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Blood Biofuels

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ABSTRACT

Modern energy policy aims to ratchet up the manufacture and use of biofuels, i.e. any fuel produced from biological materials. Yet biofuels derived from agricultural crops and residues, wood, forest residues, or other kinds of plant-based biomass feedstocks can be as environmentally and socially devastating as the finite fossil fuel resources they seek to replace. Often overlooked are their globalization impacts on land grabs, food security, greenhouse gas emissions, drought, deforestation, interference with climate change adaption measures, population displacement, desertification, sea level rise, biodiversity, and scalability. These environmental and social consequences result in food shortages, violent conflicts, urban riots, rural protests, and rising food costs. There is, however, hope for biofuels. Certain other types of biofuels, known collectively as second generation biofuels, are a more suitable alternative for global and regional energy needs because of their availability as well as their significantly reduced public health, environmental, and climate change impacts on society. These new biofuels are derived from algae, seaweed, food waste, and other plant and animal residues.

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While these biofuels are a more appropriate replacement for fossil fuels than first generation biofuels, they too carry with them potentially significant impacts. Therefore, a cautionary analysis of regulatory and governance regimes for second generation biofuels is critical for improving innovation and investment for this energy resource. To that effect, I provide an inquiry into biofuel law and policy through the theoretical framework of science, technology, society, and the environment (STSE) to assess the hurried development of biofuels and how this biofuel gold rush has had adverse social, economic, and environmental consequences globally. This article concludes with two correlative policy interventions to counter the negative consequences of conventional forest- and agriculturally-based biofuels. First, I question the environmental efficacy of all biofuels as clean energy as defined by the Renewable Fuel Standard (RFS), including those derived from natural resources that compete with food and timber supplies.). Second, I argue that the more stringent Low Carbon Fuel Standard (LCFS), as implemented in California and British Columbia, would provide better social and environmental outcomes as a part of the national energy policy plan.

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INTRODUCTION

> Each threat, disappearance and murder is part of the campaign of terror against us. We are blamed for killing each other and publicly called assassins, drug traffickers and drunks. We live, work and negotiate with guns pointed to our heads.
>
> - Vitalino Alvarez, MUCA leader[1]

Farmers in the remote Honduran region of the Bajo Aguán Valley organized resistance to corporate coercion and harassment by forming local *campesino* groups to negotiate contested property rights.[2] Following heated negotiations for land ownership claims by a company harvesting African palms for biofuel production, the farmers were awarded provisional land title.[3] As the small farmers resumed their activities on the land, armed security forces employed by the biofuel company, Dinant Corporation, greeted them and attempted to physically remove them from their land.[4] In one such encounter on Monday, November 15, 2012, when the farmers went to the fields, Dinant's armed security operatives killed six farmers and critically injured two others.[5] On that same day in November 2012, two thousand miles away from this horrendous attack in Honduras, in the blistering cold of the American city of Denver, de facto Honduran president Pepe Lobo planned to meet with the director of the

1. Nina Lakhani, *Honduras and the dirty war fueled by the west's drive for clean energy,* GUARDIAN (Jan. 14, 2016), https://www.theguardian.com/global/2014/jan/07/honduras-dirty-war-clean-energy-palm-oil-biofuels. The organized resistance groups of small farmers in the Baja Aguán Valley region included the Unified Campesino Movement of the Aguán (MUCA) and the Authentic Revindicative Campesino Movement of the Aguán (MARCA). *Campesinos* refers to peasant farmers in Latin America.

2. Lauren Carasik, *Honduran campesinos in the crosshairs*, AL-JAZEERA (Apr. 6, 2012), http://www.aljazeera.com/indepth/opinion/2012/04/201242111850554190.html.

3. Annie Bird, *World Bank-Funded Biofuel Corporation Massacres Six Honduran Campesinos,* RIGHTS ACTION (Nov. 23, 2012), http://rightsaction.org/sites/default/files/Rpt_130220_Aguan_Final.pdf.

4. Annie Bird, *Human Rights Abuses Attributed to Military Forces in Bajo Aguan Valley in Honduras,* RIGHTS ACTION (Feb. 20, 2013), http://rightsaction.org/sites/default/files/Rpt_130220_Aguan_Final.pdf.

5. Bird, *supra* note 3.

Millennium Challenge, a development fund operated by the U.S. government.[6] Lobo was seeking development funding for renewable energy projects in Honduras, including first generation biofuel production and hydroelectric dams.[7] Honduran political leadership may have been unaware of the violent tactics of Dinant Corporation on the ground. Following an internal investigation and massive public outcry, the International Finance Corporation (IFC) admitted to failures in the application of its own social and environmental policies vis-à-vis Honduras.[8] The complex web of land title disputes in the Global South leading up to this massacre originated from well-intended renewable energy projects in the Global North.[9]

From the deaths squads in Honduran villages mentioned above to slash and burn techniques in Indonesian forests to the lesser-known use of land grabbing in Guatemala and harvesting of wood from ecologically important hardwood forests across the southeastern United States, agriculture and forest biofuels are hardly the vision of a pristine clean energy future.[10] In the wake of the Asian Financial Crisis of 1997-1998 and the Global Financial Crisis of 2007-2008, biofuels emerged as a boon for energy security and a means to stabilize volatile energy markets.[11] The environmental and social perils of biofuels,

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6. *Id.*

7. *Id.* The renewable energy plan was part of a larger project grant, initially funded by the Inter-American Development Bank, after the military coup in June 2009. Following concerns for serious human rights violations, the World Bank's International Finance Corporation gave Dinant Corporation a $30 million loan for biofuel production. Declaration of Juliana Bird, Budha Ismatl Jam v. International Finance Corporation, Civil Action No.15-cc-00612(JDB) https://www.earthrights.org/sites/default/files/declaration_bird.pdf.

8. Nina Lakhani, *World Bank lending arm forced into U-turn after Honduras loan row,* GUARDIAN (Jan. 23, 2014), https://www.theguardian.com/global-development/2014/jan/23/world-bank-ifc-forced-uturn-honduras-dinant.

9. Sumudu Atapattu & Carmen G. Gonzalez, *The North-South Divide in International Environmental Law*, *in* INTERNATIONAL ENVIRONMENTAL LAW AND THE GLOBAL SOUTH 2 (Shawkat Alam et al. eds., 2015). The terms *Global North* and *Global South* draw a distinction between privileged nations, including the United States, Canada, Australia, New Zealand, Japan, and European Union nations from less prosperous nations in Asia, Africa, and Latin America. *Id.*

10. Nadia Ahmad, *Unearthing Clean Energy,* TEDxOcala (Nov. 4, 2016), https://www.youtube.com/watch?v=QP39lio396s&app=desktop; *See also* Eitan Haddok, *Biofuels Land Grab: Guatemala's Farmers Lose Plots and Prosperity to "Energy Independence"* (Jan. 13, 2012), SCIENTIFIC AMERICAN, http://www.scientificamerican.com/article/biofuels-land-grab-guatemala/; Autumn Spanne, *US forests under threat as demand for wood-based biofuels grows – report,* GUARDIAN (Oct. 21, 2015), http://www.theguardian.com/sustainable-business/2015/oct/21/us-forests-under-threat-as-demand-for-wood-based-biofuels-grows-report.

11. *See generally* STANLEY FISCHER, IMF ESSAYS FROM A TIME OF CRISIS: THE INTERNATIONAL FINANCIAL SYSTEM, STABILIZATION, AND DEVELOPMENT (2004); WILLIAM

though, have outweighed their economic promise. Considering the short-to-medium term risks associated with agriculture biofuels contributing to food shortages, land use conflict, and water scarcity, this Article proposes a cautionary approach to the rapid industrialized production of biofuels.

Agriculture and forest biofuels are only slightly less environmentally and socially devastating than the finite fossil fuel resources they seek to replace.[12] Their impacts, such as natural resource scarcity, greenhouse gas emissions, drought, deforestation, interference with climate change adaption measures, resettlement of displaced populations, desertification, sea level rise, biodiversity, and scalability, are significant.[13] For example, in Indonesia, scientists warn that inter-annual changes in worldwide atmospheric growth of carbon dioxide concentrations are based, in part, on the variability of emissions from biomass burning.[14]

This article suggests two policy interventions to counter the negative consequences of conventional agriculture-based and forest biofuels. First, I question the environmental efficacy of all biofuels, including those derived from natural resources that compete with food and timber supplies, as clean energy under the Renewable Fuel Standard (RFS).[15] Second, I argue that the more stringent Low Carbon

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RHODES, BANKER TO THE WORLD: LEADERSHIP LESSONS FROM THE FRONT LINES OF GLOBAL FINANCE (2011); ROBERT RUBIN & JACOB WEISBERG, IN AN UNCERTAIN WORLD: TOUGH CHOICES FROM WALL STREET TO WASHINGTON (2003).

12. Ahmad, *supra* note 10.

13. *See generally* Jorg Peters & Sascha Thielman, *Promoting Biofuels: Implication for Developing Countries*, 36 ENERGY POL'Y 1538 (2008). Acreage availability for biofuel production is a natural limitation that leads to conflicts with food production. *See also* Mandu Khanna, Amy W. Ando & Farzad Taheripour, *Welfare Effects and Unintended Consequences of Ethanol Subsidies,* 30 APPLIED ECON. PERSPECTIVES & POL'Y 411, 411 (2008) (noting that subsidies to farmers for ethanol production in the form of reduced air pollution and carbon emissions may not justify the costs associated with federal subsidies).

