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WORKING PAPER

ENDING TROPICAL DEFORESTATION: A STOCK-TAKE OF PROGRESS AND CHALLENGES

THE GLOBAL DEBATE ABOUT BIOFUELS AND LAND-USE CHANGE

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KEY POINTS

- There is increasing global demand for biofuels in both industrialized and developing countries, which is driving conversion of forests and other native ecosystems to grow food crops used for biofuels feedstocks.
- There are three competing views regarding how substituting biofuels for fossil fuels impacts climate emissions. The first sees burning plants as inherently beneficial because it is "carbon neutral"; the second views burning plants as conditionally beneficial if impacts on land-use change are taken into account; and the third asserts that burning plants is nearly always bad for the climate.
- Current biofuels policy debates center on the importance of accounting for emissions from indirect land-use change induced by the use of crops for biofuels feedstocks, and ensuring that new sources of demand for biofuels—including from the aviation and shipping industries—are accompanied by adequate sustainability standards.

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THE ISSUE

The biofuels industry has grown rapidly in the past decade, driven by government blending requirements and clean fuels standards in major economies.[1] There is potential for significant new demand for biofuels from the aviation sector, which is looking for ways to meet its goal of carbon neutral growth by 2020, and from the maritime sector, which recently announced greenhouse gas (GHG) emission reduction targets. The ways these policies account for reductions in GHG emissions from biofuels are disputed. One particular area of controversy is the role biofuels play in driving tropical deforestation.

WHY DEMAND FOR BIOFUELS IS IMPORTANT TO FORESTS, CLIMATE CHANGE, AND DEVELOPMENT

The global biofuels industry represents a large and growing source of demand for food crops as feedstocks, including corn, sugarcane, rapeseed, soybeans, and palm oil. Expansion of the land area dedicated to production of several of these crops, including soybeans in Latin America and palm oil in Southeast Asia, is a significant driver of tropical deforestation, and in the case of palm oil, conversion of carbon-rich peatlands to plantations. Accounting for the GHG emissions associated with biofuels, and thus the degree to which they are part of the problem or the solution to climate change, is the subject of considerable controversy.

Biofuel policies have also been associated with adverse social impacts on poor communities in developing countries, including through the mechanism of increased and more volatile food prices (Elliott 2015), and increased incentives for land grabbing (see, for example, Matondi et al. 2011). Further elaboration on these issues is beyond the scope of this paper.

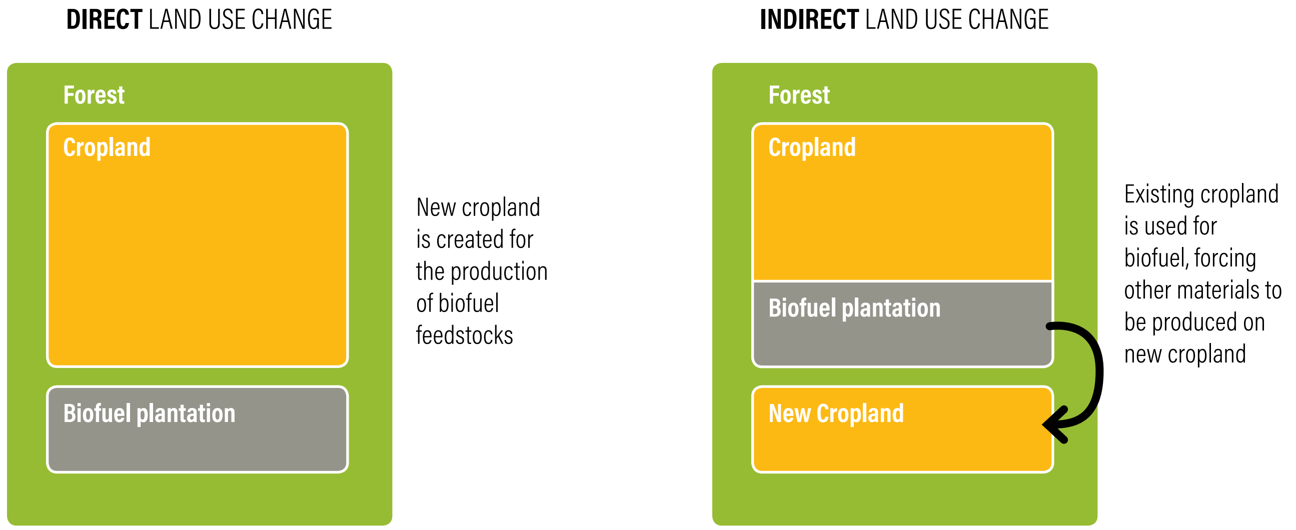
Three competing views about the carbon benefits of biofuels

