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How biofuel policies backfire: Misguided goals, inefficient mechanisms, and political-ecological blind spots☆

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ABSTRACT

The development of an economically viable biofuel industry rests on strong state subsidies for production and processing, creation of markets through government procurement, fuel-blending mandates, price controls, as well as foreign trade tariffs and quotas, and multiple interventions in agricultural, ecological, and other regulations. We use an approach grounded in agrarian political economy to critically analyze the literature on how biofuel policies interact with broader production, trade, and agro-ecological processes. We focus on policies involving the most prominent crops in the places where biofuel production has advanced the most (i.e. USA, Brazil, and the EU), but also extend analysis to their relations with broader transformations in production, commercial, and even governance practices around the world. We investigate the political and economic interests driving biofuel policies, and how these set the terms in which state interventions and policies are conceived and implemented. We find that these are not developed and implemented according to environmental or inclusive pro-poor development purposes, but according to state interests in energy security and its intersection with a tense alliance between corporate sectors, rendering many policy mechanisms ineffective or even outright counterproductive to effectively facilitate more socially and environmentally sustainable energy production and agricultural practices.

1. Introduction

Biofuel[1] policies have been controversially discussed worldwide during the last decade. How biofuels transform the agricultural market, if they can become profitable, and how much land would be necessary to achieve the different blending targets set by various countries have been major points of concern (OECD, 2006). Their environmental and social costs and benefits have also been under scrutiny (FAO, 2013). Previous research has surveyed the policies that have fostered the expansion of the biofuel economy around the world (Sorda et al., 2010), and overviewed how (in)effective biofuel policies have been at climate mitigation (Fargione et al., 2008; Searchinger et al., 2008), and attending the further expectations of fostering energy security, driving rural development, enhancing food security, and even rehabilitating degraded lands (Hunsberger and German, this volume; Ekener-Petersen et al., 2014). Also, non-state forms of regulation through certifications and other market mechanisms have been reexamined (Reinier et al., this volume). Here we argue that biofuel policies must be understood in their historical and socio-economic context, as the state-economy relations in which they are embedded determine how they are conceived and implemented. This central role of the state evokes the need and possibility for multiple interests and discourses to structure biofuel production. Understanding the state as a contested terrain where different actors compete to uphold their interests (Sousa Santos, 1992), our purpose is to analyze how biofuel policies arise from and interact with broader production, trade, and agro-ecological processes in the major producer and consumer blocs of biofuels (USA, Brazil, and the EU) and how they condition the broader commercial, technological, and political landscape into which smaller states possibly integrate.

We find that biofuel policies in major producer and consumer blocs are not in fact developed and implemented according to environmental or inclusive pro-poor development purposes that currently serve as the main discourses promoting them, but rather according to a tense alliance between major corporate sectors – particularly agroindustrial traders and processors, petroleum extraction and refinery, and automotive industry – structured by state interests in energy security and its intersection with private interests in profit. Biofuel policies seek, then, to create markets and subsidize production/processing for increasing profits in domestic agro-energy sectors, even if they lock-

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[1] In the article, we refer to liquid first generation biofuels unless otherwise specified.

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in dependence on fossil fuels by sustaining automobile infrastructure with first generation biofuels (Smil, 2010a, 2010b; Oberling et al., 2012; Berti and Levidow, 2014) and agricultural practices marred by negative social and environmental effects (see discussion below). Ultimately, we argue that despite attempted improvements to both state and market-based governance mechanisms, it is not the optimization of policies and technologies that requires examination and political efforts (cf. Taheripour and Tyner, 2008; Tyner, 2013; Witcover et al., 2013; Vivanco et al., 2016). It is the underlying political economy of biofuel policy production itself, the corporate structure of the sector and its power through the state, that must be critically reexamined and radically transformed so that more sustainable and just practices can be conceived and implemented. Biofuel policies will only effectively facilitate more socially and environmentally sustainable energy production and agricultural practices when tied to land redistribution, customary rights protections, and stronger anti-trust, environmental, and labour protections that decentralize production and power.[2]

In order to identify the driving social forces behind biofuel policies and provide a basis for further and more detailed investigations on their implications, we use an approach grounded in agrarian political economy to critically analyze the literature. This approach requires an analysis into the social relations of production, reproduction, property, and power including the structures and relations of accumulation (Bernstein, 1992; White and Dasgupta, 2010). In other words, our analysis is guided by the questions: (i) who owns what (i.e. the social relations of property), (ii) who does what (i.e. the social division of labour), (iii) who gets what (i.e. surplus or wealth distribution), and (iv) what do they do with the surplus wealth that has been created (i.e. the social relations of consumption, reproduction, and accumulation) (Bernstein 2010: 22–23). Following Borras et al. (2011: 211), we further ask: "(v) what do they (note: social groups and classes) do to each other, and (vi) how are political changes shaped by dynamic ecologies, and vice versa?" (ibid). Using this framework, we analyze biofuel policies with regard to their implications for relations around land use and control, labour relations and conditions, and the structures of accumulation that they generate. The criteria we highlight in each section are derived from a combination of the principles on which biofuel policies were promoted in that particular context, and the specific aspects of those policies that backfire in their social, ecological, and political outcomes.

We first surveyed previous reviews and critiques of biofuel policies around the world, especially in the US, Brazil, the EU, in *Energy Policy* and other major journals on renewable energy and technology, agricultural economics, rural sociology, and geography. This yielded 45 articles published in the last decade, the majority since 2012. We then extended our research to the literature in agrarian political economy that we found most useful for analysis. This review methodology enables us to investigate the political and economic interests driving biofuel policies, and how these set the terms in which state interventions and policies are conceived and implemented. We argue that by continuing the expansion of capitalist industrial agriculture, biofuel policies have used justifications based in the crop's end use to increase agroindustry's control over land and labour, exacerbating forms of production that exclude the poor and exploit the environment. We trace these in the USA, Brazil, and the EU (Section 2), then evaluate their implications for an emerging global biofuel regime (Section 3), and conclude with a discussion of policy implications (Section 4).

[2] The key elements of our criteria for considering and evaluating biofuel policy are outlined in the introductory essay of this special issue (and also in German et al., 2016).

2. Biofuel policies and politics

2.1. USA

When the earliest automobiles were being developed, biodiesel, ethanol, and biofuel-gasoline blends were pervasive. Ford's Model T, for example, could be adjusted to run on ethanol, gasoline, or a "gasohol" blend that made it a truly flex-fuel vehicle. However, multiple factors during the early 20th century led to the predominance of gasoline use, including state policies that supported the expansion of the fossil fuel and automotive industry (Smil, 2010a), and with the discovery of the anti-knock properties of tetraethyl lead in 1921, ethanol-blends were largely abandoned as a fuel oxygenate (Solomon et al., 2007). The implications of this energy policy decision persist to this day, congealed into material infrastructures and the exorbitant power of the petroleum and automotive industries that dominated the policies and politics around biofuels in the USA until recently, when they have been joined by an increasingly assertive agroindustrial sector (Smil, 2010a; Mitchell, 2011). The shifting synergies and tensions between these sectors largely determine the goals, mechanisms, and priorities of US government policy on biofuels. After elucidating how the petroleum and automotive industries curtailed biofuel development, we retrace the historical emergence of agroindustrial interests that have largely (but not coherently) promoted biofuels.