14. *See generally* Robert D. Field, Guido R. van der Werf & Samuel S. P. Shen, *Human Amplification of Drought-induced Biomass Burning in Indonesia since 1960,* 2 NATURE GEOSCIENCE (2009), http://www.nature.com/ngeo/journal/v2/n3/full/ngeo443.html. This study of the frequency, severity and underlying causes of severe biomass burning in Indonesia was limited due to the lack of satellite data for fire monitoring prior to the mid-1990s. The research compiled and analyzed "continuous monthly record of severe burning events from 1960 to 2006 using the visibility reported at airports in the region." *Id.* The researchers determined that "these fires cause extremely poor air quality conditions and that they occur only during years when precipitation falls below a well defined threshold." *Id.*

15. James H. Stock, *The Renewable Fuel Standard: A Path Forward*, COLUM. CENTER ON GLOBAL ENERGY POLICY (Apr. 2015), http://energypolicy.columbia.edu/sites/default/files/energy/Renewable%20Fuel%20Standard_A%20Path%20Forward_April%202015.pdf.

Fuel Standard (LCFS), as implemented in California and British Columbia, would provide improved social and environmental outcomes.[16] Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhone Island, and Vermont are also contemplating adoption of regional LCFS programs.[17]

European renewable energy targets and United States energy policy have increased biofuel demand in the past decade.[18] In 2009, the European Union (EU) passed binding legislation in order to meet its climate and energy targets for 2020; this legislation included three primary goals: (1) twenty percent reduction in greenhouse gas emissions (from 1990 levels); (2) twenty percent target of EU energy from renewables; and (3) twenty percent improvement in energy efficiency.[19] The EU directive included an overly broad definition of bioenergy: "all biomass, whether wood chips and sawdust from a sawmill or whole trees from old growth forests," was deemed "carbon neutral."[20] Following Europe's lead, Congress considered the North American Energy Security and Infrastructure Act of 2015, which supported the use of wood for energy and failed to address the lack of carbon neutrality of forest biomass.[21]

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16. *See* CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY AIR PROTECTION BOARD, *Low Carbon Renewable Fuel Standard,* http://www.arb.ca.gov/fuels/lcfs/lcfs.htm; BRITISH COLUMBIA, *Renewable and Low Carbon Fuel Requirements Regulations,* (Jan. 30, 2017), http://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/transportation-energies/renewable-low-carbon-fuels.

17. CENTER FOR CLIMATE AND ENERGY SOLUTIONS, *Multi-State Climate Initiative* (last visited Mar. 26, 2017), http://www.c2es.org/us-states-regions/regional-climate-initiatives.

18. *See, e.g.*, *id.*; EUROPEAN COMMISSION, *2020 Climate & Energy Package* (Mar. 6, 2017), http://ec.europa. eu/clima/policies/strategies/2020/index_en.htm.

19. *Id.* at 8–9. These goals are also "the headline targets of the Europe 2020 strategy for smart, sustainable and inclusive growth." *Id.*

20. KENNETH RICHTER, NATURAL RESOURCES DEFENSE COUNCIL, *Will Europe Stop Trashing US Forests in the Name of Bioenergy* (May 23, 2016), https://www.nrdc.org/experts/sasha-stashwick/will-europe-stop-trashing-us-forests-name-bioenergy. Based on the current accounting systems, biomass fuel emissions are accounted for as zero, which leads to the assumption of carbon neutral. Giuliana Zanchi, Naomi Pena & Neil Bird, *Is woody bioenergy carbon neutral? A Comparative Assessment of Emissions from Consumption of Woody Bioenergy and Fossil Fuel,* 4 GCB BIOENERGY 761, 761–72 (2012), http://onlinelibrary.wiley.com/doi/10.1111/j.1757-1707.2011.01149.x/full. The study considered emissions from alternative energy supply sources to determine the emissions benefits of biomass compared to fossil fuel over time. *Id.* The researchers noted that the label of carbon neutrality of biomass is misleading in the context of short-to-medium term goals. *Id.*

21. North American Energy Security and Infrastructure Act of 2015, H.R. 8, 114th Cong. (2015), https://www.congress.gov/bill/114th-congress/house-bill/8. While the bill ultimately died, the initiative shows the political will to enhance biofuels in the United States.

This nuanced definition of what constitutes "biomass" lies at the heart of the biofuel controversy.[22] Furthermore, definitions of biomass vary. For example, at the federal level, the Environmental Protection Agency (EPA) expanded the definition, called a pathway, of cellulosic and advanced biofuels to include "liquefied and compressed natural gas produced from biogas and landfills."[23] Cellulosic ethanol has been referred to as "grassoline" and consists of woods, grasses, and inedible stalks of plants.[24] Commentators suggested that the EPA inflated cellulosic fuel production to align its numbers with the federal prediction of high cellulosic production.[25] In reality, the EPA simply re-categorized an existing type of fuel to its definition of "cellulosic biofuel."[26] Biofuel is now defined as any fuel that is derived from biomass, which refers to plant material or animal waste.[27]

Renewable energy mandates and energy security measures have avoided a full and fair assessment of how biofuels fit into the renewable energy mix. All biofuels are not created equal. The impact of increased production and deployment of biofuels on the environment and human development cannot be underestimated because the carbon footprint of biofuels is not as light as originally thought. Prevailing regulatory and governance mechanisms to analyze the consequences of biofuel production globally, nationally, and locally are vastly insufficient. For the United States, obtaining four percent of the country's electricity from biomass would require seventy-four percent of its timber harvest.[28] In other words, a marginal gain in energy

22. Zanchi et al., *supra* note 20, at 761. The use of forest residues can produce greenhouse gas benefits in comparison to fossil fuels "from the beginning of their use and that biomass from dedicated plantations established on marginal land can be carbon neutral from the beginning of its use." *Id.* When additional fellings are harvested for bioenergy and that proportion of felled biomass is law, the risks of short-to-medium term impacts can be negative. *Id.*

23. EPA Issues Final Rule for Renewable Fuel Standard (RFS) Pathways II and Modifications to the RFS Program, Ultra Low Sulfur Diesel Requirements, and E15 Misfueling Mitigation Requirements, Regulatory Announcement EPA-420-F-14-045 (July 2014).

24. George Huber & Bruce Dale, *The Fuel of the Future is Grassoline*, SCI. AM. (Apr. 9, 2009), http://www.scientificamerican.com/article/the-fuel-of-the-future-is-grassoline/.

25. Institute for Energy Research, *EPA Moves Goalposts with New Definition of Cellulosic Biofuels* (Oct. 16, 2014), http://instituteforenergyresearch.org/analysis/epa-moves-goalposts-new-definition-cellulosic-biofuels/.

26. *Id.* To a lot of observers, it appears that the EPA lowered its standards to meet its mandates and to comply with the law. *Id.*

27. Clarence Lehman, *Biofuel*, BRITANNICA, http://www.britannica.com/EBchecked/topic/967492/biofuel.

28. Washington Post Editorial Board, *Dear Congress: Burning Wood is not the Future of Energy,* WASH. POST, Apr. 28, 2016, https://www.washingtonpost.com/opinions/burning-wood-is-

resources would require a massive depletion of the country's forest biomass. This demand would result in increased energy insecurity and vulnerability for low income households and economically disadvantaged neighborhoods.

One solution to the concern of biofuel mandates is to limit the definition of biofuels to exclude wood biomass from biofuel classification and to reduce the standards for agriculture-based biofuels. The next step is to promote second generation biofuels, which are a superior alternative for global and regional energy needs based on their availability and their reduced public health, environmental, and climate change impacts on society. Accordingly, I provide a proposal for regulatory and governance mechanisms to catalyze the favorable innovation and implementation of advanced biofuels, including algae-based biofuel and seaweed-based biofuel, as well as used cooking oil biofuel, for energy production in parts of the world where arable land, freshwater, and land availability are at a premium. To that effect, Part I offers an analysis of biofuel law and policy through the theoretical framework of science, technology, society, and the environment (STSE) to assess the hurried scale-up of biofuels. Part II examines the varying governance regimes for biofuels and the interconnectedness of the energy resource's impacts in Europe, the Americas, Southeast Asia, and the Middle East. Parts III and IV delineate the legal history and norms of biofuel regulation from seventeenth century whale oil to modern day palm oil and lay out the failures of past and present regulatory efforts. Part V delves into solutions to address resource scarcity, land use conflict, and greenhouse gas emissions.

I. ANALYSIS OF SCIENCE, TECHNOLOGY, SOCIETY, AND ENVIRONMENT

The field of Science, Technology, Society, and the Environment (STSE) weaves together three academic subjects to examine how science can be used to solve current societal issues, technological challenges, and environmental problems.[29] The first stream examines the interplay between science and technology, whereas the second

not-the-future-of-energy/2016/04/28/9cd9376c-08b9-11e6-bdcb-0133da18418d_story.html; *See also* Timothy D. Searchinger et al., *Fixing a Critical Climate Accounting Error,* 326 SCI. 527 (2009), http://science.sciencemag.org/content/326/5952/527.summary.

29. Robert E. Yager, *The Science/Technology/Society Movement in the United States: Its Origin, Evolution, and Rationale*, 54 SOC. EDUC. 198, 198 (1990).

stream looks at the impacts and ramification of science and technology for "peace, security, community, democracy, environmental sustainability, and human values."[30] The third stream of the interaction between science, technology, and society underscores the environmental hurdles to technological applications of science-based solutions.[31] A critical approach to STSE incorporates elements of decision-making processes, sustainability, corporate best practices, action, and social reconstruction.[32] This section provides an overview of how STSE can be engaged as a theoretical discipline to show the social and environmental impacts of biofuel production globally and locally in its regulatory and governance regimes.