As nations search for politically feasible and economically rational strategies to reduce their GHG emissions in the face of mounting threats from climate change, governments have positioned biofuels as part of the transition away from liquid fossil fuels. Currently, the vast majority of biofuels are produced from food-based crops, including ethanol from corn or sugarcane and biodiesel from soybeans, palm oil, rapeseed, or other vegetable oils. Biofuels provide a technology-ready alternative to fossil fuels that can support domestic industries, especially agriculture. There is general agreement that biofuels from true organic wastes (materials that would otherwise be thrown away) reduce GHG emissions, but there are three competing views regarding whether biofuels from food crops, and even energy crops, reduce GHG emissions.

The first view is that biofuels are an inherently carbon-free source of energy, typically referred to as “carbon neutral,” apart from the GHG emissions from the fossil fuels and trace gases released in their production. Advocates of this view agree that burning biofuels releases the same or more carbon dioxide as burning fossil fuels per unit of energy, but argue that these emissions do not add carbon to the atmosphere because they are recycling carbon that was removed from the air by plant growth. This view underpins lifecycle calculations that find burning biodiesel from vegetable oils releases fewer emissions than burning ethanol from grain. This view supports higher estimates of global bioenergy potential because those crops are viewed as carbon neutral regardless of where they are produced. Scenarios supported by such estimates tend to apply “sustainability” standards to protect biodiversity or high value ecosystems, but still allow for hundreds of millions of hectares of land for energy crop production (Searchinger et al. 2017).

A second view also starts with the premise that biofuels are carbon neutral, but attempts to factor in changes in carbon storage capacity on the land required for biofuel feedstock production. As in the first view, the emissions of carbon that come from burning the ethanol or biodiesel (or fermenting the plants) are not counted. However, if biofuels are grown by directly clearing forest or other areas with native vegetation, the loss of the carbon from the cleared land is counted. In addition, if the biofuels use either food or energy crops grown on cropland, this view uses economic models to estimate how much carbon is lost elsewhere due to indirect land-use change (ILUC), illustrated in Figure 1. ILUC takes place when crops grown on existing agricultural land are diverted from use in food, feed, and fiber to be used as biofuels feedstock. Such diversion raises the overall demand for the crop, often increases prices, and can lead to cropland expansion elsewhere to increase supply. ILUC refers to this cropland expansion, which can occur in a nearby geography or another country. The increased demand for the biofuels feedstock can also increase demand for another crop that is a substitute for the original crop, leading to increased

Figure 1 | **Illustration of Direct and Indirect Land-Use Change**



Source: Takriti et al. 2016.

production of the substitute crop elsewhere. These effects are indirect because biofuels are not produced directly from the crops grown on the newly converted cropland, but rather such production causes land-use change elsewhere through market effects.

Different ILUC models tend to produce highly variable results. For example, the Global Trade Analysis Project (GTAP) general equilibrium model used by California's Low Carbon Fuel Standard (CARB 2016) estimates that biodiesel has higher GHG emissions than ethanol from maize, whereas the Food and Policy Research Institute (FAPRI) and Forestry and Agricultural Sector Optimization Model (FASOM) partial equilibrium models used by the U.S. Environmental Protection Agency (EPA 2010) project that biodiesel has lower emissions than ethanol. In 2016, the European Commission published a report designed to provide more research and insight into the issue of ILUC from biofuels consumed in the European Union. The report used the Global Biosphere Management Model (GLOBIUM), which generated estimates that showed very low emissions for maize and very high emissions for biodiesel (Valin et al. 2015). Furthermore, these models can show that dedicated energy crops will have low emissions because of the assumption that such crops will be grown on some category of "marginal" land with low carbon storage capacity.

The third view asserts that there is an additionality or double-counting error implicit in the first two views—that they do not take into account the opportunity cost of the land. The logic of this view posits that the land grows plants, and whether those plants are used for biofuels or not, the land is providing a carbon removal service to the atmosphere. If the opportunity costs of the land are considered and optimized for the climate, then the sequestration that occurs after a bioenergy feedstock has been harvested would not be considered additional (i.e., the sequestered carbon would not offset the carbon released in the burning of the biofuels). Hence, counting the opportunity cost of land would most often show that dedicating land to produce bioenergy is a bad climate strategy.

