

# A Comparative Analysis of the Equity Outcomes in Three Sugarcane–Ethanol Systems

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## Abstract

This article identifies equity outcomes associated with three biofuel systems in Brazil, Ethiopia, and Guatemala. Acknowledging that winners and losers are socially and politically generated, the article identifies some of the factors behind the distribution of winners and losers along different stages of three sugarcane–ethanol supply chains. Analyzing the outcomes for equity within each case study reveals an uneven distribution that, we argue, is related to the procedure and structure of the given sugarcane–ethanol system, and the recognition of the impacts on different actors within those structures. Increasing equity in sugarcane–ethanol systems will require greater openness in decision-making processes, in order that multiple voices are taken into account in the promotion, production, and consumption of biofuels—particularly those of smaller and less powerful actors.

## Keywords

equity outcomes, sugarcane–ethanol system, winners and losers, governance, Brazil, Ethiopia, Guatemala

Since the turn of the century, biofuels have enjoyed political support in many parts of the globe. Biofuels are argued to provide a low-carbon alternative to

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hydrocarbon fuels in the transport sector. Furthermore, because biofuels can be produced virtually anywhere there is land, these fuels also have the potential to increase energy security by diversifying energy supply. Increased global trade in biofuels offers opportunities for product diversification and macroeconomic growth, as well as offering a route out of poverty for rural communities (Mathews, 2007; Mol, 2007). These drivers have meant that biofuels have rapidly become a favored policy option, and many governments, both in the global North and global South, have established policy frameworks to promote their production and consumption. However, support for biofuels has become increasingly equivocal as concern about their unintended consequences has grown. In particular, the rationale that biofuels deliver carbon benefits has been undermined by growing evidence that suggests biofuels can be more carbon intensive than the fossil fuels they replace (e.g., Fargione, Hill, Tilman, Polasky, & Hawthorne, 2008; Pimentel & Patzek, 2005). Additionally, controversies over indirect landuse change (European Commission, 2012; Palmer, 2014; Searchinger et al., 2008), competition with food crops (Rosillo-Calle & Johnson, 2010; Thompson, 2012), and large-scale land acquisitions (Anseeuw, Wily, Cotula, & Taylor, 2012; Fairhead, Leach, & Scoones, 2012) have also undermined the purported benefits of biofuels.

Many of these controversies are intimately connected to the agricultural systems that produce the biofuel feedstock. At present, only first-generation biofuels (i.e., those produced from food crops) are commercially viable, and economies of scale mean that large-scale, agro-industrial production dominates biofuel production. Large-scale production is likely to favor actors best able to capitalize upon opportunities provided by increased demand for biofuels, while already vulnerable people in the global South are likely to bear a disproportionate share of the costs (Creutzig, Corbera, Bolwig, & Hunsberger, 2013; Dauvergne & Neville, 2010). This raises critical questions about the equity of biofuel production systems and the distribution of winners and losers within and beyond producer countries. For example, at the national level, biofuel development will depend on the dynamics of the political economy, including the relationships between states, corporate actors, non-governmental organizations (NGOs), and civil society. At the local level, wins and losses are related to the governance of land and natural resources and the level of engagement in local policy structures. However, evidence on the outcomes of biofuels at the local level is limited (Hodbod & Tomei, 2013). This article contributes to the debate through an analysis of the equity outcomes of one biofuel feedstock, sugarcane, in three countries: Brazil, Ethiopia, and Guatemala. Although purposely focused around the same feedstock (and therefore similar interactions with social-ecological systems) to allow comparison, these three case studies cover a range of institutional, regulatory, and business models.

In this article, we draw on O'Brien and Leichenko's typology, which identifies two broad theoretical traditions that have addressed winners and losers

**Table 1.** A Typology for Interpretations of Winners and Losers.

	Winners and losers are natural, inevitable, and evolutionary (NIE)	Winners and losers are socially and politically generated (SPG)
Ecological interpretations	Social Darwinism Environmental determinism	Political ecology
Economic interpretations	Neoclassical economics	Marxian political economy

Source. O'Brien and Leichenko (2003).

(see Table 1). We ascribe to the view that winners and losers are socially and politically generated (SPG), rather than natural, inevitable, and evolutionary (NIE). In other words, winners and losers are generated through processes that benefit some actors at the expense of others.

Accepting an SPG interpretation of winners and losers requires paying attention to the complex contextual and structural factors that shape the (inequitable) outcomes of biofuels. While we draw on SPG interpretations, it is beyond the scope of this article to fully analyze the complex historical, political, and economic contexts of each case study. Rather, we provide a comparative analysis across three distinct sugarcane–ethanol systems to identify factors that shape the distribution of outcomes. While this risks losing the nuanced, contextual details inherent to, for example, political ecology, by paying attention to the different scales at which wins and losses occur, we reveal the power imbalances of competing resource users who have different visions for what is desirable for the sugarcane–ethanol sector.

Much research has focused on the production phase of biofuels because this is where many environmental and social impacts take place, particularly at the microlevel (Creutzig et al., 2013; Hodobod & Tomei, 2013). This article extends such analyses by also incorporating who wins and who loses in the promotion and consumption phases. These may not be the most marginalized actors, but, as argued by O'Brien and Leichenko (2003), it is important to take into account all self-perceptions of losses and gains to fully understand the dynamics of the system and consider which options to redress or compensate. It is also important to understand what drives the development of these systems and, in particular, whose perspectives are recognized because the motivations will play a critical role in determining the outcomes. By *promotion*, we refer specifically to the development of a national policy for biofuels, specifically whose voices are incorporated into policy design. *Production* includes all stages of the sugarcane–ethanol system, from cultivation of sugarcane to the processing of sugar, ethanol, and other by-products. Finally, by *consumption*, we refer to the end consumption of fuel-grade ethanol. This includes the trade of ethanol, the

subsectors it is consumed within, and the stakeholders who influence or are influenced by this consumption.