Remarkably, the law has not *fully* accounted for the environment in its rule-making decisions. The environment tends to be an addendum instead of being at the forefront of rule-making, project management, and project design. This trend of neglecting the importance of the environment and social impacts in rule-making is ironically most evident in energy policy. While a shift away from hydrocarbon fossil fuels through the use of biofuels is laudable, renewable energy policy does not account for the full scale of environmental externalities associated with varying forms of renewables. The economic concept of environmental externalities refers to "uncompensated environmental effects of production and consumption that affect consumer utility and enterprise cost outside the market mechanism."[33] For example, wind and solar energy are plentiful, but both resources are intermittent. Biofuels provide added

30. *What is STS?*, HARV. KENNEDY SCHOOL http://sts.hks.harvard.edu/about/whatissts.html (last visited May 10, 2017). *See also* Mario Biagioli, ed., THE SCIENCE STUDIES READER (1999); Wiebe Bijker, Thomas P. Hughes, & Trevor Pinch, eds., THE SOCIAL CONSTRUCTION OF TECHNOLOGICAL SYSTEMS (1987); DAVID J. HESS, SCIENCE STUDIES: AN ADVANCED INTRODUCTION (1997); Sheila Jasanoff, Gerald Markle, James Petersen & Trevor Pinch, eds., HANDBOOK OF SCIENCE AND TECHNOLOGY STUDIES (1995); Bruno Latour, REASSEMBLING THE SOCIAL: AN INTRODUCTION TO ACTOR-NETWORK THEORY (2005); SERGIO SISMONDO, AN INTRODUCTION TO SCIENCE AND TECHNOLOGY STUDIES (2003).

31. *See e.g.* Erminia Pedretti & Joanne Nazir, *Currents in STSE Education Mapping a Complex Field, 40 Years On*, 95 SCI. EDUC. 601, 612 (2011).

32. Sarah Elizabeth Barrett & Erminia Pedretti, *Contrasting Orientations: STSE for Social Reconstruction or Social Reproduction,* 106 SCHOOL SCI. AND MATHEMATICS 237, 238 (2006).

33. Organization for Economic Co-operation and Development (OECD), *Environmental Externalities,* (Sept. 25, 2001), https://stats.oecd.org/glossary/detail.asp?ID=824. Based on negative externalities, the private costs of production are lower than the actual "social" cost. "[T]he aim of the 'polluter/user-pays' principle to prompt households and enterprises to internalise externalities in their plans and budgets." *Id.*

energy security to the global energy mix, because they add to the diversity of energy sources.[34] However, agriculture and forest biofuels require large swaths of land for the cultivation of fuel crops.[35] These factors are not considered in renewable energy policy.

The intersections of science and technology provide additional opportunities to monitor environmental impacts and address climate change adaption measures. Scientific exactness is important in accounting for environmental protection schemes in energy policy. The exactness in science is a means to provide more concrete legal solutions to environmental threats and energy challenges. Science is exact if it a) derives its principles and axioms from observations of phenomena as they occur naturally and if b) it uses mathematical logic to draw conclusions by subjecting them to rigorous experiments.[36] One methodological approach for accurate decision-making when dealing with critical social, economic, and political problems is to augment the scientific thinking of managers and decision-makers.[37] Environmental policies and agreements on global issues must be determined "on the basis of incomplete and uncertain information to avoid the period when the environmental damage becomes irreversible."[38] To accomplish a sound environmental or scientific agreement, negotiating parties must be aware that the commitments are based on sound

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34. Diversity of assets is essential to an energy investment portfolio: a country benefits from greater energy capacity and security if it harnesses its electricity and power needs from a multitude of generation sources, including the sun, wind, waves, and biomass. Nadia Ahmad, *"Turn on the Lights" – Sustainable Energy Investment and Regulatory Policy: Charting the Hydrokinetic Path in Pakistan*, 5 WASH. & LEE J. ENERGY, CLIMATE, & ENV'T 165, 179–80 (2014). *See also* Mukhtar Ahmed, *Meeting Pakistan's Energy Needs,* in FUELING THE FUTURE: MEETING PAKISTAN'S ENERGY NEEDS IN THE 21ST CENTURY 17, 18–23 (Robert M. Hathaway, Bhumika Muchhala, & Michael Kugelman eds., 2007), http://www.wilsoncenter.org/sites/default/files/Asia_FuelingtheFuture_rptmain.pdf.

35. Biomass fuel for fossil fuel, The Maureen & Mike Mansfield Center, Ethics and Public Affairs Program, University of Montana, http://www.umt.edu/ethics/debating%20science%20program/odc/climatechange/climatealternatives/biomassfuelforfossilfuel.php.

36. Yousef Sabouti, *The Morality of Exact Sciences*, *in* SCIENCE AND TECHNOLOGY AND THE FUTURE DEVELOPMENT OF SOCIETIES: INTERNATIONAL WORKSHOP PROCEEDINGS 10, 12 (Glen Schwietzer ed. 2008) ("In this procedure there is no place for the beliefs and convictions of the scientist.").

37. Alimohammad Kardan, *How to Promote Scientific Thinking Amongst Decision Makers*, *in* SCIENCE AND TECHNOLOGY AND THE FUTURE DEVELOPMENT OF SOCIETIES: INTERNATIONAL WORKSHOP PROCEEDINGS, Glen Schwietzer 51st ed. 49, 52 (2008).

38. RICHARD J. SMITH, NEGOTIATING ENVIRONMENT AND SCIENCE: AN INSIDER'S VIEW OF INTERNATIONAL AGREEMENTS FROM DRIFNETS TO THE SPACE STATION 150 (2009).

science, and accept that the pertinent scientific knowledge is still evolving.[39]

International environmental legal instruments and best corporate practices have sought to account for environmental externalities through sustainable development and have incorporated various sustainable development principles in their business models.[40] For example, governments, environmental groups, and industry recognize the environmental harms of extractive industries and have sought to improve public confidence and apply greater stewardship principles.[41] In the case of biofuels, this level of concern and scrutiny on the biofuel enterprise has been lacking.[42] In other words, biofuels are hailed as a clean energy source, and the negative environmental and social externalities are not completely calculated under the existing RFS program.[43]

Accounting for environmental externalities is related to the concept of sustainable development, which is defined *in Our Common Future* (the Brundtland Report), as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[44] The future effects of biofuels, including greenhouse gas emissions, deforestation, population displacement, and food security, must be included in the calculus of the sustainable development of biofuels. Principle 15 of the Rio Declaration on Environment and Development provided the first acknowledgment of the actual lack of knowledge embedded in the decision-making processes regarding socio-environmental issues and the necessity to actively deal with the irreversibility of techno-scientific high-power experimentation.[45] This approach introduces the notion "that science

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39. *Id.*

40. Nadia Ahmad, *A National Mineral Policy as an International Investment Law Stratagem: The Case of Tajikistan's Gold Reserves*, 27 PAC. MCGEORGE GLOBAL BUS. & DEV. L.J. 1,9 (2014).

41. Heledd Jenkins & Natalia Yakovleva, *Corporate Social Responsibility in the Mining Industry: Exploring Trends in Social and Environmental Disclosure*, 14 J. CLEANER PRODUCTION 271, 274 (2006), http://www.sciencedirect.com/science/article/pii/S0959652605000375.

42. Mairon G Bastos Lima, *Biofuel Governance and International Legal Principles: It is Equitable and Sustainable?*, 10 MELBOURNE J. INT'L L. (2009) http://law.unimelb.edu.au/data/assets/pdf_file/0012/1686189/Lima.pdf.

43. Gregory Iwahashi, *Biofuels Energy*, GREENIACS (Oct. 25, 2011), http://www.greeniacs.com/Energy/Biofuels-Energy.html.

44. Brundtland Report, REPORT OF THE WORLD COMMISSION ON ENVIRONMENT & DEVELOPMENT: OUR COMMON FUTURE, U.N. Doc. A/42/427 (Oct. 1987).

45. Alice Bernessia, *From Certainty to Complexity: Science and Technology, in* A

can be temporarily unable to produce a certain and exhaustive body of knowledge suitable for a rational decision."[46]

Balancing social values and science is crucial for evaluating the sustainability of the biofuel enterprise, particularly in cases of high complexity or high uncertainty due to crop yields, market forces, social impacts, and environmental costs. These complex and uncertain variables create added layers of caution and concern, which, in turn, weaken the notion of exactness in the sciences. The decision-making process for the sustainability of projects relies on a traditional division of responsibilities in which laypeople assess nontechnical matters and scientists determine technical issues.[47] In terms of processual issues, scientists are decision-makers about the nontechnical issues, but the reverse is not true.[48] The differences between science, technology, and law and their interaction with each other are not fully appreciated. Joseph W. Dellapenna argues that to "understand and to manage this intersection of law with science and technology" requires reconfiguration of the "means for collecting and analyzing our knowledge of scientific concepts and the technologies reshaping the world even while we reconsider the institutions for decision-making appropriate to our increasingly interdependent and technologized world."[49] A malady of science policy in underdeveloped countries is to

DEMOCRATIC SOCIETY IN SCIENCE, SOCIETY AND SUSTAINABILITY: EDUCATION AND EMPOWERMENT FOR AN UNCERTAIN WORLD 15-16 (Donald Gray, Laura Colucci-Gray & Elena Camino eds., 2009). Principle 15, Rio Declaration on Environment and Development (1992) states: In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious and irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. *Id.*

46. Bernessia*, supra* note 45, at 15–16. A political choice is made to decrease "what are known as Type-II errors, which are errors of accepting harmful developments (false positives) over progress-based optimistic ideal of the Type-I errors, which are the errors of rejecting harmless developments (false negatives)." This normative step results "an epistemic shift from a two values theoretical science, based on the evaluation of the truth/falsity of a hypothesis, to a three-value science 'applied to risks,' which includes uncertainty as a possible outcome of scientific assessment." This shift epitomizes "the change in the relationship between scientific truth and the correspondingly right political decision by introducing risk acceptability through normative means." *Id.*

47. Daniel Lee Kleinman, *Democratizations of Science and Technology, in* SCIENCE, TECHNOLOGY AND DEMOCRACY 139, 142 (Daniel Lee Kleinman ed. 2000).

