–2020, which outlines a roadmap to produce sugar, molasses, and ethanol (Ministry of Energy and Mining of Jamaica 2010). It has been estimated that E10 and B5 will comprise 16 % of renewable energy in Jamaica by 2015 (NIST 2012).

As mentioned earlier, the CBI has played a role in the biofuel-related investments in Caribbean countries. In the case of Jamaica, there have been two main ventures to process hydrous alcohol into fuel ethanol. One is through PetroJam and

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[11] In addition, there are several Haitian projects listed in the *Jatropha* Book database (*Jatropha* Book 2013). As with the projects in the Dominican Republic, little data are available and the projects' current status is unknown.

the other is by a local agribusiness group called Jamaica Broilers (JB). There are three ethanol dehydration plants in total, with a combined capacity of 830 million liters per year (Petroleum Corporation of Jamaica 2013). The plants produce ethanol for local consumption and export to the USA under the CBI. As mentioned earlier, beginning in November 2008, ethanol was added to the local fuel mix to reduce costs (Jackson 2012).

PetroJam is a company that is jointly owned by PDVCaribe, a subsidiary of Petroleos de Venezuela (PDVSA) and the Petroleum Corporation of Jamaica (PCJ). Petrojam Ethanol Limited (PEL), a subsidiary of PCJ, and the Brazilian company Coimex Trading Company financed the construction of a 150 million liter per year hydrous alcohol processing plant ethanol in 2005. Since 2008, PEL has owned the ethanol dehydration plant, which is located at the PetroJam refinery. PEL was formerly owned directly by PetroJam but was restructured in 2008 as a subsidiary of PCJ, which is now parent to both energy operations. The plant closed in November 2009, eliminate "however," after the partnership with the Coimex to supply alcohol stopped (Jackson 2011). Moreover, sugar prices more than doubled between 2007 and 2012 (US$ 0.20 vs. US$ 0.09 per pound), creating less attractive economic conditions for Jamaica to import hydrous alcohol from Brazil (Jackson 2012). As a result, the PEL plant will probably remain closed until 2014 because of ethanol shortages, but it will continue to import and distribute ethanol from the USA for local blending and consumption for E87 and E90 gasoline (Jackson 2012).

JB, an agribusiness group in Jamaica, operates two other dehydration plants, each with a total installed capacity of 227 million liter per year (MIF-BNEF 2012). However, their business climate is very similar to PEL's. By March 2010, ethanol sales had decreased by 50 % relative to 2009 (Gordon 2010). By July of that year, ethanol production was suspended (Titus 2010). The suspension was caused by the drop in ethanol prices and increased costs of raw material. More recently, JB's business activities appear to be rebounding. In August 2012, it announced that it had secured contracts that would increase ethanol production by 200 % (Thame 2012). Under these contracts, the plants would process customer's ethanol for a fee.

These changes in ethanol production are reflected in Fig. 10.1, as Jamaican ethanol production increased from 114 to 400 million liters between 2005 and 2009, but declined sharply to 116 million liters in 2010 and 170 million liters in 2011. Prices of raw materials imported from Brazil and fuel-grade ethanol in the USA affect the viability of Jamaica's ethanol industry. The revival of the sugarcane industry in Jamaica tied to the production of ethanol will also depend on these economic dynamics.

Although much of the focus in Jamaica's biofuel industry has been on ethanol, PCJ is also supporting the development of two small-scale biodiesel pilot projects. In July 2009, the two projects began testing a B5 blend in their own fleets and in some public transportation vehicles. The feedstocks include both castor oil and *Jatropha*. The projects' estimated cost is US$ 300,000, of which one-third comes from the UNEP Risoe Center (Petroleum Corporation of Jamaica 2010a, b). However, as OAS and Winrock (2011) note, small-scale production seems infeasible because of raw material costs. The cost of processing vegetable oils into biodiesel is roughly equivalent to refining petroleum. Unless there are subsidies for the production of biodiesel, it is unlikely that biodiesel production will take off.

10.5.7 *Puerto Rico*

Unlike Caribbean countries where the sugarcane industry has declined, but still remains somewhat viable, for Puerto Rico it has declined over many years. In 1950, Puerto Rico was the world's seventh largest producer, but for economic reasons production became increasingly less viable and was eventually abandoned altogether (Fischer et al. 2008).