Biodiesel and ethanol use was almost entirely repressed by the allied petroleum and automotive industries until the 1970s, when environmental restrictions on leaded gasoline and a perceived energy crisis reignited interest in ethanol use as a fuel oxygenate and volume extender (Solomon et al., 2007). Yet this intended use for biofuels meant it was not expected to replace but rather sustain the petroleum-based industry and existing automotive infrastructure (Smil, 2010a; Mitchell, 2011). Consequently, the policy mechanisms utilized – tax credits with loan and price guarantees for ethanol *blenders*, starting with the Energy Tax Act of 1978 – actually strengthened the power of the petroleum and automotive industries over the emerging biofuel economy (Smil, 2010a). This was reflected in the limited expansion of ethanol production *and infrastructure* during the 1980s, when petroleum prices stabilized at low levels. It is important to underscore ethanol infrastructure (not only agricultural feedstock production and biofuel processing facilities, but also flex-fuel engines that can operate on ethanol-gasoline blends, and the specialized distribution network to supply them), because it largely contained the early policy attempts to transform ethanol from a gasoline-additive to a true *alternative* to fossil fuels (ibid.; Mitchell, 2011). The Alternative Motor Fuels Act of 1988 and the Energy Policy Act of 1992, for example, provided auto companies with tax credits and exemptions from compliance with the Corporate Average Fuel Economy (CAFE) standards for vehicles that can run on E85 fuel (a blend of 85% ethanol and 15% gasoline), and created demand by requiring that certain government agencies renew their fleets with such vehicles (Solomon et al., 2007). But since only very few E85 fueling stations exist (mostly in the Midwest, and largely inexistent elsewhere in the USA), to this day the estimated five million such vehicles in the country operate primarily on gasoline alone, and the program is "frequently criticized as a mechanism for automakers to avoid CAFE requirements while being ineffective at supporting purchases of E85" (ibid.: 418).

It was only with increasing restrictions on unleaded fuel oxygenates (such as methyl tertiary butyl ether – MTBE), the emergence of a powerful agroindustrial lobby for corn-based ethanol production during the 1980s (when new markets were required to avert price collapse due to overproduction), and the rising petroleum prices at the turn of the 21st century that biofuel policies in the US began to shift away from the goals and mechanisms that explicitly and directly favour the petroleum and automotive industries (Solomon et al., 2007; Smil, 2010a). Concurrently, environmentalist concerns over greenhouse gas (GHG) emissions that developed during the 1990s have since become

an important discursive instrument to promote the biofuel economy, but the "strategic importance" of the agroindustrial sector and cheap fuel still result in government policies that prioritize security of supply and boosting agroindustrial profits over environmental or social concerns (Bailis and Baka, 2011; Hunsberger et al., 2014).

The long-term trend of agricultural commodity prices to decline, driven by policies that encourage overproduction to sustain low food prices domestically and leverage "food power" abroad (i.e. the use of food aid and exports to attain foreign policy goals), increasingly fostered the development of corn-based ethanol production as a goal of the agroindustrial sector alongside the federal and Midwestern state governments (Gillon, 2010; Friedmann and McMichael, 1989). Thus, ethanol production became yet another surplus reduction strategy, aligning agroindustrial profits with geopolitical and domestic state interests independent from the petroleum and automotive industries (Carolan, 2010). Just as significantly, corn-based ethanol became a powerful assemblage or combination of production practices and policies that subordinate farmers to agroindustries (Gillon, 2016). Tracing this political transformation is essential for understanding how the agroindustrial lobby was able to shape biofuel policies in the US early during the 21st century.

After the boom-and-bust cycles of expanding commercial agriculture in the US led to environmental and social catastrophe during the 1930s, most notably with the Dust Bowl on the high plains (Worster, 1982), New Deal policies were implemented to provide price-support mechanisms and loan guarantees to farmers that resulted in overproduction even while supporting soil conservation practices and limiting production on marginal lands. Post-war surpluses became chronic, and policies were implemented to subsidize grain exports and the integration of grain feed for concentrated livestock production. All this began to change during the 1970s, however, as policies shifted from supporting farmers to subsidizing the crops themselves with direct payments that enable prices to fall below production costs. This created massive windfall profits for agroindustrial processors and traders while farmers became dependent on these subsidies to remain operational (Guthman, 2011). Ethanol production emerged then as an instrument to sustain corn prices and allow farmers to capture a portion of agroindustrial profits through the establishment of cooperatively-owned refineries. In 1984, there were at least 163 such enterprises in operation, but the unfolding pro-industry reforms in farm subsidies resulted in a serious debt crisis for farmers, and a massive transfer of wealth to agroindustrial processors who increasingly shaped farm policy. By 1990, only 56 refineries remained, and the agroindustrial conglomerate Archer Daniels Midland (ADM) controlled 75% of the entire ethanol market in the US (Gillon, 2016). There was a brief attempt to "decouple" farmer and crop subsidies from the 1990s to the early 2000s, and a rebound of farmer-owned ethanol plants with the Small Ethanol Producer Tax Credit, resulting in 46% of ethanol refineries being locally or cooperatively owned in 2005 (ibid.; Guthman, 2011; Solomon et al., 2007). But movements toward a blending mandate and the establishment of new tax credits for agroindustrial processors transformed them into major vehicles for financial investment that in effect brokered an alliance between the petroleum/automotive industries and agroindustrial traders and processors (Gillon, 2016). Consequently, the proportion of farmer-owned refineries fell again to less than 23% after 2009, and the sector became once again concentrated in the hands of a few agroindustrial corporations (ibid.). Coupling the reinstatement of direct payments and the integration of biofuel-crops into the Conservation Reserve Program in 2002 (Guthman, 2011) with the restrictions on MTBE mentioned above, this assemblage of production practices and subsidies sealed Midwestern farmers and their communities into a powerful voting block that "now advocate[s] *with* industry on behalf of their commodity, rather than together, as a class, to take back value in commodity chains *from* industrial interests" (Gillon, 2016: 126, emphases in original, cf. Goodman et al., 1987; McConnel, 1953).

By the time tax incentives for biofuel production were strengthened (through the Volumetric Ethanol Exercise Tax Credit, VEETC, implemented in 2004) and the first blending mandate was established with the inclusion of Renewable Fuel Standards (RFS) in the Energy Policy Act of 2005, the goals and mechanisms of these policies were drafted primarily by the corn-based agroindustrial lobby,[3] dragging Midwestern farmers along and "forcing the hand" of the petroleum and automotive industries to adapt (Gillon, 2016; Smil, 2010a). Several major oil companies publicly recognized the contribution of fossil fuels to greenhouse gas emissions already in the late 1990s, but it was only in 2005 that Shell shifted from research and development (R & D) in a portfolio of renewable energy to a concrete biofuel production policy, and soon became the largest distributor of ethanol in the US (Oberling et al., 2012). The VEETC and RFS policies were followed by the Energy Independence and Security Act of 2007 and the Biomass Program of 2008, alongside increased grants and loan guarantees for R & D of all aspects of the biofuel economy, which sustained the momentum for a veritable ethanol boom in the US (Solomon et al., 2007; Sorda et al., 2010). It was only at this point that BP, ExxonMobil, Texaco, and other petroleum companies in the US launched meaningful efforts at R & D for first and second generation biofuels (Oberling et al., 2012). Their largest participation in biofuel production itself, however, has focused largely on joint ventures with Brazilian agroindustrial conglomerates rather than US ethanol producers (Oberling et al., 2012).