48. *See id.* (stating that unlike cases that constitute a serious challenge to traditional views of scientist self-governance, a distinction between the technical and the social is crucial and appropriate.).

49. Joseph W. Dellapenna, *Law in A Shrinking World: The Interaction of Science and Technology with International Law*, 88 KY. L.J. 809, 878–79 (2000). ("Only by attending to the intellectual structures as well as to the material conditions of the decision-making processes can

concentrate most of the national research effort "on one major project and to plan its development far beyond the actual capacities or the need of the country for this particular branch of research or its results."[50] This trend is especially true in the Middle East, which focuses intensively on oil and gas production. To increase lay involvement in the production and evaluation of scientific knowledge and technologies, the government or private foundations might establish citizen fellowships.[51]

The commercialization of public sector science (such as science for mass-produced biofuels) is shaped by three factors: 1) commercial interests where corporate sponsors are setting research programs, 2) work conditions and relationships between research teams, and 3) access to information for scientific fact-finding.[52] Academics, particularly those in technology studies, leave the university thinking that they now possess the skills to solve the problems of the world.[53] Instead Sheila Jasonhoff argues that the approach should be one of humility—humility about both the limits of scientific knowledge and about when to stop "scientisizing" (or treating knowledge inquiries with a scientific approach) all research problems addressing global systems.[54] Consequently, she views humility as a "guiding concept" to shift "public engagement. . .towards conviviality."[55] Social values are significant in developing technologies to create ethical systems for assessing and resolving conflicts that arise. For example, the social effects of a new technology should be scrutinized. Further, an

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we hope to make reasonably appropriate decisions in the face of the pervasive uncertainty generated by the rapid changes in science and technology.").

50. Stevan Dedijer, *Underdeveloped Science in Underdeveloped Countries*, *in* COMPARATIVE STUDIES IN SCIENCE AND SOCIETY 61, 76 (Sal P. Restivo & Christopher K. Vanderpool eds., 1974).

51. Kleinman, *supra* note 47, at 154.

52. CAREERS IN CLINICAL RESEARCH: OBSTACLES AND OPPORTUNITIES, 1994, https://www.ncbi.nlm.nih.gov/books/NBK236333/

53. Angela Guimares Pereira, *Post Normal Relationships between Science and Society: Implications for Public Engagement*, *in* SCIENCE, SOCIETY AND SUSTAINABILITY: EDUCATION AND EMPOWERMENT FOR AN UNCERTAIN WORLD 45–46 (Donald Gray, Laura Colucci-Gray, & Elena Camino eds., 2009) (arguing that this learned "arrogance" should be combatted by teaching universities how to train and educate others).

54. *See generally* Sheila Jasanoff, *Technologies of Humility*, 450 NATURE 223 (2007) (proposing that "technologies" of humility are necessary to reflect on the sources of ambiguity, indeterminacy, and complexity); Sheila Jasanoff, *The Idiom of Co-production*, *in* STATES OF KNOWLEDGE: THE CO-PRODUCTION OF SCIENCE AND SOCIAL ORDER (Sheila Jasanoff ed., 2004).

55. Guimares Pereira, *supra* note 53, at 46.

economic assessment should be considered for the effects on the local populations.[56]

Innovations in science and technology have transformed virtually all characteristics of life in the Global North as well as the Global South. This phenomenon is especially true in less developed nations, where "applied modern science is a new experience, and scientific and technological know-how is lacking."[57] For less developed nations, the distress over being a scientifically underdeveloped country is approximated to the distress of being an economically underdeveloped one.[58] Wangari Maathi points out the disparity between those who have benefited from commercialized science and been able to understand its impact:

> Scientific technology can sometimes lighten the burden, but does not seem to be doing so. Perhaps part of the answer lies with people themselves. Humans have to reassess their role on this planet, reassess their values, and reassess their understanding of the universe and they must reassess their perception of what constitutes their happiness and fulfillment. We may also have to reassess governance and security and peace not in a pyramid but in a balanced and harmonious whole. For, as long as we sustain a pyramid, the bottom will continue to gather momentum and take all of us where it is always going, the abyss of the bottom.[59]

In underdeveloped countries, less awareness exists as to the importance of science, which is related to "the low priority given to science in development policy" combined with "the carelessness about the cultivation of a scientific potential necessary to produce that science."[60] Not only does the Third World account for only a small percentage of total R&D expenditures, but this expenditure was often uncoordinated, misdirected, and allocated to research projects which

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56. For example, a biofuel production plant and processing facility, which is set up by a multinational corporation, can consider implementing a local content requirement so that a certain percentage of the workforce and the intermediate products are sourced domestically. In renewable energy policy, local content requirements occur in two instances: 1) "a precondition to receive government support, such as tariff rebates" or 2) "an eligibility requirement for government procurement in renewable energy projects." SHERRY STEPHENSON, INT'L CTR. FOR TRADE AND SUSTAINABLE DEV., ADDRESSING LOCAL CONTENT REQUIREMENTS IN A SUSTAINABLE ENERGY TRADE AGREEMENT 2 (2013), http://www.ictsd.org/downloads/2013/06/addressing-local-content-requirements_opt.pdf (internal citation omitted).

57. Wangari Maathi, *A View From the Grassroots*, *in* SCIENCE FOR THE EARTH: CAN SCIENCE MAKE THE WORLD A BETTER PLACE 279, 281 (Tom Wakeford & Martin Walters eds., 1995).

58. Dedijer, *supra* note 50, at 61–62.

59. Maathi, *supra* note 57, at 291.

60. *Id.* at 65–66.

bore little relationship to the needs of the poor countries.[61] E.F. Schumacher advocated the idea of intermediate technology as an alternative to Western advanced technology.[62] He said that traditional indigenous technology was not productive enough to generate high incomes for the Third World producers and could not eliminate poverty; instead, he proposed intermediate technology as a mid-way between the local and the Western to generate new employment, increase income, and create opportunities in rural communities.[63] The biogas fertilizer plant is one type of technology to develop in the Third World as an alternative to Western systems of energy and fertilizer production.[64] Schumacher's ideas, though, did not fully account for the modern rise of Asian superpowers, such as China and India. The divide between the Global North and Third World is less clear today than it was forty years ago. In early 1980s, the goal of learning about the relationship of science, technology, and society (STS) rose to prominence in the United States and United Kingdom.[65] Robert

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61. David Burch, *Science, Technology, and the Less-developed Countries, in* SCIENCE, TECHNOLOGY, AND SOCIETY: AN INTRODUCTION 211(Martin Bridgestock et al. eds., 1998). Burch notes:

> Priority was accorded to pure or basic research rather than relevant applied research that would address critical problems associated with energy, food and agriculture, health, housing, and so on. In other words, much science and technology activity carried out within the Third World was marginal or alienated from production, and was not directly associated with the kinds of activities to generate economic growth improve the quality of life. Instead scientific R&D stood apart of the enclave activity which took its cue from the research orientations of the Western scientific community, and which reflected the priorities of Western science and technology.

Id. at 211–12. For example, the number of researchers has increased worldwide since 2009. Of the 7.76 million researchers worldwide, 6.74 million live in G20 countries, equivalent to 87% of the total. *The G20 accounts for 92% of global spending on research*, UNESCO (May 9, 2016), http://www.unesco.org/new/en/media-services/single-view/news/the_g20_accounts_for_92_of_global_spending_on_research/.

62. *See generally* E.F. SCHUMACHER, SMALL IS BEAUTIFUL: A STUDY OF ECONOMICS AS IF PEOPLE MATTERED (1973).

63. *Id.* at 172–90. Intermediate technology is technology used in developing countries based on less costly materials that are present there. Intermediate Technology, MacMillan Dictionary, http://www.macmillandictionary.com/us/dictionary/american/intermediate-technology

64. Union of Concerned Scientists, Growing Energy on the Farm: Biomass Energy and Agriculture, 2003, http://www.ucsusa.org/clean-energy/increase-renewable-energy/biomass-energy-agriculture#.WNgIqkeiMWw. A biogas plant converts agriculture biomass and animal waste into a nitrogen rich slurry for fertilizer through the process of anaerobic fermentation. The process also generates methane gas, which is for heating, cooking, and driving generators for electricity. Burch, supra note 61.

65. NEXT GENERATION SCIENCE STANDARDS, APP. J – SCIENCE, TECHNOLOGY, SOCIETY AND THE ENVIRONMENT (Apr. 2013), http://www.nextgenscience.org/sites/default/files/APPENDIX%20J_0.pdf.

Yaeger highlighted this reform in science education.[66] "STS became common in state science education standards during the first decade of the millennium, with an increasing focus on environmental issues."[67] As a consequence, "the core ideas that relate science and technology to society and the natural environment have been consistent with efforts in science education for the past three decades."[68]

In the case of bioenergy, this resource type can expedite national energy self-sufficiency in net energy importing countries, but for countries that are already net energy exporters, like many of the nations in Cooperation Council of the Arab States of the Gulf (GCC), biofuels can conserve hydrocarbon resources for export to strengthen and diversify existing economic structures.[69] Biofuels allow each country to use indigenous resources appropriately for its environmental, social, and economic conditions and energy needs.[70] Furthermore, bioresources can be used in large-scale operations in decentralized rural communities.[71] "[W]ithout . . . renewable standards and without government subsidies to biofuel producers," green energy cannot be cost competitive with oil and gas . . .[T]he percentage of energy supplied by green sources is still small."[72] Thus, despite a calm outlook on the long-term availability of petroleum resources, major disquiet about the energy security of consuming nations still rightly exists.[73]

Biofuels cannot solve the world's energy problems, according to the National Academy of Sciences.[74] Biofuels cannot "replace much

66. *See generally* ROBERT YAEGER, SCIENCE-TECHNOLOGY-SOCIETY: AS REFORM IN SCIENCE EDUCATION (1996).

