Chapter 5
Brazil Between Bioeconomy Barons and Grassroots Agroecology

Abstract Despite grand bioeconomy ambitions in this megadiverse country, sugarcane and soy dominate Brazil's agenda so far. National policies have driven particularly biofuel expansion, consumed essentially in the domestic market. Those policies have included regulatory and economic instruments such as blending mandates, fiscal incentives, and public credit to key agroindustries, in addition to public investments in biofuel R&D, production, and storage infrastructure. This agenda has economically benefited agribusiness, helped substitute fossil fuels, and supported Brazil's energy independence. However, by relying only on a few industrial monocultures, this expansion has also furthered socio-environmental impacts, such as on agrobiodiversity and freshwater resources. Sugarcane-ethanol production has helped increase large agribusiness' control over natural resources at the expense of smallholders and indigenous peoples. Biodiesel chains, in turn, have attempted but broadly failed to include smallholders, relying in the end mainly on soy. The prevalence of these production patterns reflects the dominance of an agribusiness coalition in governance. Some critics advocate for structural change towards agroecology, but private agroindustries and like-minded state actors have prevailed thanks to their more considerable material capabilities, better access to positions of legal authority, and a successful discourse that promotes large Brazilian agribusiness as working for the national interest.

Keywords Biofuels · Sugarcane ethanol · Biodiesel · Equity · Governance · Value chains

Brazil has long been a hub of biofuel and now bioeconomy promotion. With a large ethanol sector since the 1970s, an expanding biodiesel industry, and coordinated efforts to export its production model abroad (most notably in Africa), the South American country is a key player as well as a significant case study for how biofuels and the bioeconomy may develop. Brazil is the only nation where biofuels account for more than 10% of the energy used in the transport sector (REN21 2019). From economic and ecological standpoints, its sugarcane-ethanol is considered the most efficient biofuel commercially produced from standard crops (Pereira et al. 2019). The country also pioneered policies to include the rural poor in biodiesel production chains, and many have regarded it as an example that other developing countries in the

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tropics could or should follow (Mathews 2007; FAO 2008; Mitchell 2011). Indeed, despite various fluctuations through the 2010s, the biofuels and bioeconomy sector has remained prominent throughout—from the heyday of Lula da Silva's presidency to the Bolsonaro administration. The Amazon is occasionally flagged as a source of virtually inexhaustible resources for bioeconomy development, but a reality check may be in order.

This chapter looks deeper into the Brazilian case to understand why it has engaged so actively with the bioeconomy in the way it has. First, this chapter describes the context of biofuel production and consumption in Brazil, its national policy framework, and examines institutional causality. Then, it analyzes the distributional outcomes and social impacts of that production as the most substantive example of bioeconomy to date—and the axis around which the country is now developing other novel bioproducts. Finally, the chapter delves into politics and agency, identifying the key agents of bioeconomy governance in Brazil's domestic context, advocacy coalitions and their policy beliefs, and strategic uses of power. The chapter concludes with key insights on why certain biofuel production and bioeconomy patterns have prevailed in Brazil.

5.1 Biofuels in Brazil: How and Why

5.1.1 The Brazilian Setting: Energy and Agri-Food Contexts

5.1.1.1 Energy Context

A high rate of renewables characterizes Brazil's energy mix. They made up 45.2% of the country's energy supply in 2018, a high share it has more or less maintained since the early 2000s despite absolute increases in consumption (EPE 2019a). This rate contrasts with 19% in the European Union and merely 10.8% on average in OECD countries (IEA 2020). Biofuels alone represent 19% of the total energy use, including ethanol, biodiesel, and electricity produced from sugarcane biomass. Still, fossil fuel dependence remains significant, particularly in transport, which represents one-third of Brazil's total energy consumption and is expected to remain the fastest-growing energy consumer among all sectors in the 2020s (EPE 2020). While 83% of Brazil's electricity comes from renewable sources, the renewables rate is 23% in the transport sector. Fossil diesel (mainly used for heavy road vehicles) meets nearly half of this sector's demand. Gasoline and ethanol (for light-duty vehicles), in turn, have shares of 26 and 19%, respectively.[1]

Meanwhile, domestic oil production is on the rise. Since 2006, Brazil's oil production has exceeded its domestic consumption, and in 2018 the country was a net

[1]This refers to energy content, not volume. The same volume of ethanol has only two-thirds of gasoline's energy content, therefore volumetric comparisons that do not take this into account may be misleading (EPE 2019a).

energy exporter for the first time. However, a share of its crude oil supply (11% in 2018)—usually oil of lighter quality—as well as of gasoline (11%) and diesel (23%) consumed are still imported (EPE 2019a). Such imports mainly owe to Brazil's limited oil refining capacity, aggravated by stagnant ethanol production that has not kept pace with growing demand, which has forced gasoline imports and the importation of corn-based ethanol from the US. Petrobras, the country's state-controlled oil company and leading fuel distributor, until the 2010s owned three-quarters of Brazil's refineries (EPE 2013a). However, in 2019 the government decided to sell such assets to foreign investors—notably Chinese (EPE 2020). If Brazil's energy strategy during its economic heyday of the early 2010s was to double refining capacity by 2020 and eliminate diesel imports as early as 2015 (EPE 2013b), financial troubles and government changes have maintained its import dependence on refined fossil fuels. Domestic gasoline production is forecast to grow by a modicum of 3% between 2020 and 2029, while official projections expect oil refining into diesel to increase by only 23% in the decade (EPE 2020). These precisely are the fuels that ethanol and biodiesel replace, and it remains to be seen how such a persistent import dependence will affect biofuel expansion.

5.1.1.2 Agri-Food Context

Of Brazil's 350 million hectares (Mha) of arable land, approximately 200 Mha are used as pastures, 35 Mha for soybean cultivation, and 10 Mha for sugarcane—these two being the country's most valuable crops in economic terms (IBGE 2019; CONAB 2019, 2020). More than half of the sugarcane is used for making ethanol instead of sugar, though the exact rate varies every year as mills can switch between one and the other based on market conditions (CONAB 2019). Soybeans, in turn, are used mainly for animal feed, having vegetable oil as a co-product of secondary importance.

Since Brazil is a net exporter of both sugar and soybean oil, the diversion of those crops for fuel making has not posed a supply problem. Greater diversity of uses has, in fact, helped raise their international prices and earnings from exports. Brazil exports the majority of its sugar production, being by far the world's top exporter. As low oil prices and the COVID-19 pandemic hit fuel markets in 2020, sugar production and exports are expected to increase (Barros 2020). Soybean, meanwhile, is mostly exported uncrushed to China or—to a much lesser extent—as soy meal to Europe for animal feed. Soybean oil is but a by-product for which producers continually seek new downstream markets. Since biodiesel blending mandates came into force in 2008, soybean oil exports have significantly dropped. Exports currently take only 11% of Brazil's soybean oil supply, and half of what stays in the country is used for fuel, the other half as food (Ustinova 2020). Overall, if biodiesel manufacturing used 29% of Brazil's total vegetable oil consumption in 2012, this by 2018 had increased to 37%, a share that continues to rise as the domestic bioeconomy grows (OECD/FAO 2012, 2019).

5.1.2 Biofuel Production and Consumption Chains

5.1.2.1 Ethanol

Although Brazil has a nascent corn-ethanol industry, the bulk of the country's commercial ethanol production is based on sugarcane. The processing industry itself owns approximately half of the sugarcane cropland, showing some degree of vertical integration (Goldemberg et al. 2008; MAPA 2013). Historically it has also been characterized by the utilization of a large number of workers in manual cutting, a process associated with the burning of sugarcane fields before harvesting to reduce accidents.[2] However, concerns about air pollution and poor work conditions—leading to mounting health issues, cases of bonded labor,[3] and manual cutters' deaths due to overwork (Novaes 2007; Gomes et al. 2010a)—have led to the legal phase-out of crop burning. These issues have caused larger growers to seek mechanized harvesting, now widely used. While undoubtedly beneficial to the environment and human health, this has created a barrier to smaller producers who cannot afford expensive machinery.

Processing mills utilize sugarcane both from their cultivation and from suppliers. Prices are usually set based on the *total recoverable sugar* rate, i.e., the sugar content per ton of sugarcane. Most sugarcane mills in Brazil can choose how much sugar and ethanol to produce based on price signals, which gives them leverage but creates inevitable volatility in the ethanol and sugar markets. They can also strike a balance between the two types of fuel-ethanol commercialized in Brazil: *anhydrous* (to be mixed in gasoline at a fluctuating mandated rate, set since 2015 at 27%) and *hydrated* ethanol (to be used in "pure" form). In either case, mills must sell the ethanol to a distributor that then performs the fuel blending and sales. The main final consumers are automobile—and increasingly motorbike—drivers, which count on flex-fuel engine vehicles that can run on any combination of (hydrated) ethanol or gasoline. These engines allow drivers to choose between fuels based on price or other criteria (see Fig. 5.1).

The growing market for Brazil's sugarcane agroindustry and its high efficiency have attracted multinationals from the oil and agricultural technology sectors. This attractiveness has increased the number of acquisitions, mergers, and the industry's horizontal consolidation significantly, especially after the 2008/2009 financial crisis. For instance, British Petroleum, Bunge, and Louis Dreyfus Commodities acquired much of the Brazilian sugarcane-ethanol sector between 2008 and 2011. The country's largest sugarcane company, COSAN, became a joint venture with Shell called Raízen. Monsanto, now owned by Bayer, acquired some of the leading sugarcane research and development centers—with biotechnology that public funds had helped develop, to the chagrin of many Brazilian researchers and public complaints

[2] This refers to poisonous animals in the field, risks of workers cutting each other, and to the sugarcane leaves themselves, which can easily cut the skin (Ripoli et al. 2000).