It is clear from the earlier discussion that the identification of winners and losers is largely subjective. Equally, the way in which these wins and losses are perceived and accepted will depend on utilitarian or egalitarian perspectives of equity (O'Brien & Leichenko, 2003). As such, we do not aim to provide definitive answers to the question of who wins and who loses. Rather, we aim to highlight the complex factors that shape the outcomes at different phases of the biofuel supply chain. In this task, we have been guided by O'Brien and Leichenko (2003) and Eames and Hunt (2013), who identify a number of issues that influence the equity outcomes for different actors. These include the social, spatial, and temporal distribution of costs and benefits; access to and participation in decision-making and wider governance processes; who and what are afforded recognition in such processes; and whether wins and losses are voluntary or structural, relative, or absolute. These different factors are likely to come into play at different phases of the sugarcane–ethanol supply, and therefore this article discusses these in relation to our three cases.

In the next section, we describe the materials and methods used to generate the data upon which this article is based. We then provide an overview of the three different case studies, before highlighting the winners and losers within the promotion, production, and consumption phases, comparing and contrasting between case studies. The article concludes by examining factors that lead to such differentiation of winners and losers, raising questions about transparency and openness in regulation and politics.

## **Materials and Methods**

The data analyzed in this article result from three in-depth field studies carried out between 2010 and 2012. All three authors adopted a multiscale approach to the research, collecting primary data at a local scale (São Paulo, Brazil [Blaber-Wegg, 2015]; Metehara, Ethiopia [Hodbod, 2013]; and the Pacific Coast and Polochic Valley, Guatemala [Tomei, 2014]), as well as at the regional or national level. While utilizing similar research methods, the three studies were designed separately and applied different theoretical frameworks (see Table 2):

- The Brazilian case study applied environmental justice concepts to identify and explore equity issues along a Brazil–United Kingdom sugarcane–ethanol fuel supply chain. Qualitative data collected from interviews with people living in and around the sites of production and consumption, as well as actors involved in the distribution, regulation, and governance of biofuels, formed the primary basis for this analysis.
- The Ethiopian case study studied biofuel expansion through an integrated resilience-political ecology framework to illustrate the dynamics of

**Table 2.** Summary of Data Sources Analyzed in This Article.

Case study	Conceptual framework	Research methods	Key stakeholders
Brazil	Environmental justice, and social life cycle analysis	Interviews (88) Field visits Secondary data analysis	Local and national government (Brazil) Sugarcane sector (Brazil and UK) Local communities (Brazil) Ethanol sector (UK)
Ethiopia	Social-ecological resilience	Household surveys: production subsystem ( $N=8,377, n=498$ ); consumption subsystem ( $N=2,470, n=283$ ) Interviews (21) Observation Secondary data analysis	Local and national government Sugarcane sector NGOs Local communities
Guatemala	Political ecology	Interviews (80) Observation Field visits (20) Document analysis	National government Sugarcane sector Other private sector NGOs Local communities Donor community

Note. NGOs = non-governmental organizations.

socioecological systems. By including the differentiated impacts for actors across multiple scales, the study enabled power relations to be taken into account—the lack of which is a common criticism of resilience studies.

- The Guatemalan case used a political ecology frame of analysis. Paying attention to the material and discursive factors that influence outcomes of biofuels in Guatemala, the actor-oriented approach also emphasized the interests, characteristics, and actions of different actors involved in the sugarcane–ethanol system.

Although the number of case studies is limited, the analysis is based on in-depth, primary research and therefore provides robust evidence for these specific contexts, even if this is not representative of all ethanol production within each country or all countries active in the sector. For example, the Ethiopian and Guatemalan case studies focus on the whole sector, which was possible due to

the relatively small size of the sugarcane sectors; conversely, the Brazilian case study focuses on a specific Brazil–United Kingdom sugarcane–ethanol fuel supply chain. The analysis in Brazil focused on a single mill which may be considered both typical (it is of average size, i.e., industrial scale, and produces both sugar and ethanol for domestic and international markets) and atypical (it is a family-run business, with a long-term ethos of corporate social responsibility and environmental sustainability). This inevitably influences this analysis of equity, and we acknowledge that this more positive example may not be representative of the Brazilian sugarcane–ethanol system as a whole. While this *ex post* analysis has limitations, not least that it covers three very different countries with different social and ecological histories, we believe that a comparison is of great value as the literature contains few examples of comparative studies that begin to identify the factors that influence the equity outcomes of sugarcane–ethanol systems.

During data collection, participants from different stakeholder groups were asked to give their perceptions of the impacts of the sector on their own standing, as well as on the position of other actors. These data have been aggregated to enable a comparison across the three countries. This article therefore presents homogenized groups of actors (Table 3), which contain not only diverse opinions (i.e., within and between households) but also different actors in the case study countries (e.g., pastoralists in Ethiopia, subsistence farmers in Guatemala). We utilize aggregated categories where our data show common outcomes across actors within a category. Where there is differentiation within a stakeholder category, we disaggregate the category into subcategories and provide additional explanation.

In the next section, we describe the sugarcane–ethanol sector within each of the three case study countries. The history of each country’s sugarcane–ethanol

**Table 3.** Main Stakeholders Encompassed Within Four Stakeholder Categories.

Stakeholder categories	Subcategories
Government	Local; national (including environment, energy, and economic ministries)
Private sector	Sugarcane–ethanol industries (including affiliated bodies, sugar mill owners, land owners, sugar estate managers); oil companies; cookstove manufacturers
NGOs	International; local and grassroots
Communities	Local urban; local small-scale farmers (including subsistence farmers and pastoralists); unskilled, seasonal, and migrant workers; skilled permanent workers

*Note.* NGOs = non-governmental organizations.

system is outlined, as are the key policy drivers and actors involved in the promotion of ethanol. These summaries also provide an overview of the sustainability concerns in each country and the efforts to redress these.

## **Case Studies**

### *Brazil*

Ethanol production has a long history in Brazil, with roots firmly in the sugar industry. Sugarcane has been used to produce sugar since the 1500s, but it was not until the 1970s that the government's response to the oil crisis created industrial-scale production of ethanol from sugarcane, utilizing existing sugar industry infrastructures to improve national energy security. Since 1993, measures such as blending mandates, tax incentives, and import tariffs have ensured a large and stable domestic market; the introduction of the E25 blending mandate in 2003, alongside the introduction of flex-fuel vehicles, led to further expansion of the industry (Coelho & Guardabassi, 2014; Sorda, Banse, & Kemfert, 2010).