With ethanol out of the picture, Puerto Rico has focused on biodiesel production for public transportation and government vehicles. Caribbean Business (2012) reports that Genuine Bio-Fuel, a biodiesel producer based in Florida, through its subsidiary Caribbean Bio-Fuel, is investing to build a biodiesel processing plant to open in the spring of 2013. The plant, with a production capacity of 45 million liters per year, will use a variety of feedstock such as vegetable cooking oil, plant oils, and animal fats.

Puerto Rico has also experienced some activity with alternative feedstock. For example, the University of Georgia has partnered with the University of Puerto Rico in a Renewable Energy R&D Center that intends to produce algae-based biofuels located in Rio Piedras, San Juan (Hastings 2011). The collaboration was funded by a US$ 4 million grant from the US Department of Defense.

10.5.8 *Trinidad and Tobago*

As in other Caribbean countries, the sugarcane industry has declined in Trinidad and Tobago. Despite efforts to revive it and convert sugar mills to produce ethanol for fuel, by 2008 the Government of Trinidad and Tobago dismantled the sugar industry and did not consider a shift to biofuel production (Blechinger and Shah 2011). The only major investment in the sector has been the construction in 2008 of the US$ 222.5 million dehydration plant designed to take advantage of the CBI arrangement previously discussed (MIF-BNEF 2012). As with Jamaica, the changing fortunes of Trinidad and Tobago's ethanol industry are reflected in Fig. 10.1.

According to MIF-BNEF (2012), further biofuels development appears unlikely for two reasons. First, all domestic fuel sales in the country are subsidized, with total subsidies representing 2.8 % of the GDP or US$ 730 million by 2011 (Nathaniel 2012). Of those subsidies, 58 % go to diesel, 36 % to gasoline, and 6 % to premium gasoline (Franco 2011). The other factor is removal of the US government's import tariff on ethanol for non-CBI countries discussed previously. This makes the business of dehydrating Brazilian hydrous ethanol in the Caribbean less competitive than directly importing anhydrous ethanol from Brazil to the USA (though see Chap. 3).

10.5.9 *US Virgin Islands*

According to the US Energy Information Administration (EIA 2009), in 2007, GeoNet Ethanol opened a $ 50 million dehydration plant on the island of St. Croix to process ethanol from Brazil for shipping to the USA, to be sold as a gasoline additive. The facility can dehydrate up to 379 million liters of ethanol per year (St. Croix Renaissance 2013). However, the island produced ethanol from 2007 through 2009 only, reaching a peak production of 511,000 liters in 2008 (EIA 2013). Most likely, as in the case of Jamaica and Trinidad and Tobago, the increased cost of the raw material and drop in ethanol prices made the venture infeasible.

10.6 Conclusions

Given the broad overview of this chapter, we can conclude several things about the sustainability of production of ethanol and biodiesel in the Caribbean based on local feedstock. First, for ethanol production, there is much opportunity given the history of sugarcane production in the Caribbean. The technology, inputs, and know-how are in place, which positions sugarcane as the most efficient and cost-effective feedstock. Second, the sustainability of sugarcane production regarding the use of land relative to other crops and its crop and ethanol yields positions this crop above other types of feedstock for ethanol production in the Caribbean. Third, alternative crops such as sorghum and cassava have some potential to contribute to ethanol production in the region; however, these are still at an early testing stage and it will take several years of continued effort before any commercially feasible production could materialize.

For biodiesel, *Jatropha* remains as the main alternative for most of the countries in the region, though its economics are highly questionable. The majority of countries have a pilot testing to determine the feasibility of production from this crop under Caribbean conditions. Nevertheless, it remains to be seen whether large-scale operations can successfully create a viable source of biodiesel, given the current market conditions such as the lack of local markets, fiscal and economic incentives, and the technical aspects of crop management and production.