[3] In 2009 more than 2000 rural workers were released by government inspection groups from bonded labor conditions, considered analogous to slavery, in the Brazilian sugarcane sector (Gomes et al. 2010a).

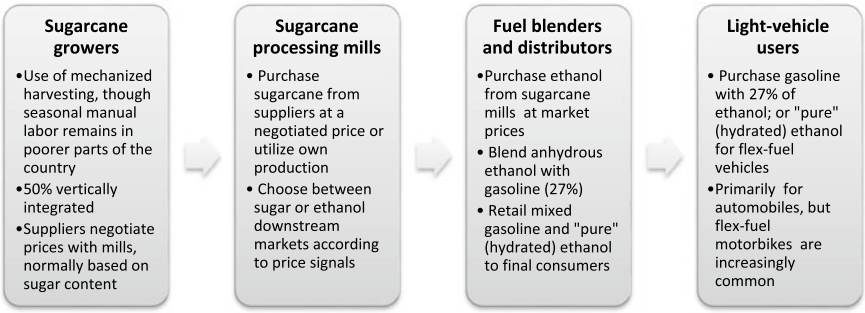

Fig. 5.1 Sugarcane-ethanol production and consumption chain in Brazil

by the minister of science and technology at the time.[4] Finally, Petrobras, too, started to make substantial investments in the sector and became a significant shareholder (see Gomes et al. 2010a), even though its participation would be forgone later in the decade due to political changes in Brazil.

Despite all the interest from large conglomerates, however, there is a clear perception that new investments in sugarcane-ethanol have fallen short of demand since 2010 (Jank 2011; REN21 2013; EPE 2019b). The 2010s saw a marked downturn in Brazilian ethanol production, with occasionally high international sugar prices also attracting producers to this other downstream market (EPE 2020). For instance, annual investments in sugarcane-ethanol decreased from 7.4 billion Brazilian reais (BRL) in 2011 (then about USD 4.5 billion) to one-quarter of it, BRL 1.8 billion in 2018 (USD 550 million at the time) (EPE 2019b). Since 2011, Brazil has had to import corn-ethanol from the US to meet its demand (Jank 2011). A once-thriving sector thus struggled under Brazil's economic hardship of the mid and late 2010s. Projections are of recovery of stability and gradual—if modest—growth through the 2020s (EPE 2020).

5.1.2.2 Biodiesel

Brazil's biodiesel production uses different feedstocks and often mixes them to achieve specific physicochemical parameters. Soybean oil (70% of the supply) and beef tallow (15%) are the leading feedstocks. The remainder of biodiesel uses other animal fats (e.g., pork fat) or plant sources such as cottonseed, castor bean and, increasingly, palm oil, which some expect to play a more significant role in the future (EPE 2019b, 2020). While the soy, cotton, and meat sectors are large industrial complexes, castor and palm oil chains tend to integrate smallholders, who biodiesel industries generally contract as feedstock suppliers.

[4]The minister of science and technology expressed his disappointment at the Brazilian private group, which had received large public funding over the years, for selling "those jewels so important to the country" to foreign groups (Escobar 2008).

Smallholder incorporation experienced a major initial crisis between 2006 and 2008 due to companies' inadequate technical assistance, low castor yields, and contract prices below market prices (Gomes et al. 2010b). Although castor was regarded as a "smallholder-friendly" crop capable of growing satisfactorily on poor soils and without water, fertilizer, or pesticide inputs, yields revealed to be small and mostly uneconomical under these conditions. As a result, companies broke many contracts and abandoned the smallholders, some of whom were later "rescued" by Petrobras Biofuels, a new state-controlled subsidiary. Petrobras started new agreements with the smallholders offering better seeds, improved technical assistance, and higher purchase prices adjustable to market conditions (Zapata et al. 2010). Rather than having farmers switch completely to feedstock cultivation (which proved harmful to local food security), Petrobras also started promoting mixed food-and-feedstock cropping, adding to the existing farming practices. Yet, despite purchasing castor beans for vegetable oil extraction, Petrobras did not use it to make biodiesel but instead sourced (cheaper) soybean oil for this purpose while selling castor oil more profitably to the oleochemical industry (Zapata et al. 2010; Bastos Lima 2012). Although later Brazilian administrations opted for a leaner state and largely dismantled Petrobras's biofuel operations, for some time it showed how different arrangements were possible—while also raising questions about who kept control of value-added.

Down the chain, all biodiesel manufacturers have to comply with rules from the National Agency of Petroleum, Natural Gas and Biofuels (ANP), which organizes auctions where fuel blenders and distributors purchase biodiesel. On average, about 25% of all biodiesel purchasing is done by Petrobras's distributor branch (down from 40% in the early 2010s), followed by Raízen (18%), and several other, smaller private distributors (ANP 2013, 2020). Distributors will then retail conventional diesel with a mandatory percentage of biodiesel mixed in it (12% in 2020, rising one-percent annually until 15% in 2023). All production is consumed domestically, primarily for heavy-duty vehicles or stationary engines in remote parts of the country (see Fig. 5.2).

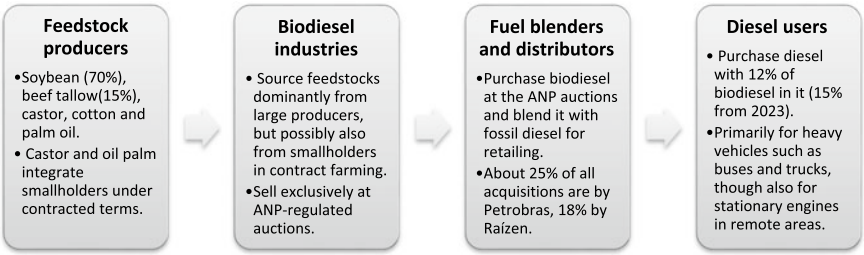

Fig. 5.2 Biodiesel production and consumption chain in Brazil

5.1.3 Brazil's Biofuel Policy Framework

Commercial biofuel policy in Brazil dates back to the 1930s, when the first ethanol blending mandates came to place. Sugar export was key for the country's colonial economy since the 16th century. Although by the first half of the twentieth century sugar was being used primarily for domestic consumption, this changed after the Cuban Revolution in 1959 left the large US market without a major supplier. Upon request from the private sector, there were significant public investments in the 1960s and early 1970s on sugarcane breeding, yield improvement, and industrial processing capacity, in addition to the subsidization of that sector (Moreira 2007; see Table 5.1).

By 1975, a crisis of overproduction led to record-low prices. Meanwhile, Brazil was spending large amounts of foreign exchange to import oil at soaring costs. These two factors led to a program of massive public financing for setting up ethanol distilleries (the "Pro-Alcohol" program). Besides, new regulations mandated the purchasing and blending of anhydrous ethanol at the rate of 22% in all gasoline (Szmrecsányi and Moreira 1991). In 1979, the government convinced—with fiscal incentives—the automobile industry to manufacture cars running on "pure" (hydrated) ethanol. This initiative diverted even more of the sugarcane overproduction and helped raise sugar prices. Brazil then lived its first ethanol boom, with record sales of ethanol-fueled cars in 1985.

By the late 1980s, however, oil prices had decreased, sugar prices increased, and many producers shifted away from ethanol, leading to supply shortages and massive consumer dissatisfaction. In addition, subsidies to (then more expensive) ethanol created a government budget deficit, which led to significant reform and the near dismantling of the program in a broad deregulation phase in tune with the neoliberal *zeitgeist* of the 1990s. Sugar and ethanol production and trade were liberalized, and sales of ethanol-fueled cars plummeted. Only the mandatory blending was maintained (Shikida et al. 2011; see Table 5.2).

The 2000s saw the resurgence of ethanol and new governmental engagement. The new approach (Law 10.453/2002) no longer relied on state-controlled prices and production but liberalization combined with economic incentives through tax breaks and public credit from Brazil's major development bank (BNDES). Fiscal incentives stimulated the introduction of flex-fuel cars in 2003, giving new traction to the commercialization of "pure" ethanol (Di Giulio 2006). Since its price is no longer set by the government but still should remain competitive with that of gasoline, the new policy became to tune the rate of ethanol blending (18–27%) as a market regulation tool. If "pure" ethanol prices are too high, the government can reduce the rate of anhydrous ethanol blended in gasoline to release supplies and lower them.[5] Since 2015 the blending rate has been fixed at 27%, but the government keeps that as a lever.

All these measures became part of the 2006 National Agroenergy Plan and were, for the first time, presented under a sustainable development rationale (see MAPA

[5]It was estimated that each percentage point down meant additional 250 million liters of ethanol that could be released in "pure" form in the market, bringing prices down (Reuters 2011).