One such opportunity cost is using land to produce food. Because food consumption is rising and food production is competing for land (Alexandratos and Bruinsma 2012), proponents of this view argue that demand for biofuels will ultimately always require more clearing of forests and savanna. If it is assumed that spare land is available, using such land for bioenergy crops to displace fossil fuels comes at the expense of not allowing that land to reforest and sequester carbon. The opportunity cost of not allowing land to reforest (lost carbon sequestration) is a cost of using land to produce bioenergy feedstocks. The net effect of bioenergy use is therefore either more carbon in the air or at best only a small reduction compared to fossil fuels. Proponents of this view also argue that solar energy technologies are a more efficient use of land because they can generally produce 100 or more times the energy per hectare as bioenergy crops.

These three views result in dramatically different estimates of the GHG consequences of biofuels and their potential contributions to reducing the emissions that cause climate change. The first view regards burning plants as inherently beneficial, the second view regards burning plants as conditionally beneficial, and the third view regards burning plants as nearly always bad. The debate increasingly focuses on the opportunity costs and global competition for land. Some advocates of the first view disagree with counting ILUC because they claim that the model results are too uncertain. Others claim that the second view assigns responsibility for ILUC emissions to the biofuel producer (and the farmer supplying the biofuel) that should instead be assigned to the farmers clearing the new cropland.

There are some areas of agreement among the three views. All agree that growing plants is good for the climate. There is also agreement on the potential to use at least some organic wastes (such as used cooking oil) as biofuel feedstocks. Advocates of the third view tend to agree with advocates of the second view that, in theory, an accurate ILUC estimate could get the accounting right, but claim that ILUC does not account for the true opportunity cost of land. Advocates of the third view also tend to agree with those supporting the first view, that economic models cannot accurately predict ILUC because the models depend on hundreds of parameters that have not and cannot be estimated with accuracy.

The remainder of this brief will not attempt to resolve the three contrasting views described above, but instead will focus on current policy debates over biofuels and their impacts on land use and carbon emissions. In particular, we focus on three key ideas:

1. Policies are currently driving market expansion for biofuels.
2. The views of the environmental community and policymakers on the impacts of growing demand for biofuels have evolved over time.
3. As current policies are revised and new policies are put in place, it is increasingly important to “get it right” and ensure that policies adequately account for the climate impacts of biofuels.

Box 1 summarizes the issues related to the use of wood for bioenergy, which will not be treated further.

Policies driving growth in biofuels

Although over 60 countries now have biofuels mandates or subsidies (Wise and Cole 2015), the three largest markets for biofuels—the European Union, United States, and Brazil—have been the primary drivers of market expansion and trade in biofuels feedstocks over the past decade.

The EU’s Renewable Energy Directive

The EU’s 2009 Renewable Energy Directive (RED) requires member states to secure 10 percent of their transportation fuels from renewable sources by 2020. The Fuel Quality Directive requires a carbon intensity reduction for transportation fuels of at least 6 percent by 2020. Neither directive has incorporated accounting for ILUC, and both mandates have been largely met by food-based biofuels. In 2015, biofuels accounted for 4.2 percent of EU’s transportation energy, roughly 80 percent of which was from biodiesel.

Much of the biodiesel being used in the EU is derived from palm oil, which has a high ILUC value. Around 46 percent of palm oil imported into the EU is used for biodiesel (OilWorld, as cited in T&E 2016). The overall composition of biodiesel feedstocks used for biofuels production in the EU (i.e., not including biodiesel that is refined elsewhere and imported into the EU) is shown in Figure 2. Particularly because much expansion of palm oil plantations has occurred on peatlands in Indonesia and Malaysia, this direct reliance on palm oil has led to concerns in Europe that its policies are encouraging carbon and biodiversity losses in Southeast Asia.

In 2015, the EU amended its RED to limit the share of biofuels produced by food-based crops to 7 percent by 2020. In November 2016, the European Commission proposed discontinuing the overall transportation fuel target and phasing down crop-based biofuels to 3.8 percent by 2030. The Parliament rejected this proposal in favor of the existing 7 percent cap on food-based biofuels. In January 2018, the EU Parliament voted to phase out the crediting of palm oil as a renewable transport fuel by 2021. Both of these proposals are currently under discussion and will be resolved in late 2018 as the RED II is finalized.

Box 1 | Forest Biomass and Bioenergy with Carbon Capture and Storage: Growing Issues

Challenges similar to those associated with biofuels pertain to the use of woody biomass as a renewable energy source, primarily to generate heat and power. Like biofuels, biomass markets are driven by policies designed to reduce GHG emissions and are based on the assumption that burning biomass is carbon neutral.