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Chapter 11
Conclusions

Barry D. Solomon and Robert Bailis

Abstract This final chapter provides a summary and conclusions of the book, as well as some directions for future research. It was found that despite recent changes in ethanol markets, Brazil has maintained its dominant position for production and trade in Latin America and the Caribbean (LAC), though in recent years its exports have plummeted. In the case of biodiesel, however, the situation is much more volatile. Both Brazil and Argentina have grown to challenge the USA for the production lead. Argentina dominated trade and exports until recently, when its practices have been challenged in Europe. The increasing importance of trade in LAC (and also with the USA) and changes in agricultural markets underscores that biofuels present both opportunities and challenges for the region.

11.1 Summary

This volume has attempted to provide a comprehensive overview of biofuels development in Latin America and the Caribbean (LAC), focusing on the key countries, evolution of their programs, sustainability dimensions, policies, and governance. While dominated by Brazil since the 1970s, the region has witnessed the more recent emergence of competitors, some successful ones (e.g., Argentina, Colombia, and Guatemala) and some not (e.g., Mexico and El Salvador). In addition, the USA has overtaken Brazil as the leading biofuel producer in the Western Hemisphere, which has a major influence on regional trade patterns. As a result, there has been significant interest in the patterns, trends, and developments in biofuel markets throughout LAC. This book has therefore tried to fill a gap by providing a clear snapshot of these issues and challenges for LAC as a whole.

Chapter 1 provided background for consideration of biofuel sustainability in LAC. First, national production levels of ethanol and biodiesel in the region were presented

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and placed in the context of all LAC and the world. This demonstrated the dominance of the USA and Brazil for ethanol, but a much less concentrated market for biodiesel. Regional cooperation and trade was also addressed, as well as a few initiatives that encourage it. More extensive discussion was given to the numerous sustainability concerns (environmental, social, and economic), challenges, and policy responses, including many external nongovernmental organization governance programs—certification schemes and standards for biofuel and feedstock production. These international governance programs were addressed in Chap. 2 in much more detail. Chapter 2 also provided a context-specific perspective by examining the national-level blending mandates and targets, as well as the broader policy environment within LAC's biofuel-producing countries. While international certification schemes do not replace national-level regulation of biofuel development, they are especially important for biofuel producers that intend to export to Europe and the USA, such as Brazil and Argentina, where they have gotten the most traction. There is also some interest from Guatemala, which is a far smaller, but still export-oriented producer, as well as from Colombia, which does not yet export biofuel, but trades large quantities of sugar and palm oil. While these certification schemes are voluntary, they generally require a third-party verification of performance. In addition, several voluntary schemes were labeled "qualifying standards" for the European Union Renewable Energy Directive (EU RED), giving operations certified under those schemes access to EU markets. Owing to the large number of these biofuel sustainability standards and schemes, some comparisons of coverage were discussed along with compliance challenges.

Given the dominance of Brazil, its biofuel programs were addressed in Chaps. 3 and 4. Chapter 3 provided an extensive history of the ethanol program, Proaloccol, its key features, and recent developments. Long considered a success story worth emulating elsewhere in the global south, the Brazilian sugarcane ethanol program (like most other biofuel programs) was initially subsidized. Despite the efficiency and low cost of sugarcane ethanol, several sustainability challenges were uncovered. These include agro-ecological zoning, the gradual phase-out of crop harvest burning, a ban on slave labor, and stricter regulation of working conditions. A surprising recent development was the shift of Brazil from being a major ethanol exporter to net importer, though this has been a temporary phenomenon reflecting international sugar prices more than program sustainability.

Chapter 4 addressed biodiesel in Brazil, which is primarily based on soy oil. Brazil's National Program of Production and Use of Biodiesel (PNPB) is much more recent than its ethanol industry. The program is based on the three "fundamental pillars" of sustainability: social inclusion, environmental sustainability, and economic viability. Despite this overt attention to sustainability, the PNPB has raised concerns about both social and environmental impacts. The majority of Brazil's biodiesel is derived from soy oil, and soy production in the region has been implicated in the destruction of Amazon and Cerrado biomes. In addition, soy is a highly mechanized crop that is typically planted in large monoculture plantations and requires minimal inputs of labor. In fact, while soybeans cover $\sim 35\,\%$ of Brazil's annual cropland, the sector accounts for only 8 % of employment in annual crop cultivation, which makes soy one of the smallest employers of all Brazil's agricultural sector, including cattle.