Table 5.1 Import-substitution phase of biofuel promotion in Brazil

Year	Policy	Policy instrument type and target	Effect
1931	First mandatory ethanol blending	Blending mandate (*fuel distributors*)	Mandatory 5% blending (E5) to all imported gasoline to reduce dependence on foreign fuel[a]
1933	Creation of the Sugar and Alcohol Institute (IAA)	Economic regulation (*sugarcane processing industry*)	State to set sugar and ethanol prices and production quotas, and to mediate exports. Mills forced to source at least 40% of the sugarcane from suppliers to prevent too much sectoral consolidation[a]
1938	Ethanol blending expansion	Blending mandate (*fuel distributors*)	E5 extended to all gasoline, imported or domestic[a]
1961	Creation of an Exports Division within the IAA	Public credit (*sugarcane growers and industry*)	Subsidized loans to increase sugar production and exports, particularly to the US market[a]
1962	Investment package to enhance sugar production	Public credit and investments in production capacity (*sugarcane growers and industry*)	Expansion of production quotas, public investments, and financing for increasing sugarcane's agroindustrial capacity upon private sector requests to meet growing market demand[a]
1971	National Program of Sugarcane Improvement (*Planalsucar*)	Public investment (*sugarcane R&D*)	Public-funded R&D program on sugarcane breeding and agronomics to improve yields and adapt it to different soils and agro-climatic conditions[a,b]
	Rationalization Program to the Sugar Industry	Public credit (*sugarcane growers and industry*)	Subsidized loans to modernize the sector, prioritizing larger enterprises as a way to increase economies of scale[a,b]
1973	Support Program to the Sugar Industry	Public credit (*sugarcane growers and industry*)	Follows the Rationalization Program, nominally replacing it but maintaining the same agenda[a,b]
1975	Pro-Alcohol ethanol program	Public investment in ethanol processing infra-structure; Blending mandate (*fuel distributors*)	Public investment in sugarcane-ethanol distilleries; Petrobras to absorb that production and mix it in gasoline up to E22[a,b]
1979	Pro-Alcohol phase 2	Fiscal incentives and public credit (*automobile and sugarcane industries*)	The automobile industry to produce cars running on ethanol only, and the sugarcane industry to make hydrated ethanol (E100) directly from sugar juice[a,b,c]

[a]Szmrecsányi and Moreira (1991); [b]Moreira (2007); [c]Hall et al. (2009)

Table 5.2 Deregulation phase of biofuel promotion in Brazil

Year	Policy	Policy instrument type and target	Effect
1990	Extinction of the IAA	Economic (de)regulation (*sugarcane industry*)	Start of the deregulation phase, eliminating the IAA and Planalsucar[a,b]
1994	Liberalization of sugar exports	Economic (de)regulation (*sugarcane industry*)	Permission for the industry to export sugar directly, without government mediation (previously done by the IAA)[b]
1997	Deregulation of anhydrous ethanol prices	Economic (de)regulation (*sugarcane industry*)	Anhydrous ethanol prices no longer set by the government; they can fluctuate freely in the market[b]
1998	Deregulation of sugarcane prices	Economic (de)regulation (*sugarcane industry*)	Sugarcane prices no longer set by the government; mills and growers to negotiate[b]
1999	Deregulation of hydrated ethanol prices	Economic (de)regulation (*sugarcane industry*)	Hydrated ("pure") ethanol prices no longer set by the government but to fluctuate freely and compete with gasoline in the market[b]

[a]Szmrecsányi and Moreira (1991); [b]Shikida et al. (2011)

2006). This new emphasis was accompanied by key initiatives to address social and environmental concerns, such as a National Plan for the Eradication of Forced Labor (Brazil 2003)[6] and an "agroecological zoning" policy for sugarcane, to reduce deforestation risks. Through this mechanism, public credit became limited to producers who complied with the zoning, even if cultivation did not become strictly forbidden (Manzatto et al. 2009). (This zoning policy would remain in place for over a decade until the Bolsonaro administration abolished it in late 2019.)

In 2012, the government announced massive new public investments in sugarcane expansion and ethanol storage,[7] totaling about USD 38 billion by 2015. It also changed regulations to allow greater state control over ethanol markets, given a lack of private investments and shortfall in ethanol production after 2010 (MAPA 2012a). Such modifications included, for instance, legally changing ethanol from an "agricultural product" to a "fuel" and a "public utility," which allows the government to prevent price volatility and interfere in international trade in the name of national and public interest.[8]

[6]Although the policy targets forced labor in all sectors, there was a clear link with the sugarcane sector, which has been in the spotlight in this regard since at least the early 2000s.

[7]This is particularly key for periods in between harvests, when ethanol supplies tend to be lower.

[8]Law 12.490/2011; Law 12.666/2012.

An economic recession (2015–2016) significantly slowed Brazil's ethanol prospects, but policies would experience a come-back in 2017 with a National Biofuels Policy.[9] This time, the emphasis has been on systematically using biofuels to meet the country's international climate commitments. Brazil's increasingly neoliberal administrations—first the business-oriented Temer, followed by far-right Bolsonaro—consolidated a radical political U-turn, away from the Workers' Party governments (2003–2016). Yet, the country has maintained its commitment to the Paris Agreement. The *RenovaBio* program, instituted as a National Biofuels Policy, has adopted 2025 and 2030 fuel emissions reduction targets, has created a grading system to certify biofuel producers according to their emissions reductions, and set up a market for Certificates of Decarbonization by Biofuels (CBIO). The program should operate initially from 2020 through to 2030, with the expectation of renewal after that (MME 2018). Table 5.3 summarizes the key policies from this current, sustainability-oriented phase of ethanol promotion in Brazil.

In contrast to ethanol, biodiesel in Brazil is a far newer commercial sector, and it has a much leaner policy. Its framework was laid out in the National Program on Biodiesel Production and Use (*Programa Nacional de Produção e Uso do Biodiesel—PNPB*), launched in 2004. PNPB introduced a sequence of biodiesel blending mandates: 2% blending (B2) came into force in 2008; B3 was initially foreseen for 2010 but anticipated to July 2008 thanks to industry readiness; and the same happened to B5, pulled from 2013 to 2010 (Law 11.097/2005). These blending mandates continue to be the core of Brazil's biodiesel policy. Later increases have been steadily implemented, with B12 coming into force in 2020 and an expectation of B15 by 2023. Besides, the government has offered credit and fiscal incentives to biodiesel producers. Finally, PNPB established that biodiesel sales to distributors would take place exclusively through state-regulated auctions (Law 11.116/2005). By early 2020, more than 70 such auctions had taken place, trading a continuously growing amount of fuel.

A key element of PNPB has been its social orientation. The policy determines that biodiesel industries that source feedstock from smallholder "family agriculture" (which has a legal definition in Brazil[10]) receive a *social fuel seal*, which grants additional credit, fiscal advantages, and priority in 80% of the auctioned sales.[11] Due to the initially problematic integration of smallholders, the program was reformed in 2009 and subsequently amended in 2011 and 2012 to add further requirements and specifications. The policy started requiring that biodiesel industries provide smallholders with technical assistance and that supply contracts be validated by a representative labor union or social movement to safeguard smallholders' interests (MDA 2009). This change coincided with the creation of Petrobras Biofuels—then presided by the

[9]Law 13.576/2017.

[10]Law 11.326 of 24th July 2006 defines family farmers as those who run the farm with and use primarily labor from his/her own family, whose income derives mainly from farming, and who owns not more than four fiscal modules—an area measure which varies depending on the region of the country, from 20 ha in more developed to 400 ha in remote regions.

[11]The requirement is that at least 30% of the company's total expenditures on feedstock sourcing must be directed to smallholders (MDA 2009).

Table 5.3 Sustainable development phase of biofuel promotion in Brazil: ethanol

Year	Policy	Policy instrument type(s) and target(s)	Effect
2000	Creation of the Inter-ministerial Council on Sugar and Alcohol	Governance and overseeing	A deliberative body on sugarcane and ethanol policies, comprising the ministries of agriculture (coordinator); finance; mines and energy; and development, industry, and foreign trade[a]
2002	Law on ethanol subsidies	Governance and overseeing	Sets a new legal framework for ethanol subsidization to ensure stable supplies[b]
	(São Paulo state) Law phasing out sugarcane burning	Environmental regulation (*sugarcane growers*)	Phasing-out of sugarcane field burning, made illegal by 2021 on flat areas where mechanized harvesting is possible and by 2031 in all areas[c]
2003	Fiscal incentives for the production of flex-fuel cars	Fiscal incentives (*automobile industry*)	Reduced taxation on flex-fuel vehicles, able to run on any combination of hydrated ethanol and gasoline[d]
	National Plan for the Eradication of Forced Labor	Labor regulation (*sugarcane growers*)	Stricter laws against forced labor, linking it to rural public credit; farm inspection teams from the Ministry of Labor are set up[e]
2006	National Agroenergy Plan (2006–2011)	Public investment (*R&D on biofuel value-chains*)	Orchestrates the rationales, means, and goals for biofuel expansion in Brazil; announces funding for biofuel R&D[f]
2009	Sugarcane Agroecological Zoning	Zoning (*sugarcane growers*)	Agronomic classification of lands based on suitability to sugarcane cultivation, and recognition of environmentally sensitive, no-go areas where public credit is unavailable[g]
2011	State regulation of ethanol stockpiling and trade	Economic regulation (*sugarcane industry*)	Ethanol legally treated as a "fuel," not anymore as an "agricultural" product, to allow greater state regulation on ethanol stockpiling and foreign trade; blend range widened, E20–25 to E18–25[h]
2012	Subsidized credit for ethanol stockpiling	Public credit (*sugarcane industry*)	Subsidized credit to increase ethanol stockpiling capacity, to prevent supply shortages and ensure ethanol's price competitiveness face gasoline[h]
	BNDES *Pro-Renova* credit	Public credit (*sugarcane growers*)	New billion-dollar credit line at Brazil's Development Bank (BNDES) to renew and expand sugarcane cultivation[i]
	Strategic Plan for the Sugar-and-Ethanol Sector	Public investments (*sugarcane growers*)	BRL 29 billion (~USD 14 billion) to renew 6.4Mha of sugarcane cropland and BRL 23 billion (~USD 12 billion) for an additional 3.8 Mha[j]
2015	Increased blending mandate (E27)	Blending mandate (*fuel distributors*)	Ethanol blending mandate widened to E18–27 and set at 27% for the time being[k]
2017	*RenovaBio*—National Biofuels Policy	Emissions reduction targets and carbon market (*domestic ethanol industry*)	Annual carbon intensity reduction targets, producer certification, and trade of Decarbonization Credits[l]
2017	Ethanol import tariff	Tariff on imports (*domestic ethanol industry*)	A 20% tariff on imported ethanol beyond a 600 million liters quota (raised to 750 million in 2019) to protect domestic ethanol producers[k]
2019	Abolition of sugarcane zoning	Zoning (*sugarcane growers*)	Zoning restrictions to sugarcane growers (keeping the Amazon off-limits) lifted

[a]Decree 3.546/2000; [b]Law 10.453/2002; [c]São Paulo State Law 11.241/02; [d]Di Giulio (2006); [e]Brazil (2003); [f]MAPA (2006); [g]Manzatto et al. (2009); [h]Provisional Measure 532/2011; Law 12.666/2012; [i]BNDES (2012); [j]MAPA (2012a); [k]Barros (2020); [l]MME (2018)

former Minister of Agrarian Development—and its direct engagement with smallholders contracting in the country's most deprived areas where the private sector had given up (Gomes et al. 2010b). Petrobras then adopted as its policy the provision of improved seeds from the—also state-controlled—Brazilian Agricultural Research Corporation (EMBRAPA). It started promoting mixed food-and-feedstock cultivation to avoid food insecurity problems that smallholders experienced when converting exclusively to feedstock cultivation. Finally, Petrobras began to experiment with alternative feedstocks to castor, such as sunflower oil.