Europe has long been the largest import market for biomass. The European Union's 2009 Renewable Energy Directive (RED) and accounting framework for land-based emissions explicitly account for woody biomass as a carbon-neutral source of energy. As a result, European imports of wood pellets from the United States, Eastern Europe, and other places have increased significantly over the past decade. Biomass markets are also opening in Japan and South Korea, threatening forests across Asia.[a] Both Japan and South Korea now have feed-in tariffs favorable for renewable energy from biomass and aggressive growth targets for biomass energy production.[b]

Researchers who view biomass for energy as carbon neutral often favor this use of forest biomass, as long as forests are not converted to other uses following harvest. Many scientists argue that harvesting forest material is harmful because when burned, trees generate more CO_2 emissions per unit of energy generated than fossil fuels; harvesting trees for energy releases carbon that otherwise would have remained stored in the forest, and the sequestration of released carbon back into biomass typically takes decades to centuries,[c] during which time carbon in the atmosphere contributes to global warming.

On the international climate policy front, bioenergy has taken on a very significant role. Many integrated assessment models (IAMs) rely on the extensive use of bioenergy with carbon capture and storage (BECCS) to limit climate change to below 2°C. However, the deployment of BECCS at scale is highly uncertain, and assessments have not fully considered the potential land constraints and the spatial colocation of suitable storage and biomass availability required to do so.[d] Other papers claim that the estimates of biomass availability for BECCS are mostly based on double-counting of land.[e]

Sources: a. ITA 2016; b. Du Plessis 2015; c. Hanson and Ranganathan 2017; d. Field and Mach 2017; e. Searchinger et al. 2017.

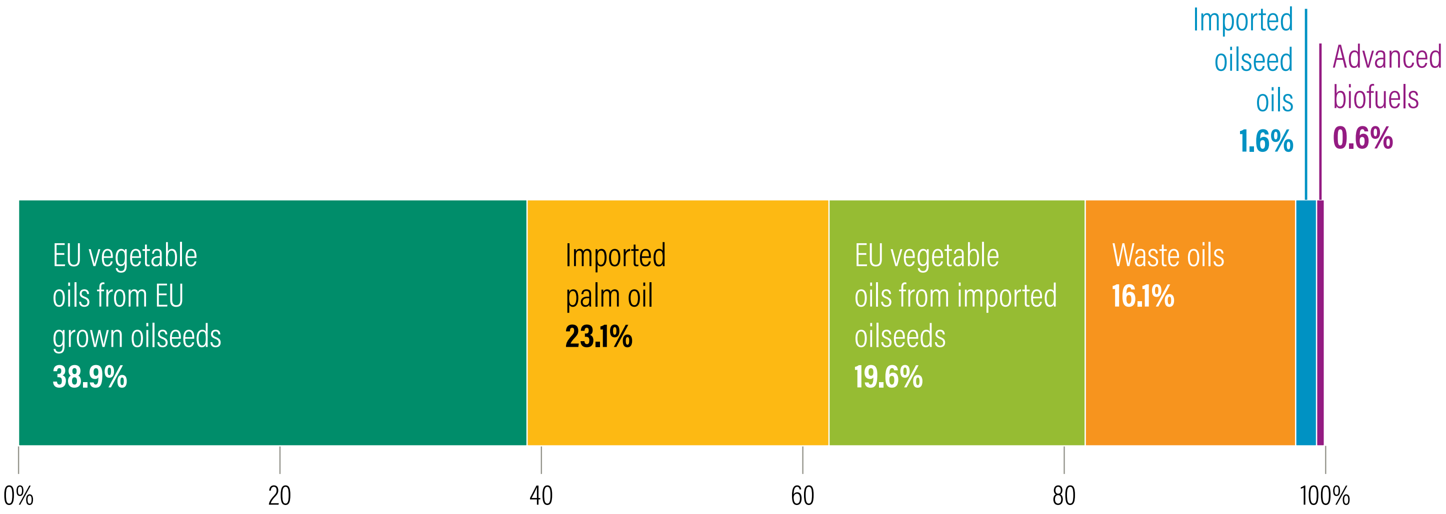
The U.S. Renewable Fuel Standard

The U.S. Renewable Fuel Standard (RFS) was authorized under the Energy Policy Act of 2005 and expanded under the Energy Independence and Security Act of 2007. It sets volumetric targets for renewable fuels, aiming for 36 billion gallons by 2022, with specific targets for different fuel categories. The initial quota for 2022 was set to allow a maximum of 15 billion gallons of corn ethanol, with the rest to be supplied by "advanced biofuels," which include virtually any biofuel other than corn ethanol. The RFS sets a target of 16 billion gallons of cellulosic ethanol, although the government has viewed that goal as subject to waiver (Energy Policy Act of 2005; Energy Independence and Security Act of 2007).