67. NEXT GENERATION SCIENCE STANDARDS, *supra* note 65.

68. *Id.*

69. THE ECONOMIST INTELLIGENCE UNIT, THE GCC IN 2020: RESOURCES FOR THE FUTURE 3 (2010).

70. Ayhan Demirbas, The social, economic, and environmental importance of biofuels in the future, 12 Energy Sources, Part B: Economics, Planning, and Policy 47, 47–55 (2017), http://www.tandfonline.com/doi/abs/10.1080/15567249.2014.966926?src=recsys&journalCode=uesb20.

71. The Minnesota Project, Anaerobic Digesters: Farm Opportunities and Pathways, 2, 2010, https://www.americanbiogascouncil.org/pdf/Anaerobic%20Digesters%201-20-11-HR.pdf.

72. Jacqueline Lang Weaver, *The Traditional Petroleum Based Economy: An "Eventful" Future*, 36 CUMB. L. REV. 505, 568 (2006).

73. By 2020, about one in every three barrels of oil traded will come from Saudi Arabia, Iraq, and Iran. Lynn Garner, *BP Chief Executive Outlines $8 Billion Investment Plan for Green Energy Projects*, DAILY REPORT FOR EXECUTIVES, at A14-A15 (Nov. 30, 2005).

74. *Biofuels: Ethanol Not the Savior for Nation's Energy Problems, Study Says*, GREENWIRE (Jul. 11, 2006), http://www.eenews.net/greenwire/stories/46094 (reporting on a study published in the July 10, 2006, Proceedings of the National Academy of Sciences).

petroleum without impacting food supplies."[75] This overview and analysis of STSE explains how current policies for innovation and investment of biofuels must incorporate better stewardship for environmental and land use practices.

II. BIOFUEL HARVESTING PRACTICES

> [B]iofuels alone are not the quick-fix answer to global warming.
> - David Suzuki, geneticist and environmental activist[76]

The two most common types of biofuels are biodiesel and bioethanol, which are both derived from vegetable oils, seeds, and lignocelluloses.[77] Since such feedstock material can be replenished readily, biofuel is classified as a source of renewable energy.[78] Biofuel cells can "directly transform chemical to electrical energy" via "electrochemical reactions involving biochemical pathways."[79] Fuel wood, charcoal and animal dung are the primary energy sources for many people in developing countries.[80] The general source categories

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75. H. Josef Hebert, *Study: Ethanol Won't Solve Energy Problems,* WASHINGTON POST, Jul. 10, 2006, http://www.washingtonpost.com/wp-dyn/content/article/2006/07/10/AR2006071000788_pf.html.

76. David Suzuki with Faisal Moola, *Biofuels not necessarily all that green*, SCI. MATTERS, (Sept. 14, 2007), http://www.davidsuzuki.org/blogs/science-matters/2007/09/biofuels-not-necessarily-all-that-green/.

77. Masjuki Hj. Hassan & Md. Abul Kalam, *An Overview of Biofuel as a Renewable Energy Source: Development and Challenges*, 56 PROCEDIA ENGINEERING 39, 40 (2013) ("Common biodiesel feedstock are derived from plant oils, including rapeseed, soybean, sunflower, palm and some other non-edible oils like Mahua, Neem, Karanja, Jatropha"). Animal fats for biofuel use include beef tallow and used cooking oil. *Id.* Nanotechnology inspired biofuels like algae and seaweed are sometimes described as third generation biofuels, but for purposes of discussion in this article, I refer to them as second generation biofuels.

78. Lehman, *supra* note 27.

79. R. A. Bullen et al., *Biofuel Cells and their Development*, 21 BIOSENSORS & BIOELECTRONICS 2015, 2015–45 (2006), http://eprints.soton.ac.uk/49019/1/Biofuel_cells_and_their_development.pdf. Biological fuel cells (biofuel cells) rely on enzymatic catalysis for at least part of their activity. A broader definition would consider biofuel cells as those fuel cells which use biocatalysts, which includes systems utilizing non-enzyme proteins as well. G. T. R Palmore & G.M. Whitesides, *Microbial and Enzymatic Biofuel Cells*, *in* 566 ENZYMATIC CONVERSION OF BIOMASS FOR FUELS PRODUCTION, 271–90. (E. Himmel ed., 1994).

80. *Biofuels*, GREENFACTS, http://www.greenfacts.org/en/biofuels/l-2/1-definition.htm (last visited May 10, 2017). More advanced and efficient conversion technologies allow for the extraction of biofuels from materials such as wood, crops and waste material. *See generally* T.C. Bond et al., *Bounding the Role of Black Carbon in the Climate System: A Scientific Assessment*, 118 J. GEOPHYSICAL RESEARCH, 5380 (2013) (discussing the effect of black carbon aerosol on the climate). *See also* Andrew Grieshop, *A Black-Carbon Mitigation Wedge*, 2 NATURE

of biomass include: 1) agricultural and forestry residue, 2) fast growing tree plantations, 3) fast growing annual crops, 4) hydrocarbon vegetation, 5) manure, 6) aquatic systems, and 7) human byproducts.[81] The Food and Agriculture Organization (FAO) reports that bioenergy covers approximately 10 percent of total world energy supply.[82]

Biofuels may be derived "from agricultural crops, including conventional food plants or from special energy crops; forestry, agricultural, or fishery products; municipal wastes; or agro-industry, food industry, and food service by-products and wastes."[83] It is important to distinguish between primary biofuels, including forest and agriculture-based biofuels, and advanced biofuels. "[P]rimary biofuels. . .[are] organic materials [that] are used in their unprocessed form [for the purposes of] heating, cooking, or electricity production," whereas "[advanced] biofuels result from processing of biomass and include liquid biofuels such as ethanol and biodiesel that can be used in vehicles and industrial processes."[84] The source of biomass and the harvesting process impacts the overall sustainability of the fuel source. A number of factors, such as resource availability, scalability, price, demand, and conversion processes, impact the actual use of the biofuel type.

A. *Biofuels Production Risks*

Rapid population growth has stressed agriculture production in many regions. In the coming decades, as in the past century, food shortages will create conditions of famine, strife, conflict, and disease. "Climate change, water shortages, higher energy prices, crop diseases and a rapidly expanding population" impact food security and make it difficult for farmers and governments to keep adequate food supplies.[85]

GEOSCIENCE, 533–34 (2009); Ben Booth & Nicholas Bellouin, *Climate Change: Black Carbon and Atmospheric Feedbacks*, 519 NATURE, 167–68, (2015).

81. SIERRA CLUB INTERNATIONAL EARTHCARE CENTER, GLOBAL ENERGY IN TRANSITION: ENVIRONMENTAL ASPECTS OF NEW AND RENEWABLE SOURCES FOR DEVELOPMENT 47–48 (Elizabeth Bassan ed., 1981).

82. U.N. FAO, THE STATE OF FOOD AND AGRICULTURE 1, 22 (2008), ftp://ftp.fao.org/docrep/fao/011/i0100e/i0100e.pdf [hereinafter FAO].

83. Lehman, *supra* note 27. Biofuels can be solid, gaseous or liquid, even though the term tends to restrict the usage to meaning liquid biofuels for transport.

84. GREENFACTS, *supra* note 80.

85. Arieh O'Sullivan, *Food Security in a Hungry World*, JERUSALEM POST (Mar. 15, 2012, 11:30 PM), http://gantdaily.com/2012/03/15/food-security-in-a-hungry-world/. World agriculture production has not been able to keep pace with population growth. By the year 2030, an additional 1.8 billion people will be on the planet. In this decade alone, the world faces the unprecedented

Moreover, soaring population rates make protect shrinking arable lands critical.[86]

The drawbacks of biofuel production, including the negative impact on food supply, overshadow the traditional promise of this green energy. Ongoing food shortages have led policymakers and agriculture industry leaders to work toward developing more sustainable agricultural practices. In poor countries with large indigent populations, the risk of falling into a poverty trap is dangerously high. Jeffrey Sachs argues that the issue of food cultivation is the determining factor in poverty: "The poverty trap is mainly a rural phenomenon of peasant farmers caught in a spiral of rising populations and stagnant or falling food production per person."[87] In less developed countries, conditions of poverty inhibit innovation and investment in advanced renewables. The day-to-day toils of survival limit consideration of environmental externalities. Therefore, where the poverty trap looms large is where greater attention should be given to manage the limited and scarce natural resources of land, freshwater, and agriculture crops. An ancillary concern regarding food shortages is agricultural subsidies. Joseph Stiglitz comments:

> The average European cow gets a subsidy of $2 a day (the World Bank measure of poverty); more than half of the people in the developing world live on less than that. It appears that it is better to be a cow in Europe than to be a poor person in a developing country.[88]

These income and resource inequalities highlight how the Third World is providing for the living standards of the Global North through its lands, livelihoods, and lives.[89] The use of land for developing

challenge of increasing the food supply by 20 percent. Accelerated rates of urbanization and population rise have placed a premium on land. This trend is more startling since only eleven percent of the Earth's surface is suitable for agriculture. *Id.*

86. *Id.* Harris Sherman, former undersecretary for natural resources and environment for the U.S. Department of Agriculture, indicated at an international conference on food security at Tel Aviv University, "We need to protect our arable lands, and our arable lands are shrinking. We'll have a billion or two billion new people in the next 40 years. We have got to protect these arable lands." *Id.*

87. JEFFREY D. SACHS, THE END OF POVERTY: ECONOMIC POSSIBILITIES FOR OUR TIME 70 (2005). Poor countries that actually had economic growth started with high cereal yields per hectare and used high levels of fertilizer input per hectare. Meanwhile, countries that experienced economic decline between 1980 and 2000 had very low yields. *Id.* at 69.