Those changes successfully reversed the earlier problems with smallholder integration. Yet, in time the only family farmers to effectively contribute to biodiesel making would be soy producers from the more well-off South of the country. Castor and other oils appeared too valuable (and expensive) to become biodiesel feedstocks—they played a more sensible role in other bioeconomy chains, such as in the oleochemical industry, to which Petrobras Biofuels started supplying. That notwithstanding, Brazil's neoliberal administrations since 2016 have all but dismantled the state-controlled subsidiary. Poor performance, insufficient investments, and later lack of buyers led the castor bean planted area to shrink from 219,300 ha in the 2010/2011 harvest to only 28,000 ha in 2016/2017 (growing back to 45,600 in 2019/2020, but still far below its apex) (CONAB 2020).

The biodiesel sector would become effectively sustained by feedstocks from large agro-industrial complexes (soy and beef), thus mainly losing its original social purpose of addressing rural poverty through biofuel value chains. In 2019, a new ordinance would then eliminate the need for an organization to ratify supply contracts. Moreover, it made not only family-agriculture cooperatives but any cooperative that includes family farmers eligible for the Social Fuel Seal and its benefits.[12] In practice, this has allowed commercial soy-farmer organizations to occupy a niche originally envisaged for poor smallholders—without formally dismantling but making a travesty of the sector's original social orientation.

By the start of 2020, the biodiesel industry met a 12% biodiesel blending mandate using mainly soybean oil and beef tallow. These are by-products in abundant supply in Brazil, and therefore a growing mandate has been steadily implemented. With the COVID-19 pandemic, however, for the first time, the government *reduced* the obligatory blending rate temporarily to 10%.[13] Much to the chagrin of biodiesel industries, that had to do with abundant soy supplies sold in bulk—primarily to China—leaving little to be domestically processed. A devalued Brazilian currency has made raw soy exports attractive to growers, but it reduced biodiesel feedstock supplies and increased the cost of (soy) cooking oil to Brazilian households.

While it remains to be seen what will prevail in terms of using Brazil's growing soy supplies, from 2023 a 15% blending rate is to be in place, at which stage technical limitations of current engines might stall further increases. The official forecast is that this rate will remain fixed throughout the 2020s, although representing ever-larger absolute amounts as total diesel consumption is expected to increase (EPE 2020).

[12] Ordinance N.144, of 22nd July 2019.

[13] See Resolution N. 824, of 13th August 2020.

Table 5.4 summarizes the principal policy instruments behind biodiesel promotion in Brazil.

The rationales for Brazil's biofuel policies have varied through the years, arguably expanding their range and significantly shifting depending on the federal administration. Table 5.5 synthesizes the five main foci identified.

5.1.4 Assessing Institutional Causality

The state has played a crucial role throughout the history of biofuel expansion in Brazil. Unlike other markets, which may emerge spontaneously out of consumer demand and private sector initiative, biofuels have been a governmental project in all the occasions they appeared: in the 1930s, 1970s, and most recently in the 2000s. Public institutions have always been critical for the debut, development, and acquired economic viability of the sector.

All along, the Brazilian government has used a powerful combination of regulatory and economic instruments to enable private agroindustries to produce biofuels and make this production economically attractive. From their earliest days, blending mandates have secured captive markets to absorb production regardless of biofuels' competitiveness vis-à-vis gasoline and diesel. There has been vast subsidization in the forms of tax breaks, public credit, and investments in production infrastructure and R&D (including vital public-funded research to improve soybean and sugarcane yields during the 1970s and 1980s). Notably, the government never engaged in feedstock cultivation. Instead, it has mandated consumption, creating additional markets for an agricultural sector that in Brazil has historically been in private hands, while oil refining and fuel distribution have been dominated by Petrobras, a state-controlled company. Every time, surges in biofuels production came as a direct consequence of public policies.

The pattern of how public institutions drive biofuel expansion has, however, changed over the years. While direct subsidization and government-set prices characterized the sector in the 1970s and 1980s, the 1990s saw a period of deregulation that was not reversed when biofuels resurged in the 2000s. Subsidies gave place to loans, primarily from Brazil's state-controlled development bank (BNDES). Moreover, although blending mandates have been maintained, sugarcane-ethanol production was already efficient enough to compete with gasoline in the free (non-captive) market, which was crucial for the extensive adoption of flex-fuel cars since 2003.

A few other differences have marked this more recent, post-deregulation phase. First, foreign bioproduct markets appeared in the 2000s for the first time and gained relevance. Brazil initiated the so-called "ethanol diplomacy" (Jank 2011) to increase exports and promote biofuels abroad to establish them as globally traded commodities (see Chap. 4). These foreign markets can be considered additional drivers of biofuel and bioeconomy expansion in Brazil, but their influence is arguably minor compared to that of the broad framework of Brazilian institutions promoting them. Moreover, most investments and the lion's share of biofuel consumption remain domestic.

Table 5.4 Sustainable development phase of biofuel promotion in Brazil: biodiesel

Year	Policy	Policy instrument type(s) and target(s)	Effect
2004	National Program of Biodiesel Production and Use (PNPB)	Blending mandate (*fuel distributors*); Conditional public credit, procurement, and fiscal incentives (*biodiesel industry*)	Biodiesel blending allowed and phased in, aiming initially at mandatory B5 by 2013. Creates the Social Fuel Seal, providing preferential procurement and additional fiscal and credit benefits to biodiesel industries which purchase feedstock from smallholders[a]
2006	National Agroenergy Plan (2006–2011)	Public investment (*R&D on biofuel value-chains*)	Orchestrates the rationales, means, and goals for biofuel expansion in Brazil; announces funding for biofuel R&D[b]
2008	B2 mandate	Blending mandate (*fuel distributors*)	Mandatory 2% biodiesel blending (B2) comes into force
2009	New rules for biodiesel's Social Fuel Seal	Conditional public credit, procurement, and fiscal incentives (*biodiesel industry*)	Biodiesel industries must provide contracted smallholders with specified technical assistance; a labor union or social movement representing smallholders' interests must validate the contracts[c]
	B3 mandate	Blending mandate (*fuel distributors*)	Mandatory B3 comes into force
2010	B5 mandate	Blending mandate (*fuel distributors*)	Mandatory B5 comes into force, anticipated from 2013
2014	A second round of blending mandates	Blending mandate (*fuel distributors*)	New blending targets: B7 (2014), B8 (2017), B10 (2018)[d]
2018	A third round of blending mandates	Blending mandate (*fuel distributors*)	B11 (2019), B12 (2020), B13 (2021), B14 (2022), and B15 (2023)
2019	New rules for the Social Fuel Seal	Conditional public credit, procurement, and fiscal incentives (*biodiesel industry*)	Eliminates the need for a representative organization to ratify supply contracts; makes larger commercial cooperatives eligible as "family farmer" suppliers[d]
2020	B12 mandate	Blending mandate (*fuel distributors*)	Mandatory B12 comes into force.

[a]Law 11.097/2005; [b]MAPA (2006); [c]MDA (2009); [d]Magossi (2012); [e]Ordinance N.144, of 22nd July 2019

Table 5.5 Rationales for biofuel policies in Brazil

Rationale	Specific interests	Period of relevance
National energy security[a]	Reduction in imports of oil and oil derivates Diversification of the energy mix[b]	From the 1930s to the present
Economic growth[c]	Expansion of domestic biofuel markets Foreign exchange earnings from biofuel exports	From the 1970s, though exports have become relevant only since the 2000s
Social inclusion[d]	Smallholder integration in biodiesel production chains	From 2004 to 2016; only residual afterward
Atmospheric benefits[e]	Climate change mitigation and reduction of urban air pollution by replacing fossil fuels, particularly in the transport sector	From the 2000s; more systematically since 2018 with *RenovaBio*
Geopolitical power[f]	Legitimacy from the international recognition of Brazil's expertise and experience with "clean" technology in the strategic area of energy Further authority in global governance (energy, environment, trade, agriculture) Greater relevance in global trade, taking over some of the influence of oil exporters Closer relations with like-minded countries Ultimately, a permanent seat at the UN Security Council	From the 2000s, mainly 2004–2010. Political entrepreneurship on the international stage has significantly reduced since then, but these geopolitical elements arguably continue to be strategic, long-term goals

[a]Szmrecsányi and Moreira (1991) and MAPA (2006); [b]Different energy sources are subject to different supply determinants, types of price volatility, and impacts that could compromise availability; [c]Szmrecsányi and Moreira (1991) and Hall et al. (2009); [d]MDA (2009); [e]MAPA (2006) and Goldemberg et al. (2008); [f]Dauvergne and Farias (2013); see Bastos Lima (2012)

Second, through the creation of Petrobras Biofuels, the government began to engage directly with biofuel production, a degree of government-controlled vertical integration that had not happened before in the sector. Third, the government started to increasingly shape the bioeconomy by determining *how* biofuels should be produced, through a growing number of social and ecological requirements. Clear examples have been the incorporation of smallholders to reduce social exclusion, the stricter prohibitions on forced labor, and the phasing out of sugarcane field burning—all these century-old problems which the private sector had never tackled voluntarily, and which previous governments had not bothered to sufficiently address until the emergence of an environmentally scrutinized bioeconomy. Finally, the state started taking increasing advantage of its position as the leading financier of biofuels to impose conditions for credit, as seen in the sugarcane zoning policy and the Social Fuel Seal.