Brazil is the second largest ethanol producer in the world, after the United States, and has more than 400 processing mills (U.S. Department of Agriculture [USDA], 2013a). More than half of these mills are able to produce both sugar and ethanol from the sugarcane feedstock (Walter & Machado, 2014). In the 2011/2012 season, 9.7 million hectares were planted with sugarcane, producing 23 billion L of ethanol (UNICA, 2014). Sugarcane–ethanol production is dominated by large-scale companies, mainly due to the high levels of investment required to meet higher, legislated sustainability standards and to be able to compete in global commodity markets. These factors have been driving forces for economies of scale and the recent consolidation of the industry. The private sector, through UNICA<sup>1</sup> (the Brazilian Sugarcane Industry Association), and the government are the main actors in the Brazilian sugarcane–ethanol industry.

Brazil has been the focus of international concerns about the social and environmental impacts of sugarcane production. Despite the sector's historical roots in sugarcane production, these concerns concentrated around ethanol production due to raising global awareness of and interest in increased demand for biofuels. For example, the industry is renowned for harsh conditions for manual sugarcane cutters (Martinelli & Filoso, 2008; Sawyer, 2008; Smeets et al., 2008; Walter & Machado, 2014; Wilkinson & Herrera, 2010), an unfortunate legacy of the sugar industry in general. In response to these concerns, the sugarcane–ethanol sector in has become heavily regulated across social, economic, and environmental domains. For instance, Sugarcane Agro-Ecological Zoning and the Forest Code help control sugarcane expansion, protect and restore forests or land of high biodiversity value (Coelho & Guardabassi, 2014). National employment and sustainability laws have become prolific and,

while compliance and enforcement challenges remain, they are beginning to drive positive changes in the sector (International Institute for Environment and Development, 2007; Moraes, Nassarb, Mourab, Lealc, & Cortezd, 2014; Walter & Machado, 2014). For example, because many of the concerns are related to manual cutters, sustainability laws that restrict field burning and thus increase mechanization in the sector are contributing to improvements in working conditions, more job opportunities for skilled positions, and reduced health and environmental impacts (Moraes et al., 2014). While changes remain, it should be noted that wages are now often higher and conditions better for workers in the sugarcane industry than in other agricultural sectors (Blaber-Wegg, 2015; International Institute for Environment and Development, 2007).

### *Ethiopia*

Ethiopia has produced sugarcane commercially since the 1950s, although at a relatively small scale. In 2011, three sugar estates totalling 24,000 hectares were operational, with ethanol production at one sugarcane estate, with a capacity of 8 million L per year (Sugar Corporation, 2014a). After 2007, the ethanol was supplied to a transport blend but had previously been exported or used directly in the beverage industry. However, the sector is currently undergoing rapid expansion to 400,000 hectares under sugarcane and an expected 385 million L of ethanol production capacity by 2015 (Sugar Corporation, 2014b). The method of production will remain the same, with sugar as a primary product, and the resulting molasses supplied to ethanol mills.

The Ethiopian government is the key actor within Ethiopia's biofuels sector. Although the three estates were established by a Dutch company between 1954 and 1968, the collapse of imperial rule in 1975 led to the nationalization of the sugar estates (Sugar Corporation, 2015). While the estates are autonomous, the Sugar Corporation, a government ministry, is responsible for product sales. This government involvement makes Ethiopia a unique example of a biofuels system, particularly within Africa, as there is little to no involvement of private companies (Hodbod, 2013).

Sugar and ethanol are being promoted as a key aspect of Ethiopia's economic development plans and are legally supported via the *Biofuel Development and Utilisation Strategy of Ethiopia* (Ministry of Mines and Energy, 2007) and the *Growth and Transformation Plan* (Ministry of Finance and Economic Development, 2010). The biofuels strategy is unusual as it not only prioritizes domestic consumption of Ethiopian-produced ethanol over exports but also prescribes its use within both household and transport energy sectors. The use of ethanol within households aims to aid development by moving households up the so-called energy ladder, but in reality, there is little political pressure supporting this use. Furthermore, the limited demand for sugar and ethanol in Ethiopia (E10 blending is estimated to require just 31 million L) indicates that the scale of

expansion will result in excess production, and export of surplus products is expected to provide a major source of foreign exchange (Hodbod, 2013).

### *Guatemala*

Guatemala has a long history of sugarcane production but, unlike Brazil, has only recently embarked on ethanol production. In 2012, 247,000 hectares were cultivated with sugarcane (CENGICAÑA, 2013). Guatemala is the fourth largest exporter of sugarcane products globally, representing 3% of total world exports, and the second largest in Latin America, after Brazil (ASAZGUA, 2011). The USDA (2012) identified Guatemala as the strongest potential leader in Central America for the production, trade, and consumption of bio-fuels due to high yields of sugarcane (ethanol) and palm oil (biodiesel). Meeting a domestic requirement for E10 blends would require 145 million L, which, with extra processing capacity, could be met by the Guatemalan sugarcane industry (CENGICAÑA, 2012; USDA, 2013b). The sector is currently producing ethanol from sugarcane molasses on a large scale. In 2010/2011, all of the 94 million L of fuel-grade ethanol produced in the country were exported, principally to the European Union (CENGICAÑA, 2012; Tomei, 2014).

At present, there is no domestic market for biofuels in Guatemala, nor is there legislation to promote its use, despite previous governments' attempts to promote biofuels. In 1985, Decree 17/85, the Law of Fuel Grade Alcohol, was published in response to increasing petrol prices and low international sugar prices (Congreso de Guatemala, 1985). However, as sugar prices rose, and facing opposition from the hydrocarbon industry, the government failed to implement the decree. More recently, there has been renewed interest in promoting biofuels, this time driven largely by external actors, principally the Organisation of American States and via initiatives such as the Brazil–United States Memorandum of Understanding on Biofuels. Unlike the other cases presented in this article, the promotion of ethanol in Guatemala has emerged from industry, for which it represents an additional product for export, alongside crude and refined sugar. Ethanol has therefore been developed in line with an industrial strategy to diversify the product portfolio of the sugar sector.