88. JOSEPH E. STIGLITZ, MAKING GLOBALIZATION WORK 85 (2006). While the benefits and problems of agricultural subsidies are beyond the scope of this paper, I mention them to highlight the complex monetary issues at play in the agriculture industry.

89. Ahmad, *supra* note 10.

biofuels clashes with the need of land for agricultural production. Energy crop profits have caused farmers to produce food crops instead of fuel crops.[90] Not only are crops affected, but so is livestock. More than eighty percent of U.S. agricultural production goes into animal feed, which is significant, because the "[g]lobal increase in meat consumption is one of the main driving forces behind high food prices."[91] However, proponents of biofuels argue that there is "a global food surplus," and "biofuels could actually turn distribution structures upside down and reduce world hunger."[92]

Siwa Msangi observes, "biofuel production poses new food security risks and challenges for poor people. Higher food prices, subsidies for biofuels, and environmental degradation will all be felt disproportionately by the developing world."[93] As Peter Fairley as has pointed out, "the rapid scale-up of biofuels . . . has contributed to higher food prices and deforestation."[94] Based on inquiry into the ethics of biofuel, policies and targets to encourage biofuels have "backfired badly."[95] For example, increasing biofuel demand has been linked with tightening in grain markets, which in turn results in pressures on global agricultural markets and increased food costs.[96] And while several models have suggested these trends have the potential to increase agricultural wages in developing countries, they also indicate that the corresponding hikes in food prices will harm poor consumers.[97] In one case, rising food prices caused food riots in Mexico in December 2007, which later spread to other impoverished communities in developing countries.[98]

90. *See generally* Duncan Graham-Rowe, *Agriculture: Beyond Food Versus Fuel,* 474 NATURE S6 (2011).

91. *Id.* at S7.

92. David Boddiger, *Boosting Biofuel Crops Could Threaten Food Security,* 370 LANCET, 923, 923 (2007), http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2807%2961427-5/fulltext.

93. Siwa Msangi, *Biofuel Revolution Threatens Food Security for the Poor,* SCI. & DEV. NET., (Dec. 6, 2007), http://www.scidev.net/global/forestry/opinion/biofuel-revolution-threatens-food-security-for-the.html. *See also* Nadia Ahmad, *The International Sugar Trade and Sustainable Development: Curtailing the Sugar Rush*, 39 N.C. J. INT'L L. & COM. REG. 675 (2014).

94. Peter Fairley, *Next Generation Biofuels,* 474 NATURE S2, S2 (2011).

95. *Id.*

96. *See* INT'L FOOD POL'Y RESEARCH INST., BIOFUELS AND FOOD SECURITY: BALANCING NEEDS FOR FOOD, FEED, AND FUEL (2008), http://www.ifpri.org/sites/default/files/publications/bioenergygro.pdf (linking the growth of populations in developing countries, changing diet preferences, and greater requirements for grain with increasing biofuel demand).

97. *Id.*

98. Fairley, *supra* note 94, at S3 ("Although many economists agree that biofuels contributed

The skyrocketing amount of biofuel output suggests a correlation between the competition of land use between biofuels and food production.[99] Ian Crute, the chief scientist at the Kenilworth-based Agriculture and Horticulture Development Board, writes that "[i]deally, biofuel crops would be grown on marginal land that has a low carbon stock, leaving the higher quality soil for food production . . . ."[100] A report by the Energy Future Coalition, a pro-ethanol coalition of global business, labor, and environmental groups, states, "[b]iofuels could attract investment that would support agricultural improvements across the board, which would benefit food production, accelerate rural economic development, and alleviate poverty and migration to the cities."[101] According to a report by the U.S. Energy Information Administration (EIA), world energy consumption will grow by fifty-three percent from 2008 to 2035.[102] Energy use in non-OECD nations is on track to increase by 85 percent compared with an increase of eighteen percent for the OECD economies.[103] The demand for biofuels further fluctuates based on climate, crop, and market conditions as well as the implementation of laws on deforestation and ethical corporate standards for biofuels.[104] A report by the Anti Forest-Mafia Coalition and Forest Trends indicates that more than thirty percent of wood consumed by Indonesia's industrial forest sector "stems from the

less to the price hikes than commodities speculators, oil prices and weather, protestors and food rioters claimed that the conversion of staple foods into biofuels distorted global agricultural markets."). The annual output of bioethanol and biodiesel has risen from 16 million liters worldwide in 2000 to more than 100 million liters in 2010, outpacing growth in supply of corn, sugarcane and vegetable oil. *Id.*

99. *See* Graham-Rowe, *supra* note 90.

100. *Id.* at S7.

101. Boddiger, *supra* note 92, at 924.

102. U.S. ENERGY INFO. AGENCY, INTERNATIONAL ENERGY OUTLOOK 2011 1 (2011), http://www.eia.gov/forecasts/ieo/index.cfm. Additionally, the total world energy use will increase from 505 quadrillion British thermal units (Btu) in 2008 to 619 quadrillion Btu in 2020 and 770 quadrillion Btu in 2035. *Id.* Most of the increase in energy consumption use occurs in countries outside of the Organisation for Economic Co-operation and Development (non-OECD nations) because of strong long-term economic growth. *Id.*

103. *Id.* The EIA report does not account for policy changes, but renewable energy is projected to be the fastest growing source of primary energy over the next 25 years, even though fossil fuels will remain the dominant source of energy. *Id.* Renewable energy consumption is expected to increase by 2.8 percent per year and the renewable share of total energy use is expected to increase from 10 percent in 2008 to 15 percent in 2035. *Id.*

104. Nithin Coca, *Indonesia's Biofuels Push,* DIPLOMAT (May 12, 2015) http://thediplomat.com/2015/05/indonesias-biofuels-push/ ("Indonesia overplanted [palm oil], said Dave McLaughlin, Vice President for Agriculture at the World Wildlife Fund. Supply is greatly outpacing demand, and thus you have prices at a six year low right now.").

unreported clear-cutting of natural forests and other illegal sources instead of legal tree plantations and well-managed logging concessions."[105]

B. U.S. Bioeconomy, Wood Biomass, and Deforestation

President Barack Obama's All-of-the-Above energy strategy sought to "support economic growth and job creation," "enhance energy security," and "deploy low-carbon energy technologies and lay the foundation for a clean energy future."[106] The policy sought to explain the rising domestic oil and gas production combined with escalated growth of renewables.[107] One of the foremost frustrations of the All-of-the-Above energy strategy was that economic and energy security gains occur at the expense of environmental and social costs.[108] Jeffrey Ball has described the All-of-the-Above energy strategy as "so general as to be meaningless."[109] Still, the All-of-the-Above strategy incentivizes renewables, but does little to discriminate between renewables themselves, invariably encouraging energy sources that are not necessarily clean and sustainable as major energy sources. Biofuels are a prime example of why the All-of-the-Above approach needs to be refined. The Trump administration has said that it will balance concerns for food security and economic development in its long-term bioenergy policy.[110]

105. Gemina Harvey, *Saving Indonesia's Forests*, DIPLOMAT (May 1, 2015) http://thediplomat.com/2015/05/saving-indonesias-forests/. The Anti Forest-Mafia Coalition and Forest Trends found the material used by large mills (those which process more than 6,000 cubic meters of wood per year) exceeded the legal supply by the equivalent of 20 million cubic meters – enough to fill 1.5 million logging trucks. This figure was found by comparing the supply of wood as recorded by the Ministry of Forestry (MoF) against the amount industry reported using. Statistics on wood passing through smaller mills are not fully recorded, indicating the volume of illegal wood consumed may be higher. It should also be stated that with uncertainty surrounding official forestry data in Indonesia, all statistics are shaky and should only be viewed as a guide. While the source of this illegal wood is unclear the report notes it likely comes from trees harvested during forest clearance for new palm oil and timber plantations. *Id.*

106. Jason Furman & Jim Stock, *New Report: All-of-the-Above Energy Strategy as a Path to Sustainable Economic Growth*, WHITE HOUSE, (May 29, 2014, 11:30 AM), https://obamawhitehouse.archives.gov/blog/2014/05/29/new-report-all-above-energy-strategy-path-sustainable-economic-growth.

107. *See generally id.*

108. Jeffrey Ball, *Obama's Meaningless 'All of the Above' Energy Strategy is Infuriating Both Environmentalists and Fossil Fuelers*, NEW REPUBLIC, (Jan. 30, 2014), https://newrepublic.com/article/116397/obamas-energy-policy-all-above-meaningless.

109. *Id.*

110. *See* Erin Voegele, *Biomass, biofuel groups hopeful Trump will support bioenergy*, Biomass Magazine (Nov. 9, 2016), http://biomassmagazine.com/articles/13905/biomass-biofuel-gr

The definition of what constitutes biomass and biofuel determines how those energy sources will factor into the renewable energy mix. The term "bioeconomy" refers to the "integral role of abundant, sustainable, domestic biomass in the U.S. economy" and more specifically the "global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security benefits."[111] Under the auspices of the Biomass Research and Development Act of 2000, the Biomass Research and Development Board (R&D Board) was created "to coordinate programs within and among departments and agencies of the federal government for the purpose of promoting the use of bio-based industrial products by (1) maximizing the benefits deriving from federal grants and assistance; and [by] (2) bringing coherence to federal strategic planning."[112] The Board is co-chaired by senior officials from the U.S. Department of Energy and several federal agencies.[113] The Biomass R&D Board seeks to coordinate interagency collaboration on the research, development, and deployment of biofuels and bioproducts.[114]

The Federal Activities Report of the Bioeconomy explains a broader goal of interagency collaboration "on bioeconomy conceptions working to triple the size of today's bioeconomy by 2030—to more than a billion tons of biomass."[115] Soaring energy demands have led to a great incentive to reach this ambitious goal. However, a troubling amount of environmental and social degradation may occur as result of a policy of promoting an energy resource that leads to deforestation, threats to species, and the displacement of human

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oups-hopeful-trump-will-support-bioenergy.