Even if, in recent years, large agricultural interest groups have prevailed in loosening restrictions, on the whole the Brazilian bioeconomy—and particularly its biofuel sectors—provide a good illustration of a "return of the state" to the fore, after a period dominated by neoliberal policies of deregulation and privatization in the 1990s. Non-state actors surely lobby for biofuel production and other nascent bioeconomy sectors behind the scenes, but mainly through the medium of public policies. This practice in itself does not conflict with the observation that (domestic) public institutions have been the key *sine qua non* cause of biofuel expansion in Brazil.

5.2 Allocation and Access: Analyzing Institutional Performance

5.2.1 Allocation Patterns: Who Owns, Does, and Gets What

Brazil remains one of the most unequal countries in the world, and Latin America is the most unequal region of the globe (UNDP 2019). Despite reductions in economic inequality due to social inclusion policies in the 2000s, in Brazil the wealthiest 10% of the population still get as much as 55% of the country's total income (UNDP 2019, p. 107). Its Gini coefficient[14] on income remained as high as 0.53 on average between 2010 and 2017 (UNDP 2019).[15] The index on land ownership inequality reached 0.87 in 2018, worsening from 0.85 in 2009 (IBGE 2009; Oxfam 2019). The 2017 rural census showed that family farming constituted 77% of Brazil's approximately 5 million rural properties but occupied only 23% of the farmland. In turn, large-scale agribusiness held 77% of the farmland—a gradually decreasing number of

[14]For a comparison, the coefficient for income inequality in most African countries is below 0.50, and as low as 0.25–0.30 in Northern Europe (UNDP 2019).

[15]This was already a decrease from 0.59 in 1998 (Lustig et al. 2013).

ever-larger, consolidated farms (IBGE 2019). Yet, the latest data show that family farming provides for 70% of all the food consumed in Brazil and 74% of all rural jobs, employing on average 15 persons per hectare, against 1.7 persons per hectare in large agribusiness. Moreover, the former has created twice as much economic value per hectare than the latter (IBGE 2009).

Biofuels and other bioeconomy value chains have therefore entered a very skewed agricultural sector. Policy incentives have targeted and primarily benefited the agribusiness minority. Large-scale farms—often vertically integrated and owned by the industry itself—control 75% of all ethanol production in São Paulo state, the center of Brazil's sugarcane agroindustry (Goldemberg et al. 2008). This proportion is even more significant in Brazil's Northeast, where traditional structures of large landlord ownership are even more prevalent (Hall et al. 2009). As such, smallholder participation is considerably limited. Smallholders at sugarcane expansion frontiers usually sell their lands and move to a city, increasing land ownership concentration (see Novo et al. 2010 for the case of small dairy farmers in São Paulo state). Experiences are demonstrating the feasibility of small-scale distilleries and local ethanol utilization in some parts of the country. Still, these usually face financial, technological, infrastructural, and organizational limitations, and they have poor market access. Biofuels cannot be sold in Brazil without verification of technical standards, but meeting these standards incurs technology and transaction costs that small-scale producers have difficulties to afford (Moreno and Ortiz 2007). Consequently, small- or medium-size sugarcane growers are usually bound to sell their produce to processing mills controlled by large landowners or agribusiness companies who possess the necessary resources and capacities (see Hall et al. 2009; Gomes et al. 2010a). These private industries, therefore, capture all value-added stages of production.

Meanwhile, there is an increasing ownership concentration of crop genetic resources. Although much of the feedstock plant breeding and processing technology was developed with public funds since the 1960s, the recent spike in acquisitions from multinationals has shown an increasing transfer of control to international private capital. Consequently, profits are likely to become less "socialized," and access to those technologies becomes more restricted even though their base was built on taxpayers' money. This social equity issue applies to genetically modified soy and corn feedstocks widely used in Brazil as much as to sugarcane.

Advocates of the sugarcane-ethanol sector argue that there are substantial social benefits in employing hundreds of thousands of sugarcane cutters for manual harvesting every year (Goldemberg et al. 2008). However, mechanization is rapidly reducing that form of employment in some regions, and indeed an examination of the quality of those jobs quickly reveals their insecurity and health-degrading work conditions (Novaes 2007; Gomes et al. 2010a; Rocha et al. 2010). Cases of cheating on workers' payment per productivity are also common and a source of conflict

(Biondi et al. 2009). By employing primarily seasonal migrants, the sector exacerbates household disintegration, too.[16] The current transition towards mechanized harvesting has improved on these social impacts, but at the cost of consolidating the sugarcane sector's socially exclusive structure. Although many manual cutters have sometimes been trained for more skilled jobs (Jank 2011), it is clear that only a small minority is being absorbed. The larger unskilled and illiterate mass is simply being excluded from the sector.

Brazil has tried to fill these social gaps through its biodiesel policy by allocating additional economic benefits to industries that integrate smallholders. Engaging with smallholders incur further burdens and risks such as the provision of technical assistance, the need to source in smaller amounts from a larger number of suppliers, and dealing with partners who may not be used to business contracts. These were burdens the private sector seemed unwilling to take, triggering the creation of Petrobras Biofuels and its insertion in this market to save the government's agenda. Smallholder integration then quadrupled between 2008 and 2010 to more than 100.000 households (Gomes et al. 2010c).

Although this inclusion of smallholders would later erode due to Brazil's governmental changes, it is useful to analyze the experience and lessons therein. It was clear that, notwithstanding some poverty reduction benefits, allocation of control and of roles in those contracts remained skewed in favor of the industry. First, most arrangements have been made under monopsony conditions, i.e., with many potential sellers but only one buyer available, giving the latter disproportional leverage over price and negotiation terms. The disadvantageous terms smallholders initially got were crucial for the 2009 policy change requiring contract validation by a representative social movement. Second, while the industry benefits from value-added and can choose among different downstream markets (e.g., castor oil sold by Petrobras to the more profitable oleochemical market rather than for fuel), smallholders are limited to the condition of mere raw-material suppliers.[17] As a Brazilian professor describes the arrangement: "If everything works out, the farmer will live his whole life receiving a minimum salary for the crop he supplies, while Petrobras pockets the big money" (Personal interview). Finally, there has usually been an imposition of "improved" seeds that dismisses local varieties, even though the former's superiority has been questioned (Kilham et al. 2010; see also Altieri and Toledo 2011). Usually, those seeds come as a package together with fertilizer and pesticide inputs, to the dissatisfaction of many smallholders as it can easily create a form of dependence and undermine traditional knowledge, resources and local approaches sometimes based on organic agriculture (Wagenaar 2009; Kilham et al. 2010).

[16] Such seasonal migrants normally stay away for the largest part of the year. In Brazil, the wives left behind become known as "widows of living husbands" (Biondi et al. 2009). See also Hall et al. (2009) and Gomes et al. (2010a).

[17] In the particular case of Petrobras, it benefits twice from biodiesel production, not only from this market in itself, but also from reducing diesel imports. It has been estimated that the Brazil's 5% biodiesel blending saves Petrobras USD 1.4 billion per year in foreign exchange (Gomes et al. 2010c).

These biofuel production strategies thus reveal a profound imbalance in the allocation of power, roles, benefits, and burdens in the emerging bioeconomy. While control and value-added are retained mainly by private agribusiness—and previously also Petrobras, a company of mixed capital—the rural poor have been allocated at most with only the least valuable roles, with hardly any control, and minimal gains. In fact, their situation of need has often been exploited, as in the case of cheap degrading labor in sugarcane cutting. This shortage of societal benefit is even though most investments over the years in agriculture and much of the sector's financing have been public.[18] It is, however, the larger agroindustry that gets, in addition to those investments and credit, a whole new market of sizeable elastic demand, plus higher profits from increased sugar, corn, or vegetable oil prices.

5.2.2 Access to Resources: Land, Water, Food and Energy

Access to land, water, energy and food are all pressing issues that have often led to social conflict in Brazil. There are millions of landless rural workers in Brazil, while 1% of all rural properties amass as much as half of the vast country's farmland (IBGE 2019). More than four million Brazilians lack access to safe drinking water (WHO/UNICEF 2019), 400 thousand lack access to modern energy services (IEA 2019), and 13 million are undernourished (FAO 2019). Land and water, in particular, have been significant sources of conflict in rural areas. Annually there were on average over 1000 land conflicts in Brazil between 2003 and 2019, some persisting year on year. There was also a noticeable increase in water conflicts, from 87 recorded in 2010 to 489 in 2019. Overall, such conflicts resulted in 411 murders between 2010 and 2019, plus other adverse impacts on many thousands. Most cases have involved large landowners and private agribusiness, systematically at the expense of indigenous peoples and the rural poor (CPT 2020).