### *Commonalities and Differences*

The earlier summaries outline the different ways in which the sugarcane–ethanol sectors in our three case study countries have evolved. Here, we examine key characteristics to reveal some commonalities and differences of three sugarcane–ethanol systems.

*Historical development.* The three countries have very different sugarcane–ethanol histories. In Brazil and Guatemala, sugarcane has been cultivated for many

centuries; yet, of the three countries, only Brazil has been producing ethanol for any significant amount of time. The size of the country also means that the scale of sugar and ethanol production in Brazil is far greater than in either Ethiopia or Guatemala. Currently, Ethiopia utilizes the smallest amount of land and accordingly produces the least ethanol. However, as outlined earlier, by the end of the expansion period, Ethiopian production is expected to surpass that of Guatemala, although progress is slow and unlikely to be completed by the planned date. An underlying driver for the rapid expansion plans in Ethiopia are the country's sugarcane yields (an average of 162 tons per hectare; Hodbod, 2013), which are among the highest in the world (Food and Agriculture Organization [FAO], 2013). However, the Ethiopian government, which controls and promotes sugarcane cultivation, processing, and demand, also places emphasis on rural development as a driver of ethanol. While ostensibly about social benefits, such rapid expansion raises concerns about the social and environmental impacts. By contrast, in Guatemala, the state is virtually absent from the sugarcane–ethanol system. Instead, it is left to private actors—specifically the country's political and economic elites who own the sugar mills and much of the agricultural land—to promote the production and consumption of ethanol; this has resulted in a focus on more profitable export markets. Brazil represents an intermediary case, wherein the national government, private sector, and other actors, such as NGOs, are involved in the governance of the sugarcane–ethanol system to some degree. For example, Solidaridad's partnership with UNICA has helped drive sustainability standards in agriculture (Solidaridad, 2013, 2014), delivery of joint retraining schemes for workers, and support for small-scale producers (Blaber-Wegg, 2015). These differences have important implications in terms of the system that develops and, of interest here, the balance of winners and losers.

*Scale and model of production.* In all three countries, sugarcane is principally cultivated on large estates, with associated sugar mills and ethanol distilleries. In Brazil and Ethiopia, there is some small-scale cultivation of sugarcane,<sup>2</sup> but economies of scale restrict their access to the ethanol sector. In Brazil, the integration of outgrower schemes that link smaller scale producers with ethanol distilleries has proved successful in some regions; a model that could be replicated elsewhere (Scholtes, 2009). However, the participation of independent producers is falling, and in 2010, around two thirds of the total area harvested with sugarcane was in the hands of industrial-scale producers (de Andrade & Miccolis, 2011; USDA, 2013a). In Guatemala, 80% of the land used for sugarcane is directly managed by the sugar mills; independent producers, themselves large landowners, account for the remaining 20% (Tomei, 2014). In Ethiopia, a small proportion (14%) of sugarcane cultivation is provided by outgrowers at one of the original estates (Wonji-Shoa Sugar Factory), but the majority of sugarcane processed by the Ethiopian sugar mills is grown on-site, in estates of approximately 10,000 hectares (Sugar Corporation, 2013, 2014b).

*Feedstock.* Both Ethiopia and Guatemala utilize molasses as the feedstock for ethanol production, a by-product of sugar processing. Hence, the sugar mills in both countries can produce both sugar and fuel without affecting production of the primary product, that is, sugar. This is important because it means that the mills are able to add value to what was previously a low value or a waste coproduct. This not only has economic benefits but also delivers improved life cycle greenhouse gas emissions (Gopal & Kammen, 2009). Conversely, in Brazil, around 75% of the sugar mills utilize sugarcane juice rather than molasses; as a result, they can only produce sugar or ethanol. Due to the high market price of sugar in recent years, sugarcane has been diverted to the production of sugar, and hence, the production of ethanol has decreased (Blaber-Wegg, 2015; UNICA, 2014).

*Mechanization.* Another key difference in the sugarcane production systems is the level of mechanization of the harvest. In Ethiopia, a key narrative has been job creation and, as a result, mechanization is limited and manual harvesting is practiced. However, this requires field burning prior to harvest, and the smoke leads to negative environmental impacts and affects human and animal health. By contrast, in Brazil, concerns about air quality have resulted in legislation to eradicate the burning of sugarcane, which is bringing major changes to the industry. In particular, the resulting increase in mechanization is expected to lead to a significant reduction in the labor force, as well as helping to tackle some of the negative environmental and social impacts associated with manual sugarcane harvesting (de Carvalho, 2012; Guilloto, Barros, Marjotta-Maistro, & Istake, 2002; Moraes et al., 2014). Guatemala presents an intermediary scenario; here, around 15% of the crop is mechanized; however, the country's topography limits the extent to which full mechanization is possible (Tomei, 2014).

*Environmental impacts.* Local environments are affected differently in the three countries, although many of the key environmental issues, such as water consumption, air pollution, and landuse change, are common to all three. As discussed earlier, air pollution is a concern in all three countries, although landscape (in Guatemala) and politics (in Ethiopia) have limited the shift away from field burning. The use of agrochemicals is also a concern, and although the requirements of sugarcane are lower than for other cash crops (Lehtonen, 2009), the aerial spraying of crops in Guatemala has negative impacts on rural communities, which are often located just meters away from sugarcane plantations. In Ethiopia, the cost of agrochemical inputs limits their utilization on sugar estates. However, also in Ethiopia, current expansion is leading to the conversion of large areas of land, which has impacts on biodiversity, greenhouse gas emissions, and water demand. Direct landuse change is less of a concern for Guatemala because cultivation is concentrated on the Pacific Coast, where export-oriented agriculture has long been centered. Within Brazil,

agro-environmental zoning has been adopted to address land use change, although enforcement of this legislation remains a challenge (Coelho & Guardabassi, 2014). In terms of water resources, within Guatemala, the diversion of watercourses to irrigate sugarcane estates, causing droughts in the dry season and flooding in the wet season, is a key environmental and social concern. Water is likely to be a key issue in Ethiopia where expansion is occurring on two river basins, the Awash and the Omo, the latter of which is raising particular concern due to its transboundary nature and key role in feeding Lake Tana in Kenya (International Rivers, 2011). Protection of waterways has become subject to stringent national laws in Brazil, alongside those protecting biodiversity more generally (Moraes et al., 2014).