Thus, while the economic viability of soy-based biodiesel is not in question, there are numerous doubts about its sustainability, particularly regarding social inclusion. Of course, Brazil's soy industry constitutes an immense agro-industrial complex that predates the nation's biodiesel program. The industry's rapid growth occurred several years prior to PNPB, arguably driven by rising global demand for soymeal as a high-protein ingredient in animal feed.

In Brazil, less than one-third of the country's soy oil supply is used as biodiesel feedstock. Soybeans consist of 80 % meal and 20 % oil; thus, the soy oil utilized for biodiesel represents a very small portion of total material throughput in Brazil's soy industry. Therefore, the attribution of the industry's environmental impacts is somewhat ambiguous. It is quite possible that the worst impacts would occur even in the absence of a biodiesel industry. Moreover, some sustainability concerns are being addressed, including deforestation (through an industry-led moratorium). Chapter 4 also examined Brazil's use of alternative feedstocks like *Jatropha curcas*, castor oil, African oil palm, and some native palms. These crops are generally considered more environmentally acceptable than soy as well as more amenable to social inclusion. However, thus far they have been used in very limited quantities.

Chapters 5–7 addressed other important biofuel producers in South America. Argentina (Chap. 5) is predominantly focused on its biodiesel sector and produces only minimal amounts of ethanol. The country relies on soybeans to produce its biodiesel and, as in Brazil, Argentina's rapid expansion of soy predated the development of the nation's biodiesel industry. However, in contrast to Brazil, Argentina's biodiesel production is focused mainly on exports. While the industry has been relatively successful and contributes to the nation's economy, a few sustainability challenges were also uncovered. These include the need for better enforcement of native forest protections, production on fragile lands, and high use of glyphosate pesticides, which is linked to the country's near-universal adoption of genetically modified "Roundup Ready" soy. Moreover, recent challenges to subsidy practices and sustainability of Argentinean biodiesel have emerged from the EU. Nonetheless, biodiesel from Argentina was also one of the more sustainable cases examined along with ethanol from Brazil.

Peru, addressed in Chap. 6, is a small but emerging producer of biofuel. It has produced only minimal amounts of biofuel so far, both ethanol and biodiesel. Palm oil was shown to be more economical for biodiesel, and *Jatropha* has been promoted as a way to support small landholders, but thus far efforts have not been fruitful. As for ethanol, blending policies and sugarcane production in the northern zone of Peru were discussed. The only other significant biofuel producer in South America, Colombia, was covered in Chap. 7. The country produces large amounts of both biodiesel (from oil palm) and ethanol (from sugarcane), but nowhere near the scale of Brazil. Through case studies of two multi-stakeholder initiatives to introduce sustainable sugarcane and ethanol production in Colombia, Chap. 7 uncovered the challenges in operationalizing sustainability programs. Water stress, water-quality impairments, and especially the all too familiar local politics were highlighted as major problem areas.

Chapters 8–10 covered Mesoamerica and the Caribbean. While this region has not had much biofuel activity thus far, the potential for much greater production and demand (especially for Mexico) exists. Chapter 8 addressed Guatemala, which has focused exclusively on sugarcane ethanol and is the only country in Central America currently producing biofuels on a large scale (El Salvador used to). Host to the largest, highest yielding and most efficient sugarcane industry in the region, Guatemala has not provided policy guidance for biofuel development as industry has taken the lead. Moreover, most of its production is exported and its ethanol production is only a minor contributor to the profitability of the sugarcane sector. Thus, any strategy to improve the sustainability of biofuel development in Guatemala should focus on the sugar industry as a whole. Chapter 9 addressed Mexico, which stood out for lacking a commercial biofuel industry, despite "soft" promotional efforts from government. Most recently there was optimism regarding *Jatropha curcas* production for biodiesel, but, as is the case in Peru and most other countries that have promoted this crop, yields have been extremely disappointing and most plantations have been scaled back or closed. Further, as the second largest producer of sugarcane in the LAC region (after Brazil), the potential for cane-based ethanol is large. However, Mexico lags well behind other countries of the region with respect to setting blending targets or mandates, which appear to be necessary in order to jump-start a domestic industry. In addition, biofuel production costs are too high to compete with subsidized petroleum products. As a result, despite a rapidly growing population and energy demand, the future of biofuel in Mexico is highly uncertain.