The surge of ethanol markets in the 2000s saw the doubling of the sugarcane area in Brazil. It expanded from 4.82 Mha in 2000 to 8.92 Mha in 2008, after being fairly stable since the late 1980s (MAPA 2013). That expansion had two significant implications on access to land. First, ownership and control over land became further consolidated, as small farms at the sugarcane frontiers were either bought out or turned into contracted sugarcane suppliers. This pressure increased, for instance, on small dairy farms in São Paulo state (Novo et al. 2010). Second, it raised opportunity costs and increased disputes between sugarcane farmers and indigenous peoples in frontier regions. Most notably, sugarcane expansion has inflamed conflicts with the Guarani-Kaiowá indigenous people in Mato Grosso do Sul State, hindering their legal access to land and aggravating violence (see CPT 2013). Due to limited investments, the sugarcane area remained more or less stable at 8.5–10 Mha between 2010 and

[18] For the 2012/2013 harvest, the government made available R$115.2 billion (about USD 57 billion) in public credit to private agribusiness. For a comparison, public credit available to all family farming is at R$18 billion (about USD 8.9 billion) (MAPA 2012b).

2020. Still, this period of stability might again find a new boon of expansion as more sugarcane uses for the bioeconomy become commercial.

Agribusiness has also been claiming growing amounts of freshwater. Even though most feedstock crops in Brazil are rain-fed, many producers have adopted irrigation to increase yields (Takahashi and Ortega 2010). Both sugarcane and soy crops have frequently enjoyed such supplemental irrigation (EPE 2008, p. 639). In soy's case, it includes river and groundwater withdrawals in water-insecure regions that experienced shortages and social unrest due to lost access (Bastos Lima and Persson 2020). Also, pesticide use and wastewater discharges have increased alongside the expansion in the cultivated area. Biondi et al. (2009) noted that pesticide use in sugarcane cultivation increased by nearly 70% between 2004 and 2008, the years of the ethanol boom. Moreover, for each liter of sugarcane-ethanol produced, there are on average 13 L of acidic *vinasse* wastewater to dispose of (da Cruz et al. 2008). Although sugarcane-ethanol advocates have marketed this as a closed-cycle natural fertilizer (see Goldemberg et al. 2008), there is evidence that irregular and excessive applications have become a source of groundwater contamination (da Cruz et al. 2008). Meanwhile, local populations have suffered immensely from pesticide contamination in areas where soy and corn (which are usually intercropped) expand (Russo Lopes et al. 2021).

Impacts on access to food have been ambivalent, and there is a distinction to be made between the macro and micro levels. At the macro level, there is already a consensus that biofuels help drive agricultural commodity prices up (see Chap. 2), though this effect seems comparatively small in the Brazilian case. Brazil does not significantly rely on staple crops for fuel, and the food resources it uses (mainly vegetable oil and sugar juice) have abundant supplies. In the case of biodiesel, current and foreseen blends in the short term (12–15%) do not seem to pose a food insecurity issue. Still, it is unclear whether that might change if the blending mandate increases 20% as some in the sector want, or if soybean oil finds further bioeconomy utilizations in the future.

Another food security concern is the gradual replacement of smallholder family farming with ever more consolidated industrial monocultures. Family farming in Brazil provides the largest quantity and variety of foods eaten in the country; therefore, a bioeconomy expansion based on a handful of industrial monocultures can impoverish national food security over time (see Bastos Lima 2008; IBGE 2009). At the local level, too, transitions from mixed farming to feedstock cash-cropping have created major food insecurity issues. Notably, when companies abandoned contracted smallholders, they left them with crops farmers could not eat and could hardly sell (see César and Batalha 2010; Gomes et al. 2010b). The policy changes of 2008/2009 and the insertion of Petrobras in the sector improved the outcomes significantly; in 2010, the industry spent BRL 1.2 billion (about USD 600 million at the time) on smallholders growing feedstock, generating an additional income that could enhance local food security (Gomes et al. 2010c). Such mixed results suggest that impacts on local access to food vary substantially depending on the institutions in place. Yet, some in Brazil have been critical of contract farming as a model. As an interviewed analyst puts it,

> For the small farmer, it is like becoming an employee of the industry, but without job security. Although the contract ensures him an income for some time, upon any economic downturn he is the first to be discarded. Then what will he do? He can't just go back to traditional farming that easily after having turned his land into a sugarcane monoculture. (Personal interview)

Finally, although biofuels have much potential to improve access to clean energy in rural and forest areas using local resources (Cunha et al. 2007; Kuik et al. 2011), the Brazilian policy all along has been to use them primarily in the mainstream fuel market, i.e., as an additional offer directed mostly at urban drivers. In other words, biofuels have been used mainly by those who already had access to modern energy. Motorists thus benefit from more fuel options, potentially allowing them to spend less on driving and reducing the costs of goods transported by road. This focus is, of course, advantageous to the automobile industry, too, as indicated by its record sales of flex-fuel cars in Brazil (Gomes et al. 2010a). Meanwhile, to improve rural electrification rates, Brazilian governments of all political hues have systematically preferred to expand centralized grids, such as through the national program *Luz para Todos* ("Light for All"), rather than investing in rural industrialization and local biofuel use.

5.3 Agency in Biofuel Governance in Brazil

5.3.1 Main Coalitions and Their Policy Beliefs

Two main coalitions can be identified in biofuel governance in Brazil: an *agribusiness* and an *agroecology* coalition. The former is dominant and comprises most of the government, in addition to fuel industries, sugarcane, soy and other private agribusinesses, and part of the scientific community. The agroecology coalition includes mainly civil society organizations (with stronger participation of smallholder and rural worker organizations than strictly environmental NGOs) and a more critical segment of the scientific community. Other actors such as urban dwellers and indigenous peoples are not particularly relevant agents in this governance context, even if they are affected by the biofuels and bioeconomy agenda.

Table 5.6 presents the two main coalitions' key policy-beliefs. It is useful to note that, in broad lines, the Brazilian government policy-beliefs regarding biofuels have not significantly changed despite changes of administration. They have maintained a clearly optimistic spirit, aligned with ecological modernization and dismissive of calls for structural change (Lima and Toni 2020). The table shows that there may be disagreements within a coalition, but usually at the (more superficial) level of secondary aspects. For example, the sugarcane agroindustry has long lobbied Brazilian governments to tax gasoline more heavily to make ethanol more competitive (Jank 2011), but generally without success. Similarly, more radical actors in the agroecology coalition have disagreed with those who believe that smallholders'

Table 5.6 Main agents, coalitions, and policy-related beliefs on biofuels in Brazil

Main agents and coalitions	Policy-core beliefs	Secondary aspects
Government	• Biofuels can and should replace fossil fuels on a large scale, but without structural changes in fuel distribution and consumption patterns • Brazil should promote biofuels in other developing countries to establish them as global commodities and become a major exporter. The unilateral imposition of sustainability requirements by importers is unjustified "green" protectionism • Brazilian biofuels cause no food vs. fuel conflict. Biofuel crops can expand over abundant pasturelands alongside cattle ranching intensification without aggravating deforestation • Biofuel production supports development and reduces poverty by creating jobs and income for smallholders and rural workers	• ~~Castor bean is capable of producing well without inputs.~~ (Revised: Provide chemical inputs and technical assistance) • ~~Integration in biodiesel chains will be good to smallholders by default~~ (Revised: Have representative social movements ensuring fair contracts) • ~~Smallholders should shift to castor bean monocultures~~ (Revised: Add castor to mixed farming)
Private agribusiness		• ~~Sugarcane ethanol can compete easily with gasoline~~. (Revised: The government should tax gasoline more)
Fuel industry		• The biodiesel blending mandate should increase to 20% and beyond
Scientific community		• Large-scale production of sugarcane-ethanol and soybean-biodiesel reduces GHG emissions and is therefore sustainable. "Best practices" such as no-till farming can sufficiently minimize other environmental issues
Scientific community	• Agriculture should be based on agroecological and food sovereignty principles (i.e., avoiding patented seeds and chemical-input use, increasing agrobiodiversity and local nutrient cycling, and ensuring local communities' rights to decide how their resources will be used and to prioritize their own needs first, thus building resilience from external decisions, food price volatility, etc.) • Policies should ensure participation and empowerment of the rural poor, helping them climb up to value-added stages of production, with locally owned rural industrialization	• Conventional biofuel production may reduce GHG emissions but poses other ecological and social problems • Smallholder integration in biofuel chains is good but insufficient. Adopt agroecological principles, enhance local capacity, and gradually allocate better roles and more control to the rural poor
Minority within the government		
NGOs and rural social movements (moderate critics)		
NGOs and rural social movements (strong critics)		• A radical rural transformation towards agroecology and food sovereignty is needed. Smallholder integration has been a form of co-optation and of legitimizing unsustainable agribusiness • Biofuel production can be acceptable if done for local consumption

NB: Gray areas represent different coalitions; crossed-out text under *secondary aspects* indicates former beliefs replaced

inclusion in industry-controlled value chains can be positive, even if insufficient. Policy-core beliefs, however, clearly set the two coalitions apart.