Following the oscillation of ethanol production between 0.8 and 1.4 billion gallons during the 1990s, it jumped to 3.4 billion gallons in 2004, and then mushroomed to 14.8 billion gallons in 2015 (RFA, 2009). Nominally, the fundamental motivation for these policies are the reduction of GHG emissions and dependence on foreign oil – but the contestation over the scientific parameters of the original RFS and its renewal demonstrate otherwise (Bailis and Baka, 2011; Smil, 2010b). When it was first introduced, the RFS disallowed both corn-based ethanol and soy-based biodiesel because projected indirect land-use change (ILUC) impacts caused GHG emissions to exceed the threshold set by the US Environmental Protection Agency (EPA). This was hailed by environmentalists, and rabidly contested by the agroindustrial lobby and Midwestern congressional representatives. The latter pressured the EPA to recalculate its ILUC estimates using industry-provided data, resulting in estimates that suggested that ILUC emissions from corn-ethanol were 50% less than originally found, allowing it to qualify for the RFS program by a narrow margin (EPA, 2010, in Bailis and Baka, 2011). The RFS mandate thus became the most powerful instrument to drive the ethanol boom in the US, "despite multiple EPA determinations that biofuel production increased food prices, impaired water quality, reduced wildlife habitat, and only marginally contributed to GHG emissions and energy security goals" (Gillon, 2016: 133). Moreover, this contestation process around life-cycle analysis for the RFS ultimately "transitioned from a promising method for critics to curtail biofuel production into a method for narrowing the scope of and participants in an increasingly technical regulatory debate" (ibid.). Subsequent attempts along this line have been frustrated: for example, California disallowed the use of US corn-based ethanol due to more rigorous calculations of ILUC emissions than the EPA's revised estimates, prompting the corn and ethanol agroindustry to sue the state and discourage others from reproducing California's regulations (Guerrero, 2010, in Bailis and Baka, 2011). As a result, only 13% of federal and state policies involve life-cycle assessments (Soratana et al., 2014). On the other hand, concerns raised by corn and soy farmers themselves were deflected through trade protectionism, particularly against the far more competitive Brazilian sugarcane-based ethanol, scuttling plans for a transcontinen-

[3] A complex network of farmer cooperatives, agribusiness companies, think tanks, local, state, and federal government officials, in addition to the explicit lobbying firms operating among all these actors.

tal ethanol complex[4] in 2007 and sustaining import quotas and tariffs that protect US corn farmers from international competition (Hollander, 2010; Solomon et al., 2007; Sorda et al., 2010).

Ultimately, challenges to the continued expansion of the corn-based ethanol economy in the US arise from internal tensions within the agroindustrial sector, and between this sector and the petroleum and automotive industry. In 2007, for example, when the ethanol boom contributed to skyrocketing corn and other agricultural commodity prices, the Texas state government petitioned the EPA to waive biofuel mandates due to the economic hardships they were causing to the livestock sector, which relies heavily on corn- and soy-based feed (Gillon, 2016). Again in 2012, when a serious drought affected several livestock-producing regions, several other states joined Texas to make this appeal. On both occasions the EPA denied the requests, claiming that waiving the RFS mandate would not likely have a significant impact "in the relative time frame that a waiver could apply" (EPA, 2012, in Gillon, 2016: 134). Additional requests that biofuel mandates be cancelled or relaxed because of economic harm to consumers or environmental harms due to expanding corn monocultures and intensified agroindustrial processing were similarly denied (Gillon, 2016). In glaring contrast, however, the petroleum industries were actually successful in triggering a waiver of the RFS mandate in 2014 (ibid.). Reflecting its long-standing power and influence discussed above, particularly through the control of energy infrastructure, the oil sector argued mandates for increasing ethanol production that year would exceed the existing material capacity to absorb ethanol in gasoline stations and automobile engines that are limited by an E15 "blend wall" (i.e. infrastructures that cannot operate with more than 15% ethanol blend) (ibid.). This in effect prevented the petroleum and automotive industries from having to purchase ethanol at increasingly higher prices at a moment when oil prices stopped rising and were correctly anticipated to fall (ibid.). In fact, these biofuel policies actually provided a "perverse incentive for US fossil fuel producers to increase their rate of extraction," such that biofuel development in the US "might have contributed to additional net CO_2 emissions" (Grafton et al., 2014: 550; cf. Smil, 2010b; Oberling et al., 2012).

The rationale for the differential treatment of waiver petitions is highly expressive of the politics behind the policy that currently structures the biofuel economy in the US: domestic and geopolitical state interests in agroindustrial accumulation sustain corn-based ethanol production even against internal tensions with other agribusiness sectors and external tensions with broader environmental and social concerns, and the sector remains limited only when and insofar as necessary to harmonize with accumulation in the petroleum and automotive industries. Therefore, despite being justified based on discourses of climate change mitigation and benefits for corn farmers, the implementation of biofuel policies in the US subordinates the interests of farmers to the agroindustrial sector, and sacrifices rigorous GHG emissions control to maintain cheap fuel supplies and continued accumulation in the petroleum and automotive sectors. Moreover, this agroindustrial bias has also driven major US biofuel investments towards Brazil, where it (as shown below) exacerbates the concentration of property in land, infrastructure, and processing through exploitative and exclusionary labour relations.

2.2. Brazil

Brazil's first national ethanol blend mandate dates back to 1931 (Decree 19.717) and until 1975, the country maintained an average ethanol/gasoline blend ratio of 7.5%. During the aftermath of the 1973 oil price crisis, Brazil's petroleum import expenditures soared from just US$ 600 million in 1973 to US$ 2.5 billion in 1974, leading to a massive trade deficit which weighed heavily on the Brazilian economy and threatened energy security (BNDES, 2008). As a response, the military government launched the first National Alcohol Program *(Proálcool)*, in order to reduce the country's dependence on oil imports and its growing balance of payments deficit. President Ernesto Geisel (1974-79)[5] was able to persuade Petrobras directors that alternative fuels could be in their best interest, breaking the reluctance to incorporate biofuels much earlier than in the US (Stattman et al., 2013:25). Technological innovations combined with private sector lobbying from Brazil's largest sugar producer cooperative, Copersucar, provided the government with a two-fold solution to the country's oil dependency problem: "On the supply side, it could increase the production of bioethanol using the idle capacity of sugar mills; on the consumption side, it could increase the amount of ethanol in gasoline, and eventually use pure bioethanol as a fuel" (BNDES, 2008:148). With the state committed to supporting ethanol production in the interests of energy security and to reduce foreign debt, Proálcool effectively established a strong link between the state-owned oil sector and the agroindustrial sugarcane industry with a variety of incentives for both sectors: the ethanol blend mandate was progressively increased to 25%; lower consumer prices for ethanol relative to gasoline regulated by the state; state subsidies for ethanol producers, despite rising sugar prices; low-interest credit lines for sugarcane mills to increase production capacity; tax and registration fee reduction for hydrated bioethanol vehicles; compulsory sale of hydrated bioethanol at gas stations; and strategic bioethanol reserves to ensure supply out of season (BNDES, 2008: 149). It is estimated that during the first phase of *Proálcool* (1975–1989) the Brazilian government invested roughly US$ 4 billion while private investment accounted for another US$ 3.1 billion (Dias Leite, 2007). This not only enabled the sugar-ethanol sector to remain competitive, but also strengthened the industry's position well into the future with important support for R & D and infrastructure.