The RFS has been a significant driver of corn ethanol production, which grew by about 80 percent between 2007 and 2017 (USDA FAS 2017), increasing the amount of U.S. corn being used for ethanol. U.S. biodiesel production, largely based on virgin vegetable oil feedstocks, grew by roughly 300 percent in the same period (CSS 2017). In 2016, corn-based ethanol accounted for roughly 80 percent of the RFS volumetric mandate, with food-based biodiesel making up most of the remainder. That year, nearly 40 percent of U.S. corn was used for ethanol production and about a quarter of U.S. soybean oil was used for biodiesel (USDA ERS 2016; USB 2017). In contrast, the production of cellulosic ethanol and other non-food-based biofuels has lagged far behind growth projections and mandates due to technical and cost challenges (Schnepf and Yacobucci 2013). Some promising waste-based feedstocks exist (e.g., landfill methane, manure methane), but none have become commercially viable for producing liquid fuels at a significant scale.

In 2012, the U.S. Environmental Protection Agency (EPA) ruled that palm oil-based biofuels do not meet the minimum RFS GHG lifecycle emissions reduction threshold of 20 percent compared to emissions from fossil fuels (EPA 2012). However, it allowed facilities that commenced construction before December 2007 to continue to secure renewable fuel credits for palm oil-based biofuels (EPA 2011).

Figure 2 | **Feedstocks Used for EU Biodiesel Production, 2015**



Source: T&E 2016.

In the United States, growth in corn ethanol is currently limited by the "blend wall," which reflects the current mandate of 10 percent ethanol mixed into conventional gasoline. Up to 15 percent ethanol blended gasoline is allowed, except in summer months when air quality standards are higher. The primary limitation of gasolines with ethanol blends is that they have higher vapor pressures than conventional gasoline, and therefore increase harmful evaporative emissions. The EPA grants a waiver to these fuel quality standards for E10 (i.e., 10 percent blends), but so far has not granted waivers for higher blends of ethanol for year-round use. However, states are starting to apply for waivers from the EPA to allow year-round sales of 15 percent ethanol blends. These waivers, along with potential future regulatory decisions on the part of the EPA and changes to the RFS legislation, could increase the market for corn ethanol.

While U.S. legislators have generally been reluctant to revisit the RFS, there seems to be new appetite among the current U.S. Congress for revising the legislation. On March 8, 2018, U.S. Congressman Peter Welch and Senator Tom Udall introduced the GREENER Fuels Act, which would ramp down the ethanol mandate between 2023 and 2030, cap biodiesel as a general category, put specific limits on virgin vegetable oils, improve and extend supports for the best-performing biofuels (e.g., cellulosic, landfill gas, wastes, and residues), and end the mandates for biodiesel in 2030 (Udall 2018). Although this bill does not have bipartisan support and is unlikely to pass, it establishes one position for change.

California's Low Carbon Fuel Standard

Under California's Low Carbon Fuel Standard (LCFS), the overall carbon intensity of the statewide fuel blend must ratchet down by 10 percent below 2010 levels by 2020, covering all of California's transportation fuels (CARB 2014). The LCFS offers a policy framework for GHG accounting that includes ILUC but takes a different approach to that of the EU and EPA. Fuels compete on their carbon intensity based on a complete lifecycle analysis that includes ILUC, rather than being supported or constrained by volumetric mandates or caps. Carbon intensities of fuels are calculated using Argonne National Laboratory's Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation (GREET) model and the GTAP model for both DLUC and ILUC (CARB 2016). In this way, the LCFS encourages the use of biofuels that these models estimate to have lower GHG emissions, such as sugarcane ethanol rather than corn ethanol.

Oregon's Clean Fuels Standard is modeled on California's LCFS, and was implemented in 2016 (DEQ 2017). A proposed clean fuels bill, also based on the California LCFS model, is under discussion in Washington State (Le 2018).

Brazil's biofuels industry

Brazil was the first country to establish a biofuels policy (25 percent ethanol blend in gasoline) and has the second largest market for biofuels globally, after the United States. Its market is almost exclusively supplied by domestic sugarcane (Wise and Cole 2015). Sugarcane is a highly efficient energy crop due to its high yields and high energy density, meaning that it is an attractive option from a GHG reduction perspective, as long as it is not driving land-use change directly or indirectly. Brazilian sugarcane is almost exclusively grown in the south and central regions of the country, where it is not a proximate cause of deforestation. In normal years, Brazil does not provide a major market for other countries that produce biofuels or biofuels feedstocks, nor does it export much of its ethanol. Studies have found that some sugarcane expands directly into cropland and some into pasture (Egeskog et al. 2014), and there is an active debate in the research literature about whether Brazilian sugarcane ethanol is encouraging deforestation in Brazil (Lapola et al. 2010). Some studies claim large effects (Lapola et al. 2010), while others claim small effects (Ferreira Filho and Horridge 2014; Andrade de Sá et al. 2013).