111. Biomass R&D Board, FEDERAL ACTIVITIES REPORT OF THE BIOECONOMY, 1 (2016), http://www.biomassboard.gov/pdfs/farb_2_18_16.pdf.

112. Agricultural Risk Protection Act of 2000, Pub. L. No. 106–224, § 305, (2000). The Biomass Research and Development Act of 2000, later amended by Section 9001 of the Food Conservation and Energy Act of 2008 (FCEA), established Biomass Research and Development Board, annual Initiative solicitation, and Technical Advisory Committee. The Biomass Research and Development Act was most recently reauthorized in the Agricultural Act of 2014. *Id.*

113. Biomass R&D Board, *supra* note 111, at iv. The DOE partnered with the U.S. Department of Agriculture (USDA) and consists of senior decision makers from the DOE, USDA, U.S. Department of Transportation, U.S. Department of the Interior, U.S. Department of Defense, EPA, National Science Foundation, and the Office of Science and Technology Policy within the Executive Office of the President. *Id.*

114. *Id.*

115. Susan Carter, *Growing and Building the Billion Ton Bioeconomy*, USDA (Apr. 27, 2016), http://blogs.usda.gov/2016/04/27/growing-and-building-the-billion-ton-bioeconomy/.

populations.[116] Policymakers must therefore pay more attention to climate change and environmental threats associated with biofuels. The driver for the billion-ton bioeconomy vision is economics. Environmental and social effects are overlooked or outrightly ignored in hydrocarbon development, and the build-up for bioeconomy projects also fails to fully explore the scope of social and environmental impacts of the biofuel production, particularly for rural development, water use, and water pollution. In fact, the term "food security" is used only once in the *Federal Activities Report of the Bioeconomy*.[117] Food security is a primary concern of ratcheted up biofuel production.

Another concern of biofuels in the United States is what constitutes biomass. A bill for North American Energy Security and Infrastructure Act of 2016 included an amendment to provide consistency in the treatment of forest or wood biomass for energy, conservation, and responsible forest management.[118] The amendment directed the Secretary of Energy, the Secretary of Agriculture, and the Administrator of the EPA to coordinate policies for biomass for energy use.[119] Those policies sought to: "Reflect the carbon neutrality of forest bioenergy; Recognize forest biomass as a renewable energy source; Encourage private investment throughout the forest biomass supply chain; Encourage forest management to improve forest health; And recognize state initiatives to use forest biomass."[120]

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116. *See* Lakhani, *supra* note 1.

117. Biomass R&D Board, *supra* note 111, at 20.

118. North American Energy Security and Infrastructure Act of 2016, S. 2012 (2016) S. Amend. No. 3140; *see also* Sen. Angus King, *Collins, King, Klobuchar Biomass Amendment Passes Senate*, Press Release, (Feb. 3, 2016), http://www.king.senate.gov/newsroom/press-releases/collins-king-klobuchar-biomass-amendment-passes-senate?version=meter+at+10&module=meter-Links&pgtype=article&contentId=&mediaId=&referrer=https%3A%2F%2Fwww.google.com%2F&priority=true&action=click&contentCollection=meter-links-click.

119. North American Energy Security and Infrastructure Act of 2016, *supra* note 118. While the legislation was ultimately unsuccessful, the debate surrounding the proposal illustrates how biofuels issues will be considered in the future.

120. Sen. King, *supra* note 118. Senator Susan Collins issued a statement regarding biomass energy:

> Biomass energy is sustainable, responsible, renewable, and economically significant as an energy source, and many states, including Maine, are already relying on biomass to meet their renewable energy goals. While the carbon neutrality of biomass harvested from sustainably managed forests has been recognized repeatedly by numerous studies, agencies, institutions, and rules around the world, current policy uncertainty could end up jeopardizing rather than encouraging investments in working forests, harvesting operations, bioenergy, wood products, and paper manufacturing.

Id.

In urging the federal government to recognize the benefits of forest biomass as a renewable energy resource, Senator Angus King (I-ME) argued that forest biomass is "a home-grown and environmentally-responsible source of energy" that can serve as "a significant boon to rural economies in Maine and across the country."[121] Treating wood biomass like other biofuels is problematic because harvesting wood and forest biomass has different environmental and social effects. In response to a 2016 energy bill, a group of environmental organizations sent a letter to the Senate over what they perceived as a "sweetheart deal" for the biomass industry, requesting them to reject the biomass amendment.[122] *The New York Times* pressed Congress to remove the biomass amendment since it questioned whether electricity by burning trees and other forest biomass is carbon neutral.[123] Scientists have noted the flaw in declaring forest biomass as carbon neutral.[124] Eric Johnson explains that biomass fuels are not always carbon neutral, and in some cases, may be far *more* carbon positive than fossil fuels.[125] Johnson recommends using a carbon-stock change line item instead of applying sequestration credits and combustion debits.[126] This change in measuring the carbon footprint of biofuels would make the process more accurate and consistent with United Nations Framework Convention on Climate Change (UNFCCC) reporting requirements and national reporting practices.[127]

121. *Id.* ("By requiring every federal department to be on the same page when it comes to biomass policy, our amendment will ensure that biomass will play an important role in shaping a clean and affordable energy future for America.").

122. Environmental and Energy Study Institute, *Biomass Provision in Bipartisan Energy Bill Touches Environmental Flash Point*, (Apr. 26, 2016), http://www.eesi.org/articles/view/biomass-provision-in-bi-partisan-energy-bill-touches-environmental-flash-po.

123. N.Y. Times Editorial Board, *An Energy Bill in Need of Fixes,* N.Y. TIMES, Apr. 20, 2016, http://www.nytimes.com/2016/04/21/opinion/mixed-signals-on-energy.html?_r=0.

124. *See id* ("Burning wood releases carbon almost instantly, whereas it will take years, if not decades, for new trees to absorb an equivalent amount of carbon. . . .").

125. *See* Eric Johnson, *Goodbye to carbon neutral: Getting biomass footprints right*, 29 ENVT'L. IMPACT ASSESSMENT REV. 165, 167 tbl. 4 (Apr. 2009) (noting including biomass carbon-stock depletion, harvested logs have a greater carbon footprint than natural gas when used as fuel).

126. *Id.* at 167.

127. *Id.*

C. *African Palm in Honduras and Farmers' Land Rights*

Forest biofuels are not the only biofuels that are problematic. Palm oil in Indonesia and African palms in Honduras have terrible social and environmental externalities.[128] The definitional challenges of what constitutes sustainable biofuel energy requires greater scrutiny.

Social factors in the harvesting area also bear upon access to biomass resources for conversion to biofuels. The dislocation of villagers, small farmers, and rural peoples is an unaccounted cost of biofuel production in the Global South. Dating back twenty years to a World Bank-funded modernization program, local Honduran farms allege "thousands of hectares of land used for subsistence farming were fraudulently and coercively transferred to agribusinesses that grow African palms, which are lucratively exported to the west for biofuel, and are traded in the carbon credit market."[129] The Western obsession with offsetting its carbon impact "has spurred dirty war in Honduras, where U.S.-backed security forces are implicated in the murder, disappearance and intimidation of peasant farmers involved in land disputes with local palm oil magnates."[130] Historically, foreign actors have invariably displaced or negatively impacted local populations, who in response have formed grassroots resistance groups to counter the loss of property rights in their own countries.[131] Biofuel experts recommend the creation of a secretary-level body in Honduras at the national level to oversee all energy activities with core competency for "the formulation, coordination, implementation and evaluation of policies related to protection and utilization of renewable sources of energy . . . ."[132]

The conflict involving the peasant communities in the lush Lower Aguán Valley of Honduras parallels a broader struggle over land and natural resources across the country between the poor majority and the nation's ten oligarch families.[133] The lack of progress on the property

128. Lakhani, *supra* note 1.

129. *Id.*

130. *Id.*

131. *See* Marc Edelman, Carlos Oya & Saturnino M. Borras, Jr., *Global Land Grabs: historical processes, theoretical and methodological implications and current trajectories*, 34 THIRD WORLD Q. 1517, 1517–19 (2013).

132. Wilfredo C. Flores et al., *Sustainable energy policy in Honduras: Diagnosis and Challenges*, 39 ENERGY POL'Y 551, 561 (2011).

133. Lakhani, *supra* note 1. The farmers have sought to no avail to reclaim their land through legal channels and the use of roadblocks and illegal land occupations. *Id.* Deposed Honduras president Manuel Zelaya had begun investigating the land grabbing allegations, but the

rights claims of small farmers has led groups of them to large-scale illegal occupations on disputed land also claimed by the country's biggest palm oil producer, the Dinant Corporation.[134] Honduras has the climate and soil conditions that are favorable to producing high yields of African palm oil.[135] The unique ecosystem creates demand for the land on which the crop can be grown. The land grabbing for biomass is part of a larger, coordinated effort to suppress protests against land grabs, dams, mining and oil concessions, which have all increased as result of the 2009 coup.[136]

The switch to biofuel crops has also decreased the available land for subsistence and food crops in Honduras, which impacts the overall availability of resources for nutrition to the benefit of resources available for energy.[137] From 2011 to 2014, African palm plantations increased by fifty percent, dominating the Bajo Aguán terrain and replacing bananas and other food crops.[138] Honduras became the "most dangerous country on the planet outside of a full-fledged war zone" due to the unrest resulting from food scarcity and land grabs.[139] Killings for land and environmental defenders are not new, but they are on the steady rise; Global Witness documented 185 killings of individuals who were defending their land, forests and rivers against industry exploitation, which amounts to more than three people per week in 2015.[140]

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government coup in 2009 stopped progress on those investigations. *Id.*; *See also* ECLAC, SICA, *Central American sustainable energy strategy to 2020*, (2007), http://repository.unm.edu/bitstream/handle/1928/11859/EstrategiaCentroamericana2020.pdf?sequence=1&isAllowed=y.