While state subsidies and tax breaks helped ethanol production and consumption and reduced petroleum imports while oil prices were high, falling oil prices and higher refined sugar prices in the mid-1980s weakened the ability of the state to keep pace with international market conditions. Reforms rolled back state intervention in the economy in the 1990s, cutting subsidies and tax incentives for ethanol producers and consumers and ushered in a free market pricing system in the sugar-alcohol sector (Pelkmans et al., 2008). Consequently, ethanol production largely stagnated throughout the 1990s, consistent with oil prices until the subsequent oil price rise in 2003 – the same year Brazil launched its flex-fuel vehicles (FFVs) able to run on both ethanol and gasoline or combinations of both. New discourses around climate change mitigation and peak oil also emerged, fueling the biofuels boom as a purported triple-win solution to climate change, energy security and rural development (Franco et al., 2010; see also Hunsberger et al., 2016, this issue). As oil prices continued to rise, ethanol production followed suit signalling a positive correlation between Brazil's ethanol production and the price of oil (McKay et al., 2016). FFVs quickly began to outpace gasoline vehicles, representing 69% of all vehicles in Brazil in 2015 up from just 21% in 2007 (UNICA, 2016a). Though the state has had no *direct* control over ethanol production since the 1990s, tax incentives for FFVs, production subsidies for ethanol producers, and increased blending levels enable significant state influence over production and consumption, and helped maintain sugarcane derivatives (bagasse and alcohol) as an important contribution to Brazilian energy supply matrix.

This favourable regulatory environment facilitated by the state combined with the increasingly flexible and multiple uses of sugarcane provides the industrial sugarcane-ethanol complex with a diversified

[4] The upstream and downstream components of agricultural and ethanol production, their complex assemblage of infrastructures, technologies, institutional arrangements and the flexibility and relations of their production.

[5] Geisel also served as Petrobras' president from 1969–73.

market portfolio and very promising conditions for investment (McKay et al., 2016). Indicative of this is the expansion in land area and infrastructure projects. Sugarcane expansion in Brazil has nearly doubled since 2005, from 5,815,151 ha to 10,870,647 ha in 2015 – by far the largest absolute increase worldwide led by the agroindustrial sector (UNICA, 2016b). Recent investments in infrastructure such as the BNDES-financed Logum Logistica S.A. are connecting all major producer states with ethanol pipelines in a joint venture owned and operated among the industry's biggest players – Petrobrás, Copersucar,[6] Raízen,[7] Odebrecht,[8] Camargo Correa, and Uniduto (Logum, 2016). This extensive investment project which received USD 924 million in loans from BNDES is part of the state's Growth Acceleration Program (Programa de Aceleração do Crescimento, PAC) and connects the states that produce nearly 80 per cent of the country's total sugarcane production (Nielson, 2011; UNICA, 2016). In terms of R & D, the state-funded Brazilian Agricultural Research Company (EMBRAPA), under the Ministry of Agriculture, Livestock and Supply (MAPA), established EMBRAPA-Bioenergy in 2007 to develop new technologies for crop cultivation and processing for biofuels. Other public funding from BNDES and FINEP has gone to support the Sugarcane Technology Center (CTC), which is owned by corporate sugarcane giants Cosan and Copersucar (McKay et al., 2016).

The state provides much more than just a favourable regulatory institutional environment for the industrial sugarcane-ethanol complex. While there are some 360 sugarcane-ethanol mills,[9] they sell to a market oligopoly dominated by Petrobras Distribuidora, a subsidiary of Petrobras (McGrath, 2013; USDA, 2015). The Brazilian state also seeks to transfer its agricultural development model and biofuels abroad through what Paiva and Wolde-Georgis (2010) call 'biofuels diplomacy'. As McGrath asserts, the state "not only provides an institutional context through policy setting, but exercises governance within the network" (2013:38). Through Petrobras, BNDES, FINEP, and EMBRAPA, the state is just as invested in the industrial sugarcane-ethanol complex as Copersucar and Raizen. It is not surprising, therefore, that the goals and mechanisms of ethanol policies favour corporate profits and international trade balances over alternative rural development policies that would benefit small-holders and farm workers more directly (cf. Hunsberger et al., this volume). Biofuel policies have actually facilitated the concentration of control over land, infrastructure, and processing, thus increasing the concentration of wealth and power in Brazilian society.

Still, environmentalist NGOs and rural social movements have placed the sector on the defensive about its negative impacts on deforestation, land concentration and degradation, and labour exploitation (elaborated below). In response, the sugarcane-ethanol industry association (UNICA) remarks that only about 1.4% of total arable land is devoted to sugarcane for ethanol use, seemingly rendering the land questions relatively insignificant for biofuels production in Brazil. Its rapid expansion however – now reaching almost 11 million hectares – is not insignificant in absolute terms. Further, as Novo et al. (2010) point out, the "sugarcane/ethanol sector has pressed small dairy farmers to find alternative paths for providing a livelihood for their families by renting or selling land to the sugarcane industry. The ethanol industry offers high prices for land, and renting land is associated with the absence of risk, compared with other local land use options" (782). As the industrial sugarcane-ethanol complex continues to penetrate into the countryside it tends to dispossess those who cannot keep pace with its rapid form of capital accumulation. For small-scale or capital-poor farmers, this highly-mechanized, capital-intensive production model is unfeasible leading to processes of 'productive exclusion' (McKay and Colque, 2016). In the context of increased productivity in the short-term through high yielding technologies and capital-intensive production systems, exacerbated by inflating land prices close to infrastructure network and mills, capital-poor farmers tend to transition to a livelihood strategy based on wage labour and land-leasing arrangements due to their inability to access the capital requirements necessary to put land into production (McKay and Colque, 2016; Sauer and Leite, 2012). Moreover, as sugarcane expands into new territories, displaced dairy, cattle, and other traditional crop producers are forced to relocate, signalling strong ILUC generated by the sugarcane-ethanol complex (Novo et al., 2010; Sauer and Leite, 2012).

The manner that the state and the ethanol sector have responded to aggravating labour exploitation in sugarcane cutting is also very revealing of the politics behind the policy in Brazil (see Hunsberger et al., this volume). Manual cane cutting is extremely demanding both mentally and physically and in many cases it is undertaken in conditions analogous to slavery.[10] This is mainly due to the increased productivity requirements by the industry, forcing cane cutters to work harder and longer. As demand for sugarcane began to increase substantially since Brazil's national ethanol program, so did the demand for land and labour productivity. In the 1950s, average labour productivity was three tons of sugarcane per person per day; in the 1980s it doubled to six tons per day; in the 1990s it reached 9 t per day; and the current average is now 12 t of cane per person per day (Alves, 2006, 2008). The pressure to meet such production requirements with the risk of losing one's job has resulted in slave-like conditions such as over-work exhaustion and death (McGrath, 2013; Alves, 2006).