5.3.2 Strategic Uses of Power

Both coalitions have used various advocacy resources and forms of power to pursue their beliefs in biofuel governance. The agribusiness coalition has primarily relied on financial resources and members in positions of legal authority to influence policy-making—which is characteristic of dominant coalitions (see Sabatier and Weible 2007). This ability has allowed it to widely advance its development agenda while excluding non-member actors. In practice, the government promotes agribusiness through enabling policies and public financing, while the private sector uses its material capabilities such as technology and financial resources to produce biofuels. In turn, supportive scientists use information as an advocacy resource to further promote and legitimize the agribusiness approach, while they are favored with public and private funding. This collaboration works both domestically and internationally, as all three—agribusiness, scientists, and government actors—have actively helped promote Brazilian ethanol abroad and, consequently, the other two's competence. It reveals a degree of "symbiotic interdependence," i.e., a situation in which different actors depend on each other to fulfill their beliefs and therefore become inclined to cooperate (Fenger and Klok 2001). While the sugarcane sector has systematically relied on public policies, the government needs the private agroindustry to advance its ethanol agenda. Finally, scientists strengthen the coalition's technology resources (through biofuels R&D), add legitimacy, and increase public acceptance. Such a relationship of interdependency leads to strong coordination, where all these agents are better off with the pursuit of their shared beliefs (Fenger and Klok 2001).

Internal coordination is less strong in the agroecology coalition, and its financial resources and access to positions of legal authority are much more limited—which may help explain its subordinate position (Weible 2006; Sabatier and Weible 2007). Coordination arises much more out of a common view and belief system than of functional interdependence. That said, there has been cooperation around pilot projects of small-scale biofuel production following agroecology and food sovereignty principles, usually led by NGOs or rural social movements (see Moreno and Ortiz 2007; Biondi et al. 2009). The approach has counted on increasing scientific information on productivity and sustainability (see IAASTD 2009; Altieri and Toledo 2011; Horlings and Marsden 2011), but this is yet to seep through to public opinion or policy circles.[19] Tellingly, the government, too, has showed its divided nature by publishing on family

[19]See Clapp (2009) for a general analysis on how mainstream actors have largely ignored the IAASTD report, an assessment by more than 400 experts which concludes that a shift towards agroecology is necessary to improve the sustainability of agriculture.

farming's economic importance and funding smallholder biofuel projects—even if to a comparatively smaller extent.[20]

It is worth noting the government's ambivalent position in biofuel policy disputes and how such a politically instituted bioeconomy agenda increased its power. Although all along it has aligned mostly with large agroindustries, the government has had branches sharing the agroecology coalition's views, particularly on social inclusion. This ambivalence became most evident when Brazil had a Ministry of Agrarian Development distinct from the agribusiness-dominated Ministry of Agriculture during the Workers' Party administrations (2003–2016). It explains why the government pushed for the inclusion of smallholders in biodiesel production chains even though that was not in the agribusiness coalition's overall interest. It was, instead, a demand of the agroecology coalition members that filtered through the government.

The government's power grew as it became a major financier of the biofuels sector through the BNDES development bank. Similarly, it became an active player in setting a regulatory framework, best illustrated by private companies' near-obligation to obtain a Social Fuel Seal and other sustainability requirements such as the sugarcane zoning. Such a powerful position allowed the government to pose further demands and effectively lead the agribusiness coalition, according to its own policy-beliefs. That was particularly the case throughout the Workers' Party administrations (2003–2016), most notably during Lula da Silva's second term (2007–2010). However, it gradually waned afterward as economic and political crises engulfed the country from 2015 on. Eventually, the agroecology coalition's supportive minority within the government would be largely squeezed out as President Temer took power in 2016, with support to smallholders virtually disappearing later on under the Bolsonaro administration.

The agroecology coalition, in an increasingly subordinate position, historically has extensively relied on "mobilizable troops" (see Weible 2006). That refers to marches, protests, and land invasions by smallholders and (often landless) rural workers. It has been used both as policy advocacy[21] and as direct attempts to destabilize and gain ground from the agribusiness coalition.[22] The invasion and occupation of private farms is a legal imbroglio in Brazil because although the law safeguards individual property rights, it also establishes that land must fulfill a "social function" or be taken by the state for land reform (upon financial compensation). This social function has specific criteria, such as the absence of bonded labor and minimum

[20]Government data shows that family farming creates higher economic value per hectare than industrial monocultures in Brazil: on average BRL 677 (~USD 338) against BRL 368 (~USD 184) per hectare (IBGE 2009).

[21]Perhaps most notably, in 2011, the first year of Dilma Rousseff's administration (she being Brazil's first female head of state), female smallholders used a Women's Day march and encounter with the president as a window of opportunity to demand a national policy on agroecology as their number one request. The president acquiesced, and a National Policy of Agroecology and Organic Production was launched in August 2012.

[22]There were 200 land invasions in 2011, almost half of them in the so-called "Red April", which social movements organize every year (MDA 2011).

productivity levels, which governments have not revised since 1975 (Ferreira et al. 2008). The agroecology coalition, therefore, claims this law is not being implemented. The agribusiness coalition, in turn, benefits from the leniency and regular support of the judiciary—showing another instance of structural power (Gomes et al. 2010a; CPT 2013). Sometimes, this coalition resorts to instrumental power in the form of violence by murdering community leaders or environmental activists, as in the notorious case of Chico Mendes in 1988 or the hundreds assassinated in rural conflicts.

All these actions are underpinned by contrasting discourses from the two coalitions. The agribusiness coalition has portrayed industrial biofuels as sustainable and beneficial to national interests, emphasizing contributions to economic growth and to Brazil's competitiveness in the international market.[23] Agribusiness efforts on various social and political levels to attach its agenda to Brazil's national (self)image is nothing new; this tactic dates as far back as at least the 1930s, with the promotion of banana production and exports as a reason for national pride (see Rabelo 2018). The bioeconomy has been embraced under an old practice and being only the newest element or facet in a long-established advocacy repertoire.

In its latest incarnation, at least nominally embracing sustainability concerns, the agribusiness coalition also tactically focuses on CO_2 emissions instead of total greenhouse gas emissions or the environment as a whole. Agriculture and livestock farming emit more greenhouse gases than Brazil's entire energy sector—without even taking land-use change (i.e., deforestation) emissions into account (Angelo and Rittl 2019). That is also in addition to causing other environmental issues such as agrobiodiversity loss and widespread pesticide contamination. However, by focusing only on CO_2, transport emissions appear more relevant and thus more important to tackle.

Overall, the agribusiness coalition labels its adversaries as ideology-driven, out of tune with the market, and incapable of fulfilling Brazil's development needs. It has also framed land invasions as criminal actions against private property. In turn, the agroecology coalition also highlights national sovereignty interests, but from a bottom-up, grassroots perspective. This framing is captured, for instance, by peasant movements' coining of the term *Alimergia*—an abbreviation that combines food, environment, and energy—as a banner for locally controlled biofuels development within a smallholder agriculture framework (Patino et al. 2019). Such critics have contended that the dominant, mainstream biofuel production is unsustainable, primarily serves the vested interests of Brazilian elites and multinational corporations, and robs the poor of their access to resources (Mendonça 2009). Table 5.7

[23] On this, Marcos Jank, then president of the Sugarcane Industry Union (UNICA), argued that Brazil's forest code was an "anachronic piece of legislation" that could "compromise 3.7 million hectares of fertile land in São Paulo state and lead to R$5.6 million [USD 2.7 million] of annual revenues loss" (Gomes et al. 2010a, p. 24). The economicist perspective is clear, and so is the provocative nationalistic appeal used as a persuasion line. He continues: "[It is] sad to see an anachronic legislation with such a capacity to transfer income, revenues and jobs to other countries, who will certainly love this surprising modality of self-flagellation we are imposing on ourselves" (Gomes et al. 2010a, p. 24). See also Jank (2011).

Table 5.7 Features of the dispute between the agribusiness and agroecology coalitions

	Agribusiness coalition	Agroecology coalition
Key underlying interests	Economic growth; Domestic and international market shares	Agroecology; Social justice; Food sovereignty
Main advocacy resources used	Financial resources; Access to positions of legal authority; Information	Mobilizable troops; Information
Persuasion strategies	Appeals to national pride and a sense of international competition (e.g., Brazil to become a "green" global leader)	Appeals to ideas of social inclusion, conservation, and sovereignty from foreign capital and its volatility
Persuasion tools	Economic indexes (e.g., contribution of agriculture to a growing GDP, to exports); Biofuel production and consumption numbers; CO_2 emissions reduction from fossil fuel replacement in transportation	Equality indexes (e.g., Gini coefficient on wealth and land distribution); Comparisons between small- and large-scale farming in terms of employment creation, biodiversity, and contribution to food security
Strategies to undermine the opponent's arguments and actions	Focus of private property rights and criminalization of social movements	Land invasions, evoking the "social function" that by law lands must fulfill; Dissemination of information on the social and ecological impacts of large-scale agriculture
Framing of the opponent	Retrograde, anachronic, ideology-driven, incapable of fulfilling Brazil's development needs	Self-interested, socially unjust and environmentally degrading

synthesizes these discursive confrontations related to Brazil's biofuels—and broader bioeconomy—policy agenda.

5.4 Conclusions

5.4.1 Key Insights

Despite being a megadiverse country, Brazil's bioeconomy has, in reality, been highly tied to a few conventional agroindustrial complexes (e.g., sugarcane, soybean, beef). For only a period the agenda became linked to governmental support for small-scale family agriculture, and for the most part the country is yet to walk the talk on promoting novel, biodiversity-supporting value chains. Biofuels may have

provided substantive economic benefits to agribusiness and increased renewable energy supplies that support Brazil's energy independence and position in international climate negotiations; however, this prevailing bioeconomy agenda has also intensified environmental impacts from unsustainable chemical-intensive monocultures. Moreover, except for some minor poverty reduction achieved through the biodiesel program, biofuel production in Brazil has been grossly inequitable, with a skewed distribution of benefits and burdens. There are four conclusions as to why this development path has been taken and to its particular features.