*Governance for sustainability.* The Brazilian sugarcane–ethanol system is regulated across social, economic, and environmental domains, which requires high levels of investment to meet the legislated sustainability standards. Brazil has taken steps to address the human rights violations that have historically characterized the sugarcane sector, and national legislation now promotes improved working conditions for estate workers. Land zoning policies have also done much to reduce direct land use change, prioritizing the expansion of sugarcane on degraded or underutilized land (Coelho & Guardabassi, 2014). While laws exist in Guatemala to promote sustainable agricultural practices, in reality, the capacity and willingness of the state to implement, enforce, and monitor compliance of such laws is low. To supply European markets, Guatemalan sugar mills must be certified sustainable. The two mills that currently produce fuel-grade ethanol have been certified sustainable by the International Sustainability and Carbon Certification scheme; however, compliance with sustainability standards is a market rather than a legal requirement. In Ethiopia, there are some legal sustainability requirements; these are mostly social rather than environmental and, as in Guatemala, are limited by weak implementation, enforcement, and monitoring.

In the next section, we draw on our research to draw attention to the winners and losers at each stage of the sugarcane–ethanol supply chain.

## **Equity in the Promotion, Production, and Consumption in Sugarcane–Ethanol Systems**

### *Promotion*

Access to and participation in decision making is a key dimension of equity (Eames & Hunt, 2013). This factor is especially important to the promotion phase because it is at this juncture that decisions are taken that will determine the way in which the biofuel sector develops. Our research demonstrated that the specific drivers of biofuels varied according to each country, as did the actors

promoting and opposing their use. However, all three sugarcane–ethanol systems had powerful economic drivers. For example, in Brazil and Guatemala where mills are privately owned, increased domestic and international demand for biofuels had opened up opportunities to diversify production. In Guatemala and Ethiopia, where ethanol is produced from molasses, in addition to benefiting from product diversification, increased demand represented an opportunity to add value to what was previously a waste product while also removing a potential environmental pollutant. However, mills that were dependent on external biofuel markets, mainly those in Guatemala, were also exposed to the risk of fluctuations in global ethanol market prices. In Ethiopia, the sugarcane–ethanol system remains more profitable than other feedstocks and is therefore a powerful driver in the national biofuels system.

Powerful actors did not, however, always stand to win from the promotion of biofuels. For example, oil companies were potentially affected by the promotion of biofuels, primarily due to the potential reduction in market share. In Guatemala, oil companies had responded to this perceived threat through their continued opposition to plans to develop a domestic market. By contrast, in Brazil, oil companies were increasingly involved in joint ventures with sugar mills, reducing this potential conflict, but leading to further concentration and greater integration of energy and agricultural sectors. In Ethiopia, where the Ethiopian Petroleum Enterprise (a government agency) is responsible for the purchase and distribution of ethanol to petroleum companies, oil companies were relatively isolated. They were also mandated to purchase, blend, and sell the ethanol. While not typically regarded as losers, oil companies nonetheless perceived themselves to be worse off in relative terms as a result of the promotion of biofuels. Furthermore, the different strategies employed to block or foster biofuels says much about the relative power of the oil companies in each setting.

The political economic contexts thus shaped the power of different actors to influence the form of the biofuels sector. This has important implications for equity because different institutional configurations of governance will lead to different outcomes for other actors along the supply chain. Of the three countries analyzed here, Brazil is arguably the most inclusive because a wide range of actors have been purposively incorporated in the development of biofuels policy in recent years. In Ethiopia, the only actor with a voice in and power over the development of the sugarcane–ethanol sector, and therefore biofuels policy, was the national government—an influence exerted primarily via the Sugar Corporation. Although the managers of sugar mills run semiautonomous estates, they do not contribute to policy debates. In Guatemala, while the national government has expressed an interest in the development of a biofuels policy, the likelihood of a domestic mandate for biofuels was low due to the lack of buy-in from powerful actors, including those from the sugarcane sector itself, as well as oil companies. As a result, it has been left to private sector actors to determine the direction of the sector's development.

Only in Brazil do NGOs and other civil society organizations contribute to decision making on biofuels and the associated model of sugarcane cultivation. For example, through participation in the setting of international voluntary sustainability certification schemes (e.g., Bonsucro and the Roundtable on Sustainable Biomaterials) or working in partnership with the state (e.g., Solidaridad's work with UNICA: Solidaridad, 2013, 2014). This inclusion is partly a result of Brazil's longstanding history of sugarcane-ethanol production and criticisms of environmental harms and human rights violations, which have resulted in the formation of legislation and initiatives to address such issues (de Andrade & Miccolis, 2010; Duarte, Gaudreau, Gibson, & Malheiros, 2013; Oxfam, 2014). The participation of NGOs in decision making enables these actors to open up the biofuels debate within Brazil, and thus to incorporate a wider range of perspectives in policy development. Conversely, in Guatemala and Ethiopia, NGOs were typically critical of biofuels and were excluded from domestic decision-making processes. While NGOs had little input into national policy making, in Guatemala, NGOs were able to take advantage of widespread international criticism of biofuels to draw attention to the negative impacts within the country. Indeed, the impacts of the sugarcane-ethanol system on indigenous communities were taken up by a large international NGO and formed part of a campaign to lobby European policy makers place limits on the contribution crop-based biofuels can make to the Renewable Energy Directive (Tomei, 2014). This illustrates how, unable to participate in national decision making, such actors may seek alternative channels through which to influence policy debates.