Finally, Chap. 10 addressed the Caribbean. Nine individual countries and territories were considered, none of which have significant production of biofuel at present. The largest biofuel sectors have existed in Jamaica, Cuba, and Trinidad and Tobago (all for sugarcane-based ethanol). However, all but Cuba had based their industries on US policies that encouraged refineries located in Central America and the Caribbean to purchase hydrous ethanol from Brazil, dewater it, and export it to the USA free from the duty that the USA levied against ethanol imported directly from Brazil. The US tariff on Brazilian ethanol was removed in late 2011, and output from Caribbean ethanol industries, which were already facing challenges as a result of high input prices, dropped dramatically. Nevertheless, Chap. 10 concludes that there is significant potential biofuel development in several Caribbean states including sugarcane and cassava in Cuba, the Bahamas, and the Dominican Republic; maize and soybean oil in Cuba; and oil palm in both the Dominican Republic and Cuba.

11.2 Conclusions

While ethanol production in Brazil has slowed in the last 5 years, along with its exports, no emerging markets in LAC have grown enough to challenge its supremacy. Moreover, since biofuel demand is likely to grow in the region, Brazil's significant dominance since the 1970s makes it unlikely that a single nation will emerge to challenge it, at least in the near future. More likely, production will expand from several places to help meet demand. In addition, while the USA is now by far the largest producer of ethanol in the world, the fact that it lifted its import tariff in 2012, together with a US federal policy that calls for increasing quantities of “advanced” biofuels at least through 2022, implies that Brazil will enjoy a ready market for its ethanol well into the future.

In contrast to ethanol, markets for biodiesel are less concentrated, more competitive, and volatile, in part because development has been much more recent. For example, significant production in the USA only began in 2005–2006, which was followed a couple of years later by that in Brazil and Argentina (plus more modest growth in Colombia). As a result, biodiesel production in recent years has been fairly close among the USA, Brazil, and Argentina. However, production and trade have been highly volatile. US output declined sharply following the Great Recession of 2008–2009 (though it has rebounded since 2011), while most recently Argentina faced a stiff challenge from the EU to its biodiesel exports, which has questioned its subsidies. Thus, the future of biodiesel markets in LAC is more uncertain than ethanol markets.

With the leading global economies continuing to promote free trade and multilateral agreements, it is likely that biofuel trade will continue to increase. For ethanol, Brazil has historically dominated the export market owing to its low production costs, and much of it was sold to the USA (along with Canada and the EU). This changed in 2010–2012, when US exports rose dramatically while imports fell and sugar prices rose, encouraging Brazil to shift a significant level of ethanol production back to sugar. For biodiesel, while both the USA and Brazil are among the largest producers, neither are major exporters. The USA had exported large quantities of low-priced biodiesel to the EU in 2007 and 2008. This led to allegations of dumping from EU producers, who lobbied the European Commission successfully for the imposition of import tariffs on US biodiesel (Flach et al. 2010). As a consequence, this opened up trade channels for Argentina, which grew to become the world’s leading biodiesel exporter. However, with the recent adverse action from the EU against Argentinean exports (see Chap. 5), this in turn has opened up an opportunity for other biodiesel producers in the LAC region. Thus, biodiesel trade is just as volatile as biodiesel production.

If we can draw any lessons from the country case studies presented in the preceding chapters, it is that biofuels present both opportunities and challenges for the LAC region. For example, as was reviewed in Chap. 2, countries in the region have created policies, ranging from aspirational goals to voluntary targets and legislated mandates, framing biofuel production as a pathway to satisfy specific social, political, and environmental objectives. These include job creation, increased energy security, and reduced pollution among others. Several government policies and international sustainability standards (cf. Chap. 2) are also explicit about introducing biofuels in ways that maintain environmental quality and protect food security. Thus, biofuels are often portrayed as enhancing social welfare with little or no downside.

On the other hand, the LAC region remains plagued by extreme inequality in wealth and landholding (de Ferranti et al. 2004). In addition, deforestation rates in LAC, driven largely by demand for agricultural land, are among the highest in the world (FAO 2010). Moreover, the region’s biofuels are derived almost exclusively from sugarcane, soybean oil, and palm oil. These so-called “flex-crops” (Borras et al.