First, Brazil's biofuel production patterns and, thus, the shape of its bioeconomy to date owe primarily to public policies and the particular policy instruments in place. A combination of regulatory and economic tools (e.g., blending mandates, fiscal incentives and credit to key agroindustries, public investments in biofuel R&D, production and storage infrastructure) has provided essential support for the private sector—and to a lesser extent the public as well, through Petrobras—to produce biofuels. In this context, international market demands seem to have worked only as a supplementary driver, given that the bulk of Brazil's biofuel production is domestically consumed. Those instruments are essentially not transformational, i.e., they do not seek a transition from business as usual. Instead, they build on pre-existing agroindustrial sectors, with all their virtues (e.g., efficiency, scale) and vices (e.g., unsustainable agricultural practices, social exclusion), even though for a while the government succeeded in addressing the latter to a small extent through key policy instruments such as the sugarcane zoning to avoid deforestation and, perhaps most crucially, the social certification scheme to encourage smallholder integration in biodiesel chains. Such changes over the years illustrate what this chapter's assessment shows: that Brazil's public policy instruments have not only promoted but also steered the biofuel sector.

Second, behind these policy instruments, there are—sometimes synergistic, sometimes conflictive—fundamental guiding norms and interests that shape the emerging bioeconomy. On the one hand, there is a clear interest in using biofuels to boost economic growth, exports, and Brazil's international status as a rising power in global governance. On the other hand, there has been a normative underpinning—expressed in the biodiesel policy—requiring development to be socially inclusive and help reduce poverty in the country. However, the two imperatives are not that easily reconcilable. Brazil's most efficient biofuel production systems are highly inequitable, while the most inclusive ones are small in scale and could hardly meet the country's economic and geopolitical ambitions. The solution has usually been to have them in parallel, rather than trying to transform one or the other. Gradually, though, social concerns are being removed from the bioeconomy agenda as even the socially oriented policy instruments are modified to accommodate soy farmers. There is also an understanding that biofuels should be environmentally friendly, a normative underpinning that is mostly absent in other agriculture. It explains, for instance, why only feedstock crops received zoning policies even though they are not the main drivers of deforestation or land-use change in Brazil. Critically, however, this environmental norm has had a narrow focus limited mostly to climate change and rainforest protection only. Other ecological issues, such as agrobiodiversity loss and chemical-input use in agriculture, are systematically overlooked.

Third, the cause of those policies and dominant norms is to be found in agency. Although there is a coalition of contenders (smallholder movements, socio-environmental NGOs, and more critical scientists) advancing an approach based on agroecology, food sovereignty and social justice, an agribusiness coalition dominates Brazil's biofuels agenda. This dominant coalition has had a conveniently narrower view on sustainability, which coincidentally matches the key environmental concerns in export markets such as Europe (see Bastos Lima and Persson 2020). It is not interested in structural changes or power shifts—only at the international level. Using a combination of instrumental, structural, and discursive powers, this coalition has systematically succeeded in translating its policy-beliefs into the institutions that now guide Brazilian biofuel production and its bioeconomy agenda. Perhaps, the one exception is the Social Fuel Seal, which emerged due to pressure from the agroecology coalition. Now that this coalition's power waned, Brazil's biodiesel sector has been voided of its original poverty-reduction function.

Finally, a more systemic cause for the present shape of Brazil's bioeconomy agenda can be found in the distributive outcomes and social impacts of its production systems. By benefiting agribusiness disproportionately, dominant biomass production systems have increased their advocates' material capabilities, helped them reinforce their discursive power over civil society, and tightened their grip on public institutions. Meanwhile, critics and adversaries such as those in the agroecology coalition lose legitimacy, political space, and opportunities to advance their beliefs. As such, Brazil finds itself in a vicious cycle, like a power spiral where the prevailing systems of biofuel and other bio-based production reinforce the status quo, preventing any significant changes in the agenda (see Fig. 5.3). "Locked" as it is in this biofuel and bioeconomy development path, Brazil may well achieve its economic, geopolitical, and energy-related goals, but at the expense of the environment and of its society as a whole, who will continue experiencing the consequences of poverty and inequity.

5.4.2 Alternatives

More sustainable outcomes would require some key changes in Brazil's current biofuel policies and broader rural development strategy. Notably, ethanol production can be made far more equitable and socially inclusive. As a start, it could incorporate smallholders under similar requirements to those applied in biodiesel chains for social certification. However, for more significant results on poverty reduction and equitable rural development, smallholder integration in bio-based chains would need to foresee a second phase with feedstock-supplier cooperatives climbing up to value-added stages, such as ethanol distilling or vegetable oil extraction, and keeping co-products for sales or local use (e.g., as organic fertilizer or livestock feed). Smallholders could also be capacitated for local energy use or further vegetable oil processing into biodiesel, aviation biofuels or biomaterials, and to use co-products such as glycerin (e.g., in soap manufacturing).

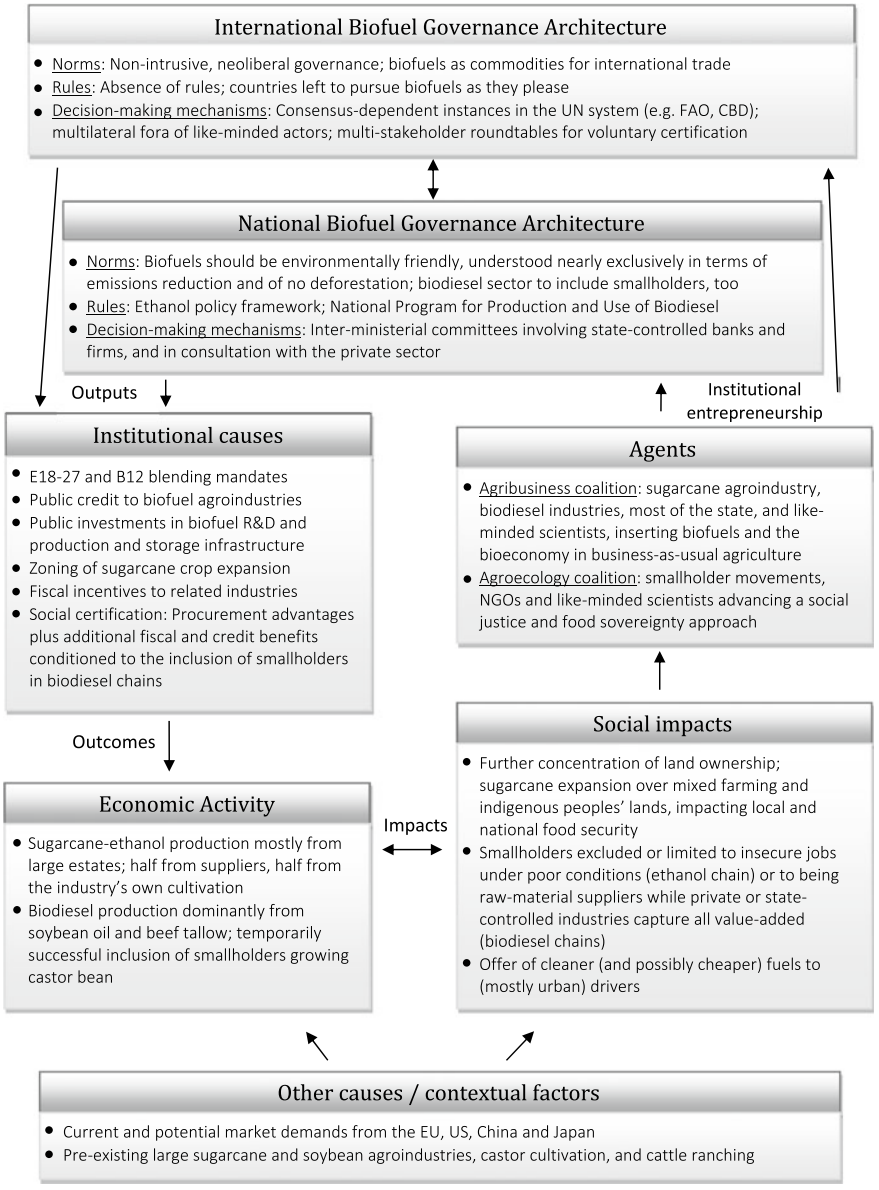

Fig. 5.3 Analyzing institutional, social and political dimensions of biofuels in Brazil

For that, the state could further its position as the leading financier of biofuels and put additional conditions on the incentives it gives. The same approach could also be used to make agricultural practices more sustainable (e.g., better water management practices, reduced chemical-input use), besides more stringent land-use and pesticide regulations. Furthermore, investment in agricultural R&D—which is mainly public through the EMBRAPA national company—would need to focus increasingly on value-adding technologies rather than primarily on crop productivity. Smallholders, in particular, would benefit from further investments in rural infrastructure, agricultural and biofuel-making technologies suitable to their contexts and scale. They would also greatly benefit from organizational capacity building (e.g., helping form cooperatives) and additional technical assistance—with proper monitoring and evaluation—to improve the use of those resources.

Finally, bioeconomy governance would be more equitable and likely facilitate the policy changes above if it included key stakeholders such as national smallholder and peasant organizations. That is not only locally at contract negotiation but also in decision-making and designing bio-based value chains—a space routinely granted to private agroindustries. However, any of these changes require either a change of beliefs within the dominant agribusiness coalition or more effective agency from the agroecology coalition. The former may realize that a better sustainability profile can effectively improve Brazil's position in global trade and environmental negotiations, as well as penetration in more demanding markets such as Europe. In turn, the contenders may need to show how agroecological development can help meet Brazil's economic and geopolitical ambitions, or it will just continue to be regarded as a niche or as a utopia.

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