Under more progressive administrations since 2003, the state did increase funding and efforts to investigate severe labour rights violations. From 2003–2010, for example, 10,010 workers were rescued from conditions analogous to slavery in the sugarcane/ethanol sector (Repórter Brasil, 2011; McGrath, 2013). Yet the only policy mechanisms directed at restructuring the sugarcane-ethanol sector itself were tax incentives for mechanization to replace manual labour. In the state of São Paulo, where over half of the country's sugarcane is produced, 70% of production is already mechanized (UNICA, 2016c). Although mechanization continues to increase throughout the country, areas where the slope is greater than 12% can only be harvested manually due to the technical limitations of machinery (Alves, 2006), and exploiting manual labour often remains more profitable than reinvesting in mechanization. Thus, the sector itself estimates there are still approximately 500,000 sugarcane cutters in Brazil (UNICA, 2016c). Moreover, it is estimated that one harvester replaces 80 sugarcane cutters, meaning massive labour cuts accompany mechanization. UNICA estimates that half of São Paulo's remaining 140,000 cutters "will have to migrate to other activities" (UNICA, 2010:73). The state has no policy to address this need, and while the industry's 'RenovAção'[11] program provides retraining schemes for those left unemployed, it has only retrained some 5700 workers since 2010, a far cry from its goal of 7000 retrained workers per year (UNICA, 2010; UNICA, 2016d). By facilitating the expansion of the agroindustrial sugarcane-ethanol complex without addressing the social divisions of labour and their exploitative conditions, biofuel policies inadvertently exacerbate these labour relations, failing to address the social aspects of ethanol production (Ribeiro, 2013).

In light of these glaring failures surrounding ethanol policies, the Brazilian government launched the National Program of Production

[6] A merger with agroindustrial giant Cargill which owns 50%.

[7] A merger between Royal Dutch Shell Company and Brazilian conglomerate Cosan.

[8] A merger between French conglomerate Tereos (56%) and Petrobras (46%).

[9] Since 2010, 60 sugarcane-ethanol mills have closed as smaller mills are being outcompeted and bought-out by larger companies (USDA, 2015).

[10] Such conditions include excessive working hours, precarious lodging and working conditions, as well as illegal retention of workers in isolated farms and/or from distant regions (Repórter Brasil, 2011; McGrath, 2013).

[11] RenovAção is a program to retrain sugarcane workers left unemployed due to mechanization launched by UNICA with the support of key players in the industry such as Case IH, FMC, Iveco and Syngenta, as well as financing from the Inter-American Development Bank (IDB).

and Use of Biodiesel (PNPB) in 2004 as a strategy to decrease diesel imports, increase 'sustainable' fuel production, and – essential for pushing forward the policy – alleviate poverty through social inclusion of family farmers in the poverty-stricken north-east. The PNPB mandates a blend ratio of biodiesel to diesel content that reached 7% in 2014, which has saved billions of dollars in biodiesel imports and contributed to Brazil's energy matrix, but its mechanisms were utterly inefficient at attending the stated 'social inclusion' goals (Oliveira and Schneider, 2016). To encourage the inclusion of small-scale farmers, particularly in the north-east, the PNPB offers tax exemptions and public procurement[12] through a 'Social Fuel Seal' administered through the Ministry for Agrarian Development (MDA) to those *companies* who source a certain percentage[13] of their raw material from small-scale family farmers. But there were no policy mechanisms for the farmers themselves to scale-up production and reach markets. The lack of logistical integration and production capacity caused companies to begin sourcing instead from commercial soy farmers in Southern and Central Brazil rather than helping to catalyse social and productive inclusion of farmers in the north-east (Oliveira and Schneider, 2016). The conditions of the region's impoverishment thus became the reason for its continued exclusion, exacerbating existing regional inequalities and representing "a notable failure of the biodiesel program in terms of social inclusion" (ibid.: 185).

Consequently, and similar to the sugarcane-ethanol industry, the PNPB has come to serve the interests of soybean agroindustry, represented by ABIOVE (Brazilian Association of Vegetable Producers), along with state institutions such as EMBRAPA, BNDES, and Petrobras that provide R & D, financing, and productive capacity. The mechanisms of the PNPB were designed primarily to increase domestic demand and provide new market access to the growing soy industry, even while the economic feasibility and environmental sustainability of biodiesel production under the PNPB has also come in question (Dauvergne and Neville, 2009; Alonso-Pippo et al., 2013). A research consensus is emerging that biofuel production has "greater aggregate environmental costs than do fossil fuels" (Scharlemann and Laurance, 2008:44; cf. Zah et al., 2007; Cavalett and Ortega, 2010) including significant carbon debt via direct and indirect land use change (Searchinger et al., 2008). Yet by harmonizing the interests of the petroleum (and, consequently, the automotive) industry with continuing expansion of industrial agriculture from an early moment, biofuels policies in Brazil have served to increase agroindustry's control over land and labour processes, and propelled the Brazilian state-owned oil company, development bank, agricultural research company, and domestic agribusinesses into lead proponents of global biofuel markets. This alliance has relegated socio-ecological protections to weak mitigation efforts at best, or excluded entirely the poor and exploited the environment with justifications based on (the presumed benefits associated with) the crop's end use.

Despite discourses of sustainability and social inclusion, this section has demonstrated that Brazil's biofuel industries operate under a similar logic to other agroindustries. Rather than being pro-poor and socially inclusive, biofuel policies have led to an agroindustrial bias which has exacerbated the concentration of control over land, infrastructure, and processing, while labour relations remain exploitative and exclusionary.

2.3. European Union

Non-fossil fuels were already widely used in the beginning of the 20th century in countries belonging to today's European Union. Yet, it was only in the aftermath of the oil crises in the 1970s that biofuel production re-emerged in the then European Community (EC) prompted by two issues: enhanced energy security and agricultural development. As in the US and Brazil, biofuel promotion in Europe was driven primarily by agribusiness interests in reducing crop surpluses and idle processing capacity to creating additional income. Investigating the historical context of biofuel development for this region, it is clear that Germany and France stand out as biofuel pioneers among the members of the EC and later EU, with their agricultural sector as a major driving force. As we show below, both developed technical know-how and experience in biofuel production already at an early stage in pre-war times, enabling them to expand their industries later on. Both founding members of what we know as today's EU consolidated their influential role since the 1980s not only in the general EU structure, but also and more specifically in its biofuel regime. Their underlying biofuel experience and the interests of their agroindustry became the key articulators with the interests of the European petroleum and automotive industry in the 2000s. It was only when this intersectoral alliance became established that that large-scale biofuel production was launched. We therefore focus on the biofuel development in these two member states and then explain policy trajectories in the EC and the EU.

The first steps in the development of biofuels in Germany and France were taken in the first half of the 20th century. Fossil fuels at that time were not the dominant form of automotive fuel, as the current technology also allowed for the use of ethanol and vegetable oil. Rudolf Diesel's engine could, for instance, not only run on fossil fuels but also on vegetable oil (Ballerini, 2011). During times of wars and crisis in Germany, fossil fuels were mixed with ethyl alcohol produced from grain and potatoes, as well as coal-based and pure benzolfor to increase the country's energy independence. During World War I, such blends accounted for more than one third of the overall fuel consumption in Germany. With the agricultural sector in decline during the Great Depression, the first blending target for potato-based fuel was introduced in the Weimar Republic, which primarily aimed at supporting the great landowners east of the river Elbe. The target was later increased during World War II for reasons of self-sufficiency, sustaining ethanol as a very significant proportion of the country's fuel supply (Beneking, 2011).

A similar development can be observed in France. While buses in Paris were running on blended denatured alcohol before World War I, ethanol from sugar beet was widely blended with gasoline from the 1920s to the 1950s to decrease the French trade balance deficit (Ballerini, 2011). However, declining oil prices made the production of ethanol relatively too expensive, and so ethanol disappeared from the French fuel market in the 1960s. Furthermore, French demand for sugar beet expanded in the food and chemical sector, meaning that the agricultural surplus that existed in pre-war years was no longer present (ibid.). Likewise, in post-war Germany the further implementation of biofuels was brought to a halt since agricultural land was cultivated for food and animal feed production. This production was needed to satisfy hunger in Europe after World War II (Beneking, 2011).