Indonesia's biofuel mandate

Indonesia's domestic biofuels market is poised to become one of the fastest growing in the world if its targets are met. In 2015, the Ministry of Energy and Mineral Resources (MEMR) increased the blend target for biofuels in diesel gasoline to 15 percent. The target increased again to 20 percent in 2016 and is set to rise to 30 percent by 2020, one of the most ambitious in the world (Malins 2018). If achieved, Indonesia's annual biodiesel consumption would rise to nearly 19 billion liters (up from a production level of 3.7 billion liters in 2016) (Jong 2018; Kharina et al. 2016). Indonesia's biofuels industry is supported by a fee on crude palm oil (CPO) exports. Despite subsidies, Indonesia has not been able to meet its mandates due to low oil prices and vehicle infrastructure that is not compatible with such high levels of biodiesel (Kharina et al. 2016). Palm oil plantations in Indonesia are required to comply with the Indonesian Sustainable Palm Oil (ISPO) certification scheme, which covers GHG emissions, land use, biodiversity, and labor. However, plantations that supply palm oil for biodiesel are specifically exempt from ISPO compliance (Kharina et al. 2016).

Policies in other countries

Beyond the EU, U.S., Brazil, and Indonesia, dozens of countries have adopted mandates for biofuels. Most of these are fairly small in total volume and aimed at providing subsidies to domestic refineries and agricultural industries and reducing dependence on imported oil. In Canada, however, a national clean fuels standard is under development. The Canadian Clean Fuel Standard (CFS) aims to reduce carbon pollution by 30 Mt CO_2e annually by 2030. To date, Canada's CFS has not taken the issue of indirect land-use change into account, risking that the policy will lead to distorted incentives for a range of biofuels feedstocks and will over-report its GHG emissions reductions (Searle 2018).

Potential growth

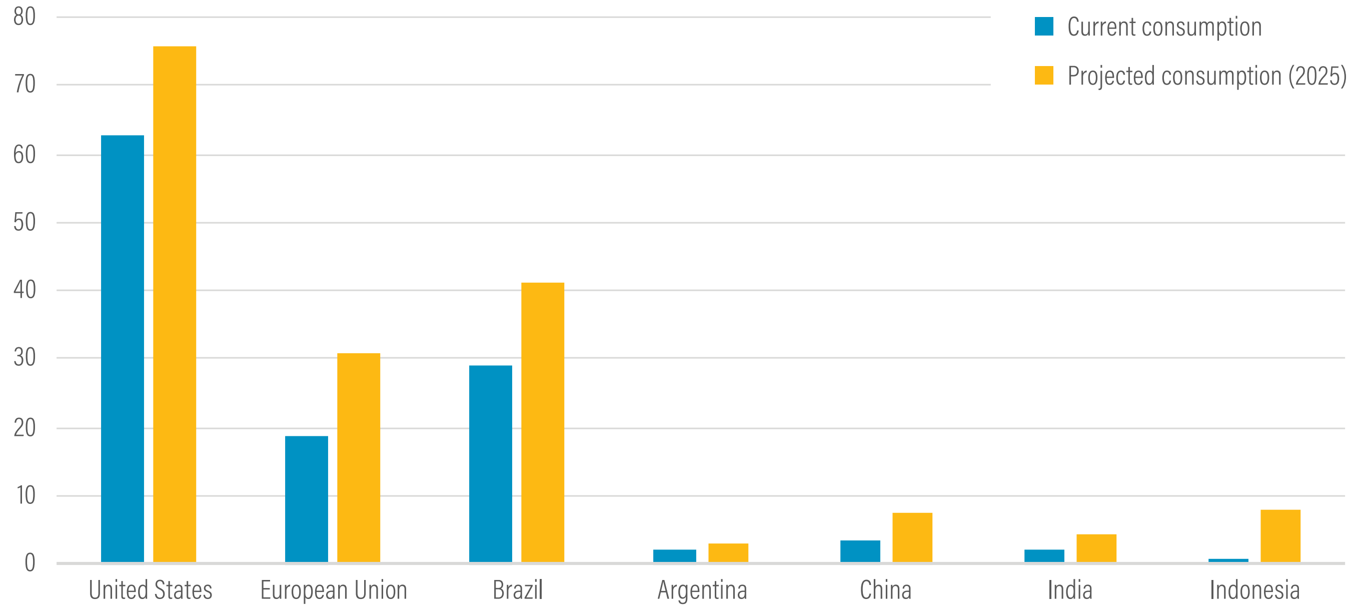
Despite discussion of various limitations, existing policies could still drive a substantial expansion of biofuels. According to a 2015 review, if existing mandates are fully met in the seven largest biofuel consuming markets (U.S., EU, Brazil, Argentina, China, India, and Indonesia), first generation biofuel consumption could grow to 43 percent over current levels by 2025 (Wise and Cole 2015) (see Figure 3).