To summarize, in Brazil and Ethiopia, the domestic biofuels market was politically instituted, while in Guatemala, the biofuel sector was marked by an absence of the state. These different institutional settings provided unequal opportunities for actors to access and participate in decision making. While in Ethiopia and Guatemala, this was limited to a few powerful actor groups; in Brazil, NGOs were increasingly included in efforts to improve the social and environmental outcomes, thus increasing transparency and legitimacy in decision-making processes. Therefore, of the factors influencing equity in the promotion phase, it is apparent that access to and participation in decision making is the key dimension of equity and the winners and losers result from larger structural processes.

### ***Production***

The patterns of winners and losers in the production phase will be affected by a number of place-specific factors, including economic development, job creation, land access, local environmental impacts, and the value placed on corporate social responsibility by the mill itself. Our research revealed that the main winners were the sugar mills, and associated bodies, because sugarcane and its

derivatives are the foundation of the sector. Echoing other studies which have examined the local level outcomes of biofuel feedstock cultivation (Hodobod & Tomei, 2013), we found that local communities were both winners and losers but that this depended on the spatial and temporal scales and the perspective from which an outcome was viewed.

In all three countries, the sugar mills had taken on some state responsibilities, providing schools, infrastructure, and health centers within their “zones of influence”, that is, those communities that were located near to the mills or in regions where a large percentage of the temporary workforce reside. In Guatemala, this transfer of responsibilities was argued to have contributed to an already weakened state and was creating a public sector dependent on private sources of credit. However, proximity to a sugarcane estate had also led to investment in local infrastructure with benefits for local communities in the form of direct and indirect employment and formal and informal economic opportunities. In Brazil, the presence of the mill has contributed to lower levels of poverty among local communities, and higher Human Development Index scores than in many other regions of the country (Blaber-Wegg, 2015; see also Martinelli, Garrett, Ferraz, & Naylor, 2011). In terms of job creation, our research showed that the cultivation of sugarcane offered direct and indirect employment opportunities for local and migrant communities. For example, in Ethiopia, the expansion of the sugarcane–ethanol sector was predicted to create 162,000 jobs once the 10 new sugar estates were operational (Sugar Corporation, 2015). However, while cultivation does create jobs, our research revealed the poor working conditions under which some workers were employed. Many jobs created by sugarcane cultivation remain unskilled and temporary, physically demanding, and poorly remunerated. In Brazil and Guatemala, the shift toward mechanization was expected to reduce the number of unskilled laborer positions required by the sector. In all three countries, skilled workers were argued to benefit from the expansion and consolidation of the sugarcane–ethanol sectors due to the higher chances of obtaining and retaining work. However, the opportunities for skilled workers were likely limited; in Guatemala, for example, the production of fuel ethanol had generated less than 50 additional direct jobs.

With regard to the impacts on small-scale and subsistence farmers (including pastoralists), we found that in Ethiopia and Guatemala, smallholders had lost access to land through forced evictions and, in Brazil and Guatemala, through increasing land prices which prevented small-scale farmers from buying or leasing land. As a consequence of this loss of land access, these actors were found to be suffering the loss of traditional livelihoods, lower agricultural biodiversity, and reduced food security. For example, in Ethiopia, around one quarter of the pastoralist households undergoing relocation for sugarcane cultivation had lost access to arable land used to produce cash crops. As a result, these households had to diversify their food access methods and employ more serious coping strategies in comparison with 4 years previously. In Brazil, local communities

were found to have benefited from strengthened regulation to address the environmental and social externalities associated with the cultivation of sugarcane. For example, greater regulation of social issues, such as workers' rights and employment laws, had led to higher wages, reduced working hours, and more opportunities for professional development for unskilled seasonal and skilled permanent workers. In Guatemala, the expansion of sugarcane had led to greater proletarianization; here, families had become more dependent on monetary income and paid employment. Whether these changes were regarded as a win or a loss depended on the actor's perspective, for some, they were undermining rural livelihoods, while for others, sugarcane expansion was driving the modernization of rural economies. These contrasting narratives highlight the inherently subjective nature of wins and losses.

Mill owners in both Brazil and Guatemala benefited from sustainability certification, which provided a powerful rejoinder to those who questioned the sustainability of their production. For others, specifically in Guatemala, this was criticized by critics of the sugarcane–ethanol sector who argued that certification effectively negated the concerns of local communities. In Brazil, regulation had other unintended consequences, particularly for outgrowers and small-scale farmers of sugarcane, who were less able to meet the cost of compliance and accreditation. This was identified as a risk for these actors due to their reduced ability to compete, which was expected to lead to further concentration of the sector. Concentration was also a feature of the Guatemalan sugarcane sector, which some actors viewed as a natural progression wherein those who were able to adapt would survive and those who could not would be overtaken by their competitors. In terms of equity, it is unclear what impact greater sectoral concentration will have on the distribution of wins and losses. While it clearly leads to a greater concentration of power, with fewer actors able to participate in decision making, the “weeding out” of those mills which are unable to meet stricter sustainability criteria would presumably have positive outcomes. However, this too is dependent on whether such schemes are able to capture those issues that matter most to local people, which our and other research has indicated it does not (Hunsberger, Bolwig, Corbera, & Creutzig, 2014; Palmer, 2014; Tomei, 2014).

As discussed earlier, the cultivation of sugarcane has largely negative outcomes for local environments, although we found that in Brazil and Guatemala regulation and certification had driven improvements in environmental management. The spatial dimension of equity is especially relevant to environmental issues. For example, in all three countries, while local workers arguably benefitted from employment on sugarcane plantations, they and their communities also bore the environmental costs of disrupted water flows, land degradation, and air pollution. These environmental impacts were not felt by migratory workers and their communities. Similarly, while field burning prior to harvesting is being phased out within Brazil, burning continues to have negative

environmental and health impacts in all three countries, which affect actors not directly associated with sugarcane estates. Efforts to address the negative environmental impacts may not, however, always benefit those who are most affected. In Guatemala, for instance, increasing concern about climate change had led the sugar association to fund research into water management, although this was found to be more likely to benefit upstream communities.