2012) are embedded in preexisting agro-industrial complexes, which, for years, have contributed to social inequality and environmental degradation throughout the region. It is unclear whether newly emergent biofuel markets will be able to alter embedded practices of agro-industries that have been in operation for decades.

This is not to argue that emerging biofuel markets *cannot* have a transformative impact on the larger flex-crop agro-industries in which they are embedded. We must, however, acknowledge that the lofty goals articulated in national biofuel policies might be slow to materialize, if they come to pass at all. Large agro-industries like Argentinean soybean cultivation, Brazilian sugarcane, and Columbian oil palm have tremendous inertia. The institutions responsible for creating and maintaining the status quo tend to be resistant to change. Indeed, numerous attempts to circumvent the large flex-crop complex by introducing alternative feedstocks such as *Jatropha* or castor, crops that may be more amenable to social and environmental sustainability, have not met with success. While many sustainable biofuel certificates have been issued for Brazilian sugarcane and Argentinean soy (see Table 2.4, as well as Chaps. 3 and 5), and even one for *Jatropha* in Mexico (Chap. 9), this volume has demonstrated that there may still be some doubts about actual sustainability of biofuel-crop production (cf. Tomei et al. 2010).

Nevertheless, the cases presented in the preceding chapters reveal that in some places, small shifts toward more socially and environmentally sustainable practices may be underway. For example, the proliferation of voluntary biofuel sustainability certification schemes, many of which have been adopted as qualifying standards for the EU RED, has created multiple channels through which feedstock cultivation and processing can be vetted for social and environmental impacts. While these schemes vary widely in terms of the breadth and depth of their principles and criteria, they have created a series of benchmarks and a means of comparing projects that would not otherwise exist. In addition, these schemes have had a discursive impact, effectively shifting discussion of *sustainable biofuels* from the sidelines of policy discussions to the forefront. As proof of this influence, many of the principles articulated by voluntary sustainability schemes have been transferred directly into national policy documents. Such a discursive shift is a necessary precondition to behavioral change.

National policies with transformative potential have also emerged. Consider, for example, Brazil's policy of social inclusion in its biodiesel program. While the PNPB has not been particularly successful in bringing small family farmers into the biodiesel supply chain in either Brazil or Peru, by incentivizing biodiesel production in poor regions the Brazilian policy has encouraged major investments in biodiesel refining in parts of the country that would have been unlikely to host such facilities in the absence of inclusive policies (see Chap. 4).

11.3 Directions for Future Research

These findings raise several questions for further research. First, what factors determine the success of alternative biofuel crop production and conversion technology, such as for cellulosic ethanol? Progress has been rather slow in both areas. In the case of oilseed crops, *Jatropha* has been very popular, but thus far has met with little success. Oil palm has been more successful, but its growth potential is uncertain and its close association with massive deforestation in other world regions raises numerous red flags about its expansion in the LAC region. Second-generation biofuel technology has been researched for decades, especially for ethanol, but very little commercial production has occurred thus far (Solomon et al. 2007). While technological and financial factors are critical, institutional and other factors may also play a role.

A couple of the findings from Chap. 2 on biofuel sustainability standards and schemes bear repetition. Given the proliferation of these standards, it is important to understand which audiences or stakeholder groups are critical to grant acceptance of a standard, the dynamics of legitimacy granting and the role of civil society. Will the weakest standards prevail, or will social pressures mount to assure real sustainability of biofuel production and use? In addition, more research is needed to determine if standard adoption runs the risk of being symbolic, lacking substantive effects. While the biofuel standards are important to host countries, especially Argentina and Brazil, an example was cited for Mexico in Chap. 9 where within months after a biofuel sustainability certificate was issued, the producer fired hundreds of workers and greatly scaled back production.

A final important area for research would be statistical analysis of the effects of national biofuel policies and certification standards on production patterns and trade. While most feasible in Brazil and the USA given the greater experience of their programs, as more national programs mature elsewhere along with international certification programs, it will be increasingly important to understand what policies and standards make a difference and which do not. Given the proliferation of certification standards and the importance of industry leaders, study of such program effects will be extremely valuable. Indeed, this experience can help to chart the way forward to increase the sustainability of biofuels in LAC.

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