Shifts in opinions about biofuels

Evolution in the views of the environmental community

A decade ago, biofuels were broadly lauded as beneficial for climate mitigation. At the time, the majority of studies conducting lifecycle analyses of burning corn ethanol compared to burning fossil fuels found that on average, replacing gasoline with corn ethanol reduced GHG emissions by 20 percent (Wang et al. 2007). The viewpoint of these studies and biofuels advocates at the time lined up with the "first view" outlined earlier in this brief. However, attitudes began to change when environmentalists were heavily influenced by papers that came out in 2008 and 2009 (Searchinger et al. 2008; Fargione et al. 2009; Searchinger et al. 2009) that expressed the accounting concerns of the second and third views, summarized earlier. Since then, most members of the European and U.S. environmental communities have become broadly opposed to crop-based biofuels, as well as the use of forest biomass for bioenergy, and at least skeptical of cellulosic biofuels. European environmentalists have favored strong

Figure 3 | **Projected Biofuels Growth in the Seven Largest Markets (in billions of liters)**



Source: Wise and Cole 2015.

caps on or phase-outs of land-based biofuels, while there is a split in the U.S. community, with some supporting that approach and others supporting a low carbon fuel standard approach. Both of these approaches are largely aligned with the second view: They assume that biofuels can be beneficial from a climate perspective if they can be regulated and accounted for effectively.

Rising European and U.S. opposition to biodiesel from vegetable oil

The European Parliament vote to phase out credits for palm-based biodiesel reflects a growing opposition to biodiesel in particular. Box 2 describes the connection between biodiesel and deforestation in Argentina. For competitive rather than environmental reasons, the U.S. has introduced countervailing duties on imported biodiesel from Argentina and Indonesia (DOC 2017). Whether these policies would have significant effect can be debated, however, because some studies have found that an increased demand for biodiesel from rapeseed or soybeans leads to an increase in vegetable oil prices that spurs increased palm oil production as well (Searle 2017).

International trade challenges for biofuels policies

Biofuels regulations and policies, which are typically structured as volumetric mandates for incorporating biofuels into the transportation fuels mix, are very effective at supporting domestic agricultural industries, whether or not they also have an explicit climate-related objective. However, the majority of biofuel feedstocks are globally traded commodities. In the EU, around half of the production of biodiesel is based on imported feedstocks, not crops grown by EU farmers, and biodiesel accounts for about 80 percent of the EU's biofuels (T&E 2017a, based on Directorate General for Agriculture and Rural Development). These dynamics set the stage for major trade debates that have played out between producer and consumer countries in the past several years.

For example, the EU has implemented a series of antidumping and countervailing duties on biodiesel imports starting with the U.S. and Canada in 2011 and moving to Argentina and Indonesia in 2013 (Elliott 2015). Indonesia and Argentina challenged the EU duties at the World Trade Organization (WTO), calling them protectionist. The WTO has recently ruled in favor of Indonesia and Argentina, asking the EU to bring its measures into conformity with WTO agreements (Reuters 2018). The U.S.

recently imposed anti-dumping duties on Indonesian and Argentinian biodiesel, and the EU Parliament has proposed to phase out the crediting of palm oil as a renewable transportation fuel by 2021, as part of the development of RED II. The EU Parliament's proposal has been presented as an environmental standard. However, the other measures, while welcomed by environmental NGOs, have been issued in response to pressure from domestic biofuel producers and to counter what importing countries perceive as unfair subsidies on the part of producer countries. Argentina and Indonesia have both stated intentions to file objections to the U.S. duties with the WTO (Kennedy 2018).