During the production phase, there is a more complex distribution of winners and losers which affect a wider range of actor groups. Where decision making in the sugarcane–ethanol system is concentrated in the hands of the minority, we see that some losses are acceptable; for example, in Ethiopia and Guatemala, the net benefits (in terms of profit) outweigh the losses, which are mainly felt by marginalized local communities. The lack of recognition of the impact on marginalized groups is again a product of these countries' complex political economic structures, and therefore influences the distribution of wins and losses. In Brazil, by comparison, there is a more egalitarian approach, and losses are increasingly deemed to be unacceptable. Therefore, legislation and regulation, for example, in the form of sustainability certification, have been introduced to ameliorate some of those losses.

### *Consumption*

For biofuel proponents, there are many actors who stand to benefit from the consumption of biofuels due to their posited beneficial impacts on climate change and local and national energy security. However, with regard to the consumption phase, we found a mixed picture.

Whether an active proponent or a bystander of biofuels, national governments were winners in all three cases. These benefits occurred through two mechanisms: first, reduced foreign exchange on oil products; and second, through increased export earnings and tax revenue. The proportion of economic benefit differed across the three countries due to different levels of consumption and exportation. For example, the Guatemalan government benefited from export earnings, whereas in Brazil, the federal government benefited from reduced foreign exchange. Due to the low levels of petroleum consumption in Ethiopia, ethanol substitution was expected to create some foreign exchange savings, but the savings were estimated to be less than 1% of the annual oil import bill (Hodbod, 2013). However, with the planned expansion, the government (as the main trading actor) stood to create huge export earnings, as exporting all the excess ethanol was expected to create export earnings of US\$550 million post-2015, thus increasing national export earnings by 15% (Hodbod, 2013). Therefore, as the Ethiopian government owns the sugar and ethanol mills in Ethiopia, they were the main beneficiary of the ethanol consumption phase.

With regard to the end consumers, our research suggested that the outcomes were mixed. Although a common theme within the biofuels literature is the

potential for energy security benefits at the local scale (e.g., Nuffield Council on Bioethics, 2011), this was only found in one of our case studies. In Ethiopia, local communities were encouraged by the mill managers to make use of the agricultural residues, which they used as fuel and fodder. In none of the cases was there local consumption of the ethanol produced in nearby mills. Rather, we found that all of the ethanol produced went either to the national market or was sold as part of large-scale, international contracts. Although Ethiopia was the only case study country which posited an alternative energy market for ethanol — in household stoves — our research found that stove adoption was minimal due to the prohibitive cost of stoves.

Other potential end users were domestic consumers in Brazil and Ethiopia, who directly benefited via reduced price volatility and, less tangibly, from being buffered from potential import shortages, that is, increased energy security. Some stakeholders also felt consumers benefitted from the use of a more sustainable fuel source; however, this was not an opinion that was shared by all. This links to another equity issue that is not often discussed in the biofuels literature but one raised by O'Brien and Leichenko (2003)—that of choice in the engagement with a phenomenon. Our research showed that end users in the United Kingdom were generally unaware that they were consuming biofuels when filling up their vehicles (Blaber-Wegg, 2015; see also Bailis & Baka, 2011; Delshad, Raymond, Sawicki, & Wegener, 2010; Upham, Dendler, & Tomei, 2013). Despite skepticism about the benefits of biofuels, because blending of biofuels with petroleum takes place further up the supply chain, in practice, consumers have little choice about whether they consume biofuels.

It appears that lack of opportunities to engage in decision-making processes, as outlined in the promotion and production phases also, impacts the shape and nature of the distribution of outcomes in the consumption phase. However, the triple bottom line (i.e., environmental, economic, social sustainability) objectives of biofuel consumption are not being realized. Rather, the benefits principally pertain to the economic dimension, and the most powerful actors who control promotion seem to be the only beneficiaries from consumption.

## **Discussion and Conclusion**

Accepting that winners and losers are SPG (O'Brien & Leichenko, 2003) has facilitated this analysis into the ways in which different actors are affected by the promotion, production, and consumption of sugarcane–ethanol systems in three different regional settings. As identified earlier, there are a number of factors that influence equity outcomes for different actors (Eames & Hunt, 2013; O'Brien & Leichenko, 2003). This analysis has revealed complex drivers, commonalities, and differences across the three case studies in relation to these factors. In all cases, an uneven distribution of winners and losers has been

exposed, shaped by the different political contexts and institutional, regulatory or business arrangements:

- *Brazil*: Initially entirely government-led, but now mainly driven by the private sector through the trade association, UNICA. There is some civil society input, and social and environmental issues are an explicit part of the policy framework.
- *Ethiopia*: Government-led, as sugarcane–ethanol is an important strategy for national economic development. The focus on the economic benefits of sugarcane–ethanol has led to environmental and social harms, which is also a result of weak sustainability regulation.
- *Guatemala*: Private sector-led, with few social and environmental benefits. Sectoral policies to address the sustainability impacts of production are largely a result of global market demands.

Despite the different political economic contexts of each case study country, Brazil, Guatemala, and Ethiopia, it is possible to draw some high-level conclusions about the equity outcomes.

First, identifying who wins and who loses in these different contexts is dependent on a number of factors, which include the spatial and temporal scale of analysis, the perspective from which a win or a loss is viewed, and the phase of the supply chain. As a result, it is not possible to unequivocally state that a particular actor will always be a winner or a loser. Oil companies provide one example: These powerful actors are not typically regarded as losers; yet, they stand to lose from increased demand for biofuels. Our cases show that these actors have responded in different ways: In Brazil, oil companies have invested in distilleries, while in Guatemala, these actors have been active opponents of the establishment of a domestic biofuels market. Acknowledging that powerful actors can also be losers is important, not least because the strategies they employ to address their perceived losses will have consequences for other actors. Another example relates to job creation, which is often cited as a socio-economic benefit of increased biofuel production. While the expansion of sugarcane–ethanol systems in the three countries has led to employment opportunities, our analysis has raised questions about the types of jobs that are created. Many of these jobs will be unskilled and temporary and are typically poorly remunerated and physically demanding. Whether the provision of such employment in areas which are often characterized by high levels of poverty is a positive or a negative will depend on the perspective from which it is viewed.