It was the recurrence of an agricultural surplus that laid the cornerstones for biofuel development in the EC, triggered by the Common Agricultural Policy (CAP). Coming into force in 1962, the CAP was originally created to ensure sufficient food supply for Europe's population as well as stable income for European farmers via a price-supporting scheme. By building a common agricultural market, the CAP was not only one of the main drivers for European integration but also pushed for agroindustrial development within the EC countries (EC, 2015). The regulation of the market created fixed prices for European farmers to provide food security on the continent, but by the 1980s it led to overproduction. As a result, 'food mountains' were produced to store agricultural surplus and the world market was flooded with subsidised European agricultural exports to the global South. Another measure to reduce agricultural overproduction was the

[12] The state guarantees the purchase of 80% of the biodiesel market through public auctions held by the National Agency of Petroleum, Natural Gas and Biodiesel (ANP) (Oliveira and Schneider, 2016: 184).

[13] Varies per harvest and per region, but usually ranges between 10–30% (Stattman et al., 2013).

set-aside payment scheme[14] that was introduced in 1989 to withdraw land from cultivation for food crops, but significantly, it allowed for the plantation of non-food crops for energy production. CAP reforms in 1992 also resulted in the transition from a market to a producer support scheme. This especially benefited rapeseed production in Germany (becoming a key biofuel feedstock) since payments were attributed according to yields, which were above European average (Beneking, 2011; EC, 2012a).

The agricultural surplus production, combined with the incentive of set-aside payments and the shift to a producer support scheme in the CAP, constituted the main reasons for the expansion in biofuel feedstock cultivation. Furthermore, a decision taken by the European Council at the end of the 1980s required the offer of unleaded fuel at all fuel stations, encouraging ethanol blending for knock resistance. In this context, biofuel pilot projects were launched at the level of member states. Again the trends in France and Germany were decisive for the overall development of the biofuel sector on the continent. France introduced a tax exemption for ethanol, triggering lawsuits by the petroleum industry. This tension eased after discovering the qualities of ethanol in ETBE[15] as anti-knock additive (Beneking, 2011). In Germany, set-aside payments for growing non-food crops and the growing demand of biodiesel refineries fostered the plantation of rapeseed. Even though official political support lacked (e.g. in terms of subsidies), a kind of tax exemption was in effect since taxes in Germany were only applied to fossil fuels. At that time biodiesel was not blended with conventional fuel but it was sold as B100 (100% biodiesel). Independent small-scale biodiesel plants emerged together with a network of small independent gas stations, and biodiesel production was meant to provide an alternative to the fossil fuel complex (Vogelpohl, 2014). However, this changed in 2005 when the Social Democratic and Green Party coalition was replaced by another between the Social Democratic Party and the Conservative Party, which favoured 'scaling up' the biofuel industry in a manner that could be harmonized with the petroleum industry (ibid.). This political decision was reflected in shifting biofuel support policies from tax exemption to the introduction of a blending target (BMF, 2005; FNR, n.d.). Because tax deficits were expected due to rising biodiesel consumption, a tax on biodiesel was introduced, and a blending target became the mechanism to ensure biofuel production instead. As result, the existing small-scale initiatives were out-competed by the rising large-scale biofuel industry as small producers (including small oil mills shutting down) could no longer provide the volume required by the petroleum industry (Vogelpohl, 2014). Agroindustrial development was thus supported by biofuel policies, reinforcing land use and control for their benefit.

The development of the biofuel sector in Germany and France enabled the emergence of a biofuel industry that advocated for their interests at the level of EU policies. Against the background of an emerging peak oil debate and climate change negotiations, biofuel policies were introduced in the European Parliament and Commission as part of a common integrated framework for energy regulation in the early 2000s. Taking the Kyoto protocol into account, which obligated the EU to reduce its carbon emissions, biofuels became part of the EU's decarbonisation strategy (Brunnengräber, 2014). However, it was only with the introduction of a blending target - the policy instrument favoured by the petroleum industry - that large-scale biofuel production in the EU gained momentum. Building on the White Paper on Energy for the Future (EC, 1997) and the Green Paper on the Security of Energy Supply by the European Commission (EC, 2000), in 2003 the EU began supporting biofuel production with its Biofuels Directive by introducing a blending target of 5.75% to be reached by 2010 (EU, 2003). The 10% blending target set as part of the Renewable Energy Directive (RED) established in 2009 was to be attained by 2020 (EU, 2009a), backed up by the large-scale biofuel infrastructure set in place with the continuous support from the agribusiness, petroleum, and automotive sectors. It was the blending target that safeguarded the existence of the biofuel industry. In addition, the Fuel Quality Directive (EU, 2009b) adopted in 2009 aimed at reducing GHG by 6% by 2020, which also supported biofuels as long as climate mitigation calculations could be sustained. As a result of this policy support, the share of biofuels in transportation jumped from 1.0% in 2004 to 5.9% in 2014 (Eurostat, 2015).

While biofuels were announced to serve as an alleged silver bullet to address problems of energy security, rising GHG emissions, and rural development, the blending target fostered primarily the consolidation of large-scale biofuel refineries. Today, this biofuel industry, which is mainly situated in Western European member states, namely in France, Germany, UK, Italy and Spain, dominates the EU's biodiesel and bioethanol market. With the European Biodiesel Board and ePure, the industry has powerful lobby groups defending their interests in Brussels (EurObserv'ER, 2015). Yet, both its supposed curtailment of GHG emissions (Searchinger et al., 2008) and rural development effects are questionable, as estimates of the numbers of jobs created within the biofuel industry vary – depending on the methods used – from less than 4000 up to roughly 120,000 (Charles et al., 2013). The industry, not small farmers, receive subsidies via market price supports, tax exemptions and R & D measures which in 2011 comprised between 5.5 and 6.9 billion Euros, exceeding the amount of money invested into biofuel infrastructure in the first place (Charles et al., 2013). Together with the vegetable oil and livestock feed industry (Fediol), the grain trading lobby (Coceral), large-scale farmers (Copa-Cogeca), and the petroleum industry, it has strong interest in sustaining the 10% blending target of 2009, since any cuts to the mandate would not only reduce the demand for their product but would also imply a reduction of subsidies (CEO, 2013; Neslen, 2013; Pesonen, 2015).

Their influence was recently reflected in an "industry-friendly compromise" (CEO, 2013) that was found when the EU reacted to growing criticism against biofuel production. Already at the time when the RED was adopted, biofuel criticism was expressed by environmental and development NGOs addressing rising food prices, the destruction of people's livelihood, dispossession of their land, and violation of labour rights, not only within but also outside of the EU (e.g. FoEE, 2008; TNI, 2007; Oxfam, 2007). To address these issues, sustainability criteria were incorporated in the RED. However, these criteria focus mainly on the reduction of GHG emissions, which themselves represent a highly contested field, leaving out any social criteria (EU, 2009; German and Schoneveld, 2012). By considering ILUC, an expert study launched by the EC revealed that biofuels do not contribute to the desired reduction of GHG (EC, 2012b). In particular, biodiesel (especially from palm oil and soybean) that makes up the largest proportion of EU's biofuel production and consumption, shows worse results for GHG emissions than conventional fossil fuel (Crisp, 2016). As also documented for biofuel policies in the UK, these existing 'industry-friendly' policy compromises backfire in 'locking-in' inefficient first-generation biofuels and forestalling the transition to more environmentally sustainable energy production and agricultural practices (Berti and Levidow, 2014; cf. Oberling et al., 2012). Due to the biofuel industry's powerful policy intervention, for example, the blending target for first-generation biofuels was set at 7% instead of 5% as originally proposed by the EC. This ensures not only the use of existing production capacities, but even grants the possibility to grow when taking into account that the mix of first-generation biofuels only reached 5.9% in 2014 (EP, 2015; Eurostat, 2015).