Potential sources of new demand for biofuels

Potential demand in the aviation industry

The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations that governs the international aviation industry. In 2016, ICAO member nations agreed to a goal of carbon neutral growth from 2020 onward through a combination of technological improvements, operational improvements, and switching to alternative jet fuels. A recent analysis from the International Council on Clean Transportation (ICCT) found that demand for jet fuel in 2050 is estimated to be 24–37 exajoules (EJ) but that the maximum availability of cellulosic biofuels that could be available to the industry by 2050 is only around 4 EJ (Takriti et al. 2017). So far, the ICAO has rejected significant curbs on the use of biofuels. In November 2017, ICAO members rejected 10 of the 12 sustainability standards proposed by its technical committee, including provisions to safeguard land rights, food security, labor rights, water, and biodiversity protections (T&E 2017b).

Potential demand in the maritime industry

In April 2018, the International Maritime Organization (IMO), a United Nations agency, announced a commitment and initial strategy to reduce and phase out GHG emissions from international shipping. The initial goal is to reduce GHG emissions by at least 50 percent by 2050 compared to 2008 (IMO 2018). While the shipping industry has some room to increase efficiencies, and more alternative fuel options than the aviation industry, it nevertheless represents around 3 percent of overall GHG emissions, and there will likely be a strong interest in biofuels as an alternative fuel for ships.

CONCLUSIONS AND NEXT STEPS

Despite persistent effort and important progress on the part of environmental organizations and scientists to incorporate the risks to forests in clean fuels policies in the EU, U.S., Indonesia, Brazil, and elsewhere, a number of challenges remain. It is clear that current policies are driving market expansion for biofuels. While there is disagreement on how biofuels should be handled by these policies, there is general agreement that safeguards need to be in place to ensure that the biofuels market is not increasing GHG emissions. The views of the environmental community and policymakers have shifted from initial consensus that biofuels are carbon neutral to encompass a range of views about the acceptability of biofuels as a source of renewable energy.

Although we have not taken a position on how to account for emissions from production of biofuels feedstocks in this paper, our description reveals that there are high stakes and wide-ranging disagreement. On one side, biofuels advocates are claiming large, low-carbon energy potential. On the other side, critics are claiming that biofuels inherently use land that is not available and can lead to large-scale loss of forests. Although there is common agreement that some forms of waste could provide a desirable source of bioenergy, it is also clear that current policies provide few incentives for biofuels from wastes, and there is disagreement about virtually all other sources of biomass.

Given the high stakes for getting this right, we highlight four areas that require close attention:

1. More clarity is required from the environmental community on the best way to account for GHG emissions from biofuels. The dramatic differences in modeling outputs instill less confidence in ILUC accounting as a promising policy tool. Is it possible to improve the models or is there an alternative system that can be used?

2. Clean fuels standards have been implemented in two U.S. states and are being considered elsewhere in the country and in Canada. It is imperative that these policies adopt appropriate mechanisms for ensuring that the climate impacts of biofuels are accurately reflected.

3. None of the major policies currently provide sufficient incentives to support the development of biofuels from waste and residues. Many waste streams could provide promising feedstocks (e.g., landfill methane, manure methane, and some agricultural residues and cooking oils) but none have become commercially viable at a significant scale. A range of additional incentives aimed at helping this category of biofuels reach industrial scale could help the biofuel sector contribute in a meaningful way to a low-carbon future. Ideally, policies that create incentives for biofuels from wastes and residues would also include sustainability provisions to ensure that demand for these fuels does not drive other negative consequences.

4. The aviation and maritime sectors require strong sustainability standards to ensure they meet their GHG reduction goals. As with the clean fuels standards, it is important to get this right up front, ensuring that industry standards provide effective incentives for high quality alternative jet fuels.

ABBREVIATIONS

BECCS	bioenergy with carbon capture and storage
CFS	Clean Fuel Standard
CPO	crude palm oil
DLUC	direct land-use change
EJ	exajoules
EPA	Environmental Protection Agency
FAPRI	Food and Policy Research Institute
FASOM	Forestry and Agricultural Sector Optimization Model
GLOBIUM	Global Biosphere Management Model
GHG	greenhouse gas
GTAP	Global Trade Analysis Project
IAM	integrated assessment model
ICAO	International Civil Aviation Organization
ICCT	International Council on Clean Transportation
ILUC	indirect land-use change
IMO	International Maritime Organization
ISPO	Indonesian Sustainable Palm Oil
LCFS	Low Carbon Fuel Standard
MEMR	Ministry of Energy and Mineral Resources
RED	Renewable Energy Directive
RFS	Renewable Fuel Standard
WTO	World Trade Organization

ENDNOTE

1. This paper only covers biological feedstocks used for transportation, although there are many other sectors that are currently using or are looking to expand the use of biological feedstocks to replace existing materials.

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COUNT IT
We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT
We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT
We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.