Second, it should not be assumed that because the sugarcane–ethanol sector is motivated by socioeconomic drivers, it will deliver positive outcomes for all. This is particularly true for Ethiopia, where sugarcane expansion is viewed as a path to economic development, and one that is expected to benefit the majority of the country. Furthermore, the explicit focus on the provision of ethanol for

household cooking, with positive implications for health and deforestation, highlights the government stated focus on the microlevel benefits. However, our analysis has revealed that in practice not only is this latter driver neglected but also that the losses borne by pastoralist and agro-pastoralist communities are accepted. It is therefore important to study the equity outcomes of the promotion phase as it is where the direction of biofuel development is defined; even when the aims, motivations, and drivers of biofuel policies are ostensibly social, this will not necessarily lead to more equitable outcomes. There are complex reasons why this is the case, many of which are beyond the scope of this article to discuss; however, it is vital that those seeking to understand the outcomes of sugarcane–ethanol, and other biofuel, systems should not look at the stated policy intentions alone when reaching a conclusion about whether a system will be more or less equitable. As this analysis has shown, how these policies are implemented matters. The sugarcane–ethanol system driven by private sector actors appears to result in very similar equity outcomes as the state-driven system in Ethiopia.

It is therefore critical to understand the political economic contexts within which such developments are taking place. In Brazil, where the sector has been driven by energy security concerns, the outcomes have been mixed and have changed as the system has evolved and matured, particularly as sustainability regulation has become more stringent and pressure from national and international stakeholders has increased. This highlights the difference between utilitarian and egalitarian approaches to addressing winners and losers from sugarcane–ethanol systems (O'Brien & Leichenko, 2003). In both Ethiopia and Guatemala, it is apparent that some losses are acceptable, given the net benefits to society and economy. The loss of traditional livelihoods is perhaps even to be welcomed in these countries, where sugarcane–ethanol systems are seen as a strategy for agricultural modernization and economic growth. In Brazil, there appears to be a more egalitarian approach, wherein the sector's poor history of human rights and environmental degradation is now beginning to be redressed. While the mill that was the focus of the Brazilian case study is perhaps atypical, because sustainability principles have been a core element of the case study mill's business rationale for some time, it nonetheless indicates an approach that can help address inequalities.

Finally, and related, is the incorporation of different voices in the decision making and wider governance of the sugarcane–ethanol system. While none of the systems may be called equitable as all have an uneven distribution of winners and losers, Brazil has done the most to address the equity concerns of the sugarcane–ethanol system and—while not perfect—now has the most open decision-making processes. Multi-stakeholder initiatives enable the incorporation of more voices but alone are unlikely to drive (equity) improvements. While unequal power relations inevitably mean that some actors will have more influence over these processes, the inclusion of more voices means that the

perspectives of different actors are afforded recognition. Ethiopia and Guatemala again represent an alternative situation, wherein power resides with just a few actors—the government in Ethiopia, and the sugarcane–ethanol elites in Guatemala. The exclusion of less powerful and typically more critical voices means that the systems that are developing in these countries reflect the interests of a powerful minority. Indeed, biofuels do little to change the current agricultural, energy and transport paradigms, instead encompassing the same actors and the same materiality. Thus, despite differences across the three cases, the poorest and most marginalized actors tend to be those that bear the greatest proportion of the costs associated with sugarcane–ethanol systems, particularly within the production phase. These actors are also those who are afforded least recognition in decision-making processes.

This article has provided a comparative analysis of the equity outcomes of sugarcane–ethanol systems in Brazil, Ethiopia, and Guatemala. Acknowledging that winners and losers are SPG (O'Brien & Leichenko, 2003), we have drawn attention to the wins and losses for different actor groups along the different phases of the sugarcane–ethanol supply chain. While this approach risks losing some of the nuance that a place-specific analysis would reveal, we believe that such a comparison is important in revealing the factors that can shape the equity outcomes in different settings. In particular, we have highlighted the importance of incorporating multiple voices into decision-making processes, and particularly those of marginalized and less powerful actors. If biofuel systems are going to deliver opportunities for the poorest and local communities, these communities will need to be incorporated so that their needs are taken into account. Our analysis highlights the need to pay attention to the multiple perspectives from which a win or a loss is viewed, across spatial and temporal scales, to reveal more nuanced patterns of winners and losers.

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### **Notes**

1. União da Indústria de Cana de Açúcar.

2. The definition of smallholder differs between countries and with agro-ecological zones. For Ethiopia, 60% of smallholders cultivate less than 1 hectare of land (International Food Policy Research Institute, 2011); in Guatemala, smallholders cultivate less than 3.5 hectares (Instituto Nacional de Estadísticas, 2004), while in Brazil, the size of a smallholder's farm will vary across the states but may be as much as 50 to 100 hectares (Scholtes, 2009).

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## Author Biographies

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**Dr Julia Tomei** is a Research Associate at UCL-Energy whose research interests focus on the social and environmental dimensions of energy, particularly in the global South. Her PhD research investigated how European biofuel policy influences the political ecology of biofuels in Guatemala, and the subsequent outcomes for national and local sustainable development. She has more than 8 years research experience and is skilled in both qualitative and quantitative methods having previously worked as a research assistant on a range of projects related to energy, environment, and society. She has published in the academic and nonacademic literature and has worked on a wide

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**Tina Blaber-Wegg** studied for her BSc (Hons) Environmental Sciences degree at the University of East Anglia (UEA) and followed this with a PhD research, exploring equity issues along an international (Brazil–UK) sugarcane-bioethanol supply chain, funded by the UK Energy Research Centre (UKERC). Tina’s research interests include the application of environmental justice concepts in energy systems. Tina’s PhD research findings suggest that attention to equity issues can help improve the social acceptance of renewable energy technologies because addressing matters of procedural justice, distributional justice, and recognition help ensure energy is provided by the types of sustainable and equitable systems that people want.