Trade relations show another point of influence of the EU's biodiesel industry on land use change as well as over other foreign biodiesel industries in particular. Already the RED (EU, 2009a) considers biofuel feedstock provided by countries outside of the EU

[14] Set-aside policy became mandatory with the Mac Sherry reform of the CAP in 1992. Initially, 15% of the land had to be put out of production to reduce agricultural surpluses and stocks. Farmers received payments per hectare as remuneration instead (EC, 1993).

[15] Ethyl tertiary-butyl ether.

and its consequences for land relations in the respective countries. Land use change due to biofuel production is thus not only triggered inside but also outside the EU (Bausch, 2016; Pichler, 2014). Estimates of the area of land grabs associated with EU biofuel policies vary from between 140,000 and 810,000 ha according to the International Land Coalition, to 6 million hectares mentioned by the UN special rapporteur on the right to food (EurActiv, 2013). Imports include not only processed biodiesel and ethanol, but also feedstock from countries of the global South as well as Eastern Europe, such as Ukraine which is one of the world's leading rapeseed exporters and major feedstock supplier for EU biodiesel producers (Plank, 2016; Schaffartzik et al., 2014). Trade relations that favour the EU's biodiesel industry were arranged with anti-dumping taxes against major biodiesel exporters as measures to protect the EU's biodiesel industry. Biodiesel imports that were coming mostly from the US until 2008 were then replaced by imports from Argentina and Indonesia when anti-dumping taxes were imposed on US imports (Dietz, 2014). A few years on, the EU imposed anti-dumping duties on these other countries as well (Reuters, 2016). Regardless of the stated objectives, therefore, the politics behind the biofuel policies in the EU demonstrate their implementation is orchestrated primarily to sustain the profits of their largest-scale biofuel industries.

Biofuel policies in the EU contribute thus to land use change and land concentration within the EU but also in other parts of the globe. They do not promote rural development, but exacerbate existing labour relations, favouring the agroindustrial complex. Also, biofuel policies do not keep the promise of improved environmental production but actually aggravate ecological degradation.

3. The incoherent emergence of a global biofuel regime

Many other states have promoted biofuel production through similar policy mechanisms (Sorda et al., 2010), but the emerging global biofuel regime remains anchored in the US, Brazil, and the EU, and largely shaped by the politics behind their policies. Although still very limited, therefore, the emergence of a global biofuel regime exacerbates the misguided goals, inefficient mechanisms, and political-ecological blind spots and incoherence of biofuel politics within these main hubs. First, given the earlier and more extensive development of biofuel production in these places, biofuel policies in the US and Brazil determine international ethanol prices, while EU biofuel policies largely determine international biodiesel prices (Rajcaniova et al., 2013). Moreover, state agencies and private corporations from these hubs actively promote direct transfer of production and processing technologies, as well as policy initiatives themselves, to neighboring countries and new biofuel producers (Dauvergne and Neville, 2009; Alonso-Pippo et al., 2013). The Brazilian state and sugarcane sector in particular has promoted its biofuel program as more sustainable than US and EU counterparts, yet its marketing is still based on overly optimistic accounting of the socio-ecological impacts in Brazil (Goldemberg and Guardabassi, 2009; McKay et al., 2016). On the other hand, protectionist policies in the US and EU to safeguard domestic farmers and agribusinesses have largely derailed efforts at establishing international quality standards and trade mechanisms to consolidate an international market on ethanol and biodiesel (Hira, 2011; Hollander, 2010). Thus, the particular synergies and tensions within and between these hubs has been the main factor both enabling and challenging the coherence and consolidation of an international biofuel complex into which other countries could integrate as suppliers or importers.

Agroindustrial traders and processors are the main actors driving cross-border biofuel production and policy integration, coming into tension primarily with protectionism in the US and EU and concerns over food security in developing countries. This is most clearly evident in the uneven development of ethanol production in Canada and Mexico following the biofuel initiatives in the US and the North America Free Trade Agreement (NAFTA) (Kedron, 2015; Solomon et al., 2015; White, 2014). Unsurprisingly, the literature documents displacement of peasants and farmer-owned cooperatives in Canada and Mexico comparable to those witnessed in the US and Brazil (Bhullar et al., 2012; Luckert, 2014), but while biofuel production has been steadily expanding in Canada, protectionist tensions have limited the sector in Mexico due to its imbalanced integration in NAFTA (White, 2014). In part, US protectionism and infrastructural challenges imposed by the petroleum sector have limited the expansion of ethanol production (Rendon-Sagardi et al., 2014). Moreover, social resistance to the use of maize for ethanol and concern for food security shifted policies towards alternative feedstocks (such as jatropha and palm oil) that result in adverse integration of small-holders (Castellanos-Navarrete and Jansen, 2015). Similar situations are witnessed in Central America, which functions primarily an *entrepot* for the re-export of Brazilian ethanol into the US (Hollander, 2010) and production base for biodiesel exports to the EU (Banse et al., 2008). In South America, on the other hand, the soy-based biodiesel sector advanced significantly in Argentina, largely because the state provides substantial tax disincentives relative to Brazil for the export of unprocessed soybeans (Solomon et al., 2015). Still, biodiesel production there is marked by similar socio-environmental problems, and these may expand along with soy production into neighboring Uruguay, Paraguay, and Bolivia (Tomei and Upham, 2009; Oliveira and Hecht, 2016).

Food security concerns and the acknowledged role of biofuel production in exacerbating food price volatility and crises in recent years (HLPE, 2011) have largely curtailed the development of the sector in several major agricultural producing countries. India, for example, set ambitious biofuel targets, but the lack of economic benefit associated with the production of sugarcane ethanol and great risks to domestic food security have rendered ethanol production and prospects relatively insignificant, at least while no alternative feedstocks exist with sufficient logistics and processing infrastructure for scaling up (Gunatilake et al., 2014). China's case is also very telling, as policies shifted from providing strong support in the early 2000s to setting significant restrictions on biofuel production after the food price crisis of 2007-8. In particular, the state prohibited the continuation of maize-based ethanol production and shifted policy mechanisms to promote only non-cereal feedstocks, particularly on so-called ‘marginal’ land. The high profile concerns over food security and the widespread environmental problems in China's agroindustrial sector have rendered even the most positive assessments of biofuel policies and production in China notably lukewarm, indicating that “the targets of China's biofuel development are cautious and feasible, but on the other hand there are still severe challenges for the sustainability of such development” (Qiu et al., 2012: 3095; Yang et al., 2009).

This relative lack of integration of some major economies in an emerging global biofuel assemblage does not mean that their powerful commercial and geopolitical dynamics are not at play in the expansion of biofuel production around the world. Palm oil from Southeast Asia (Indonesia, Malaysia, Laos, Burma) and a few other countries in Africa and Latin America (e.g. Colombia) has become a leading ‘flex crop’ commodity undergoing a boom in international markets, partially due to the competing demands for edible oil in China and biodiesel in the EU (Alonso-Fradejas et al., 2016). This commercial relation has meant that even the relative improvement of biofuel policies in the EU towards more rigorous GHG emission accounting has backfired (Rajagopal and Plevin, 2013). After all, mere inclusion of ILUC in GHG emissions from biofuel production does not guarantee emissions decline, particularly since the highest compliance costs are concentrated at early stages of supply chains that have been increasingly outsourced to developing countries (ibid.). Consequently, price-premiums of EU biofuel sustainability policies that were once thought to reward compliance disappeared almost completely by 2012, thereby encouraging unsustainable practices abroad (Pacini et al., 2013). Thus,

the manner that biofuel policies backfire (against the goal of more socially and environmentally sustainable energy production and agricultural practices) becomes significantly compounded in the externalization of biofuel production to countries in the Global South (Banse et al., 2008; Dauvergne and Neville, 2009).

4. Conclusion and policy implications

We have demonstrated that biofuel policies and mechanisms backfire because they are not in fact developed and implemented according to environmental or inclusive pro-poor development purposes, but rather according to corporate interests in maximizing profits and state concerns over energy security. Hence, biofuel production has advanced furthest when major corporate sectors such as agroindustry, petroleum, and automotive align with each other, and state interests in energy security trump concerns over food security. These state-corporate alliances set strong policies to create markets for biofuels and subsidize production and processing, but are everywhere marred by socio-ecological blind spots and weak market-based policies and capacities to regulate negative social and environmental effects. Indeed, as we have shown in the preceding case studies, biofuels policies increased corporate concentration in the US as the proportion of farmer-owned refineries declined; family-owned sugar mills decreased in Brazil due to acquisitions and market concentration by larger companies; and small-scale biofuel production initiatives in the EU were out-competed by the rising large-scale biofuel industry. The expansion of agroindustrial monocultures has also led to frontier expansion and deforestation as capital-poor farmers unable to compete are forced from their land, as shown particularly in Brazil. Yet policies continue to ignore any social criteria, as sugarcane cutters in Brazil are caught between slave-like labour conditions and unemployment, and EU policies similarly focus narrowly on reducing GHG emissions, dismissing any social criteria and ILUC (cf. Ribeiro, 2013). Perhaps even more telling however, are studies which demonstrate just how these biofuel policies backfire in achieving their own goals and rationale of reducing GHG emissions. In the US, biofuels policies actually provided incentives for increased fossil fuel extraction, likely contributing to a net increase of GHG emissions; while an expert panel by the EC concluded that when taking into account 'externalities' such as ILUC, EU biofuels are worse than conventional fossil fuels in terms of GHG emissions (Grafton et al., 2014; EC, 2012b).

As demonstrated, biofuel policies and production practices stall significantly when major corporate sectors are in tension with one another, when state concerns over food security predominate, and when opportunities for maximizing profits appear limited or become challenged, as in moments of low oil prices and demands for greater and more democratic socio-ecological benefits from energy policies and agroindustrial production. In all three main hubs of an emerging global biofuel assemblage, we witness a sinister political compromise whereby the costs for the establishment and development of a biofuel economy are socialized through public subsidies by the state, while the profits are privatized by major corporations and a few privileged managers and commercial farmers. This restructures corporate and agrarian relations far beyond biofuel crops and sectors, marginalizing small holders and food crop production, while upholding unsustainable and inefficient energy and environmental practices. Moreover, these misguided goals, inefficient mechanisms, and socio-ecological blind spots 'overflow' state borders through agroindustrial integration, global markets, and transnational investments that drive similar agrarian transformations in other countries – both in moments that biofuel crop production advances and also when it stalls given more rigorous sustainability policy mechanisms.

While almost all reviews to date limited themselves to describing the relatively recent legal and institutional development of biofuel policies and their economic repercussions, our framework shifts emphasis to the political economy of agrarian and energy production relations from which biofuel policies emerge. Thus, it serves as a useful lens through which we can examine the longer history and more complex set of relations (between various sectors and classes) that actually produce biofuel policies (regardless of their apparent public justification and social, economic, and ecological results). In turn, we have also shown how agrarian political economy can advance from the examination of biofuel production to a more refined critique of policy creation.

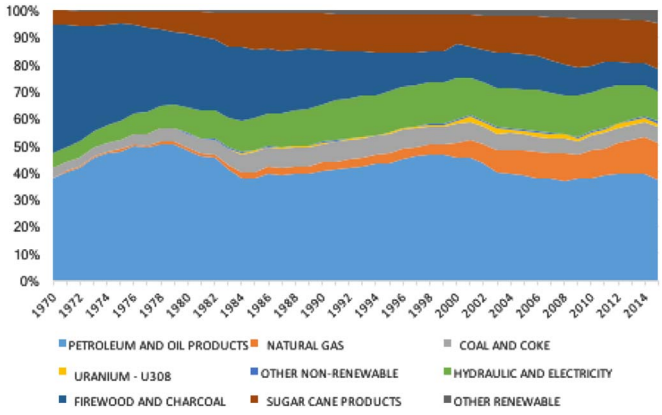

Fig. 1. Brazil's Domestic Energy Supply, 1970–2015 (%).
Source: Empresa de Pesquisa Energética (Brasil), 2015.

The politics underlying biofuels policies were originally shaped by energy security and macroeconomic stability concerns. Sustainability discourses for climate change mitigation and for rural development were later added to justify to continued expansion of what White and Dasgupta call 'agrofuels capitalism' (2010). If biofuels policies are to effectively facilitate more socially and environmentally sustainable practices, they must go beyond the crop's end use as an alternative fuel to tackle the problems inherent in the conditions and relations of production. Yet if production, circulation and distribution remain controlled by a few agroindustrial corporations, biofuels policies will only facilitate ongoing forms of socio-economic and environmental exploitation. After all, current subsidies, tax credits, and fuel-blending mandates encourage those who control the upstream and downstream components of production to expand both geographically and across sectors, but not to transform practices towards greater socio-economic equality and environmental sustainability.

Such extensive socio-ecological problems and conflicts appear impossible to reconcile with state policies that encourage biofuel production, resulting in attempts at expanding regulation through market-based and governmental guidelines (Janssen and Rutz, 2011). Nevertheless, coupling social requirements to biofuels alone could actually backfire in terms of GHG emissions by protecting fossil fuels (Ekener-Petersen et al., 2014), or lock-in less efficient first-generation biofuels (Berti and Levidow, 2014; Oberling et al., 2012). Attempting mere optimization of policies and technologies (cf. Taheripour and Tyner, 2008; Tyner, 2013; Witcover et al., 2013; Vivanco et al., 2016), including a technocentric promotion of second and third generation biofuels, will not resolve the fundamental sustainability and social justice challenges we have discussed in this article. Promoting and legitimizing biofuels based on the (assumed advantages associated with the) crop's end use is a dangerously narrow lens which can result in drastic socio-economic and environmental consequences. These blind spots point to the glaring shortcomings, inefficient mechanisms and misguided goals which reveal just how biofuels policies backfire. This suggests a need to re-think biofuel policies by widening our lens to the political-economic relations of crop production, including the institutional arrangements of labour relations, property and resources control, and their ecological implications. In other words, biofuel policies must be tied to land redistribution and stronger anti-trust, environmental, and labour protections that democratize production and

power. Only by taking into account these wider dynamics of the production process can biofuels policies start to facilitate a more sustainable, pro-poor development strategy (Fig. 1).

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