134. Lakhani, *supra* note 1. The Lower Aguán Valley area was heavily militarized in 2010, and soldiers forcibly removed the remaining farmers under disputed court orders. *Id.*

135. Christine Moser, Tina Hildebrandt & Robert Bailis, *International Sustainability Standards and Certifications*, *in* SUSTAINABLE DEVELOPMENT OF BIOFUELS IN LATIN AMERICA AND THE CARIBBEAN 41 (Barry D. Solomon & Robert Bailis eds., 2014).

136. Lakhani, *supra* note 1. These limitations on native land rights coincides with the increasing military presence of the United States in Honduras, which is a major transit point in the smuggling of illegal drugs. "Between 140 and 300 tonnes of cocaine are believed to pass through Honduras every year en route from South America to the US and beyond." *Id.*

137. *Id.*

138.*Id.* (stating that African palms, the saturated oil of used in biodiesel, are now the most profitable crop in Honduras).

139. Philip Sherwell, *Welcome to Honduras, the most dangerous country on the planet*, TELEGRAPH, (Nov. 16, 2013), http://www.telegraph.co.uk/news/worldnews/centralamericaandthecaribbean/honduras/10454018/Welcome-to-Honduras-the-most-dangerous-country-on-the-planet.html. The murder rate reached 85 for every 100,000 residents in 2012, and was on course to reach 90 per 100,000 in 2013.

140. GLOBAL WITNESS, ON DANGEROUS GROUND: 2015'S DEADLY ENVIRONMENT: THE KILLING AND CRIMINALIZATION OF LAND AND ENVIRONMENTAL DEFENDERS WORLDWIDE,

D. *Indonesia, Deforestation, and the Global Demand*

Satellite images show smoke from fires billowing in Borneo, Indonesia.[141] Home to eighty-four percent of Southeast Asia's peatlands, Indonesia leads the world in palm oil production.[142] Its rise as the world's leader in palm oil production came at a steep cost to the environment. Biofuel developers target the area's peatlands for palm oil to produce biofuels.[143] Peatlands must be burned or drained to harvest the fuel crops, a process that creates major greenhouse gas emissions.[144] In its efforts to support biofuel production that meets demand in developed nations like the Netherlands, Indonesia has ascended to the rank of the world's third-largest producer of carbon dioxide.[145] Enrique Rene de Vera notes the irony that "biofuels are intended to preserve the environment, but due to production methods that degrade the environment, biofuels potentially fall well short of achieving this intended goal."[146] Oil palm for biofuels led to 2.8 percent to 6.5 percent of deforestation in Indonesia and Malaysia.[147]

(Jun. 20, 2016), https://www.globalwitness.org/en/reports/dangerous-ground/ (noting "2015 was the worst year on record for killings of land and environmental defenders").

141. NASA EARTH OBSERVATORY, SMOKE BLANKETS INDONESIA, (Sept. 27, 2015), http://earthobservatory.nasa.gov/IOTD/view.php?id=86681.

142. Roz Pidcock, *Indonesian fires now on a par with Brazil's total annual emissions*, CARBON BRIEF, (Oct. 15, 2015), http://www.carbonbrief.org/indonesian-fires-now-on-a-par-with-brazils-total-annual-emissions; *citing* D. Murdiyarso, K. Hergoualc'h, L.V. Verchot, *Opportunities for reducing greenhouse gas emissions in tropical peatlands*, 106 PNAS 19655, 19655 (2010).

143. *Id.*

144. Peat fires are known for smoldering combustion, which is ignited more readily than flaming combustion and persists in wet, tropical conditions, such as Indonesia. Merrit R. Turetsky, Brian Benscoter, Susan Page, Guillermo Rein, Guido R. van der Werf & Adam Watts, *Global vulnerability of peatlands to fire and carbon loss*, 8 NATURE GEOSCIENCE 11, 11–14 (2015). These combustibility factors make peat fires difficult to extinguish, so they can smolder under the surface for months. Pidcock, *supra* note 142. In undisturbed peatlands areas, most of "the peat carbon stock typically is protected from smoldering, and resistance to fire has led to a build-up of peat carbon storage in boreal and tropical regions over long timescales." Turetsky, *supra* note 144. However, climate change and human activity have led to drying of these areas, which, in turn, reduced the water table and raised the frequency and extent of peat fires. *Id.* Guido van der Werf estimated that fires in Indonesia have emitted an estimated 1.6 billion tons of carbon dioxide equivalents so far in 2016, which is more than the average annual emissions of Japan. Pidcock, *supra* note 142.

145. Chris Brummitt, *Orangutans Squeezed by Biofuel Boom*, MSNBC, (Sept. 4, 2007), http://www.msnbc.msn.com/id/20478277.

146. Enrique Rene de Vera, *The WTO and Biofuels: The Possibility of Unilateral Sustainability Requirements*, 8 CHI. J. INT'L L. 661, 667 (2008).

147. David Takacs, *Protecting Your Environment, Exacerbating Injustice: Avoiding "Mandate Havens"*, 24 DUKE ENVTL. L. & POL'Y F. 315, 329–30 (2014).

This drastic level of deforestation shows why greater attention must be paid to the creation of sustainable laws and practices for harnessing and producing biofuels crops. Tropical and subtropical developing nations, including Indonesia, Brazil, and India, possess inherent advantages in costs and efficiency over larger economies in temperate climates in the Global North.[148] Antoine Halff observes that "protectionist policies designed to boost domestic biofuel production capacity in [OECD] countries while keeping out lower-cost imports have aggravated, rather than narrowed, those differences."[149]

Under the United Nations Reducing Emissions from Deforestation and Forest Degradation (REDD) initiative, Norway and Indonesia entered into an agreement in 2010 where Norway would pay Indonesia one billion U.S. dollars to suspend new concessions on conversion of forests and peatlands for two years.[150] While Indonesia implemented a moratorium on new permits for conversion of natural forests, the agreement still contained major loopholes that allowed for destructive deforestation of protected areas.[151]

The examples of Honduras and Indonesia illustrate the demands placed on biofuel-producing countries in the Global South to account for the "clean energy" mandates in the United States and Europe. Both with their land and lives, politically weak and economically poor populations in the Global South struggle to maintain the energy standards of their most economically established counterparts in neighboring provinces and countries. This disparity in efforts to supply energy demands led to the United Nations initiative for Sustainable Energy for All, which highlights the relationship between the deployment of clean energy development and alleviation of poverty.[152]

148. Antoine Halff, *Energy Nationalism, Consumer Style: How the Quest for "Energy Independence" Undermines U.S. Ethanol Policy and Energy Security*, 19 STAN. L. & POL'Y REV. 402, 404 (2008).

149. *Id.*

150. Melissa Schoeman, *The Obvious Solution to Unsustainable Palm Oil: Why National Enforcement Remains a Necessary Mechanism Despite the Emergence of Alternate Regulatory Schemes*, 40(4) N.C. J. INT'L L. & COM. REG. 1085, 1105–06 (2015). Indonesia announced it would commit to a forty-one percent reduction in greenhouse gases by 2020 with the assurance of international assistance, rather than a twenty-six percent reduction without such international support. *Id.* at 1105.

151. *Id.* at 1105–06.

152. *See* BAN KI-MOON, SUSTAINABLE ENERGY FOR ALL: A VISION STATEMENT BY BAN KI-MOON SECRETARY GENERAL OF THE UNITED NATIONS, 4 (2011), (addressing the three goals of the Sustainable Energy for All initiative, including: "[(1) e]nsuring universal access to modern energy services. [(2) d]oubling the rate of improvement in energy efficiency. [(3) d]oubling the share of renewable energy in the global energy mix"); *see* Ahmad, *supra* note 34, at 169.

The next section examines the history and norms of biofuels to establish a broader property law framework for discussion.

III. HISTORY AND NORMS

> In 2015 49 activists – 45 in the Amazon – were killed, making it the most violent year since 2004 . . . representing a huge regression of policies . . . to control violence and deforestation. Violence has been legitimized as a normal part of politics. It has become informally "acceptable." I've never seen, working for the past 10 years in the Amazon, a situation so bad. All of my friends in Marabá receive death threats. They are part of various social movements . . . or working for the state, such as IBAMA [the government's Brazilian Institute for the Environment and Renewable Natural Resources], and are afraid of being killed like they never were before.
>
> - Felipe Milanez, Former Deputy Editor at National Geographic Brazil[153]

Efforts to curb violence and deforestation are linked, but policies to combat them are handled separately. Recognizing the foundational causes of the connections and the intersection of violence and land loss is essential. The use of land for the cultivation of biofuel crops requires a more expansive property law framework for interpretation than traditional land use policies for agriculture. This section traces the origins of biofuel law in the whaling industry of the eighteenth and nineteenth centuries and explores how the historical delineations of law surrounding biofuels has expanded over the past several hundred years. Robert Ellickson examined two significant theoretical issues of property rights: 1) "a legal-centralist view, where the state is the exclusive creator of property rights" and 2) a view in which "property rights may emerge from sources other than the state—in particular, from the workings of nonhierarchical social forces.[154] He argues, "The

153. David Hill, *'Never seen it so bad': violence and impunity in Brazil's Amazon,* GUARDIAN, (Feb. 16, 2016), https://www.theguardian.com/environment/andes-to-the-amazon/2016/feb/16/never-seen-it-so-bad-violence-and-impunity-in-brazils-amazon.

154. Robert C. Ellickson, *A Hypothesis of Wealth-Maximizing Norms: Evidence from the Whaling Industry*, 5 J. L. ECON. & ORG. 83, 84 (1989). Thomas Hobbes, Garrett Hardin, and Guido Calabresi have promoted the legal-centralist thinking arguments. *See also* Thomas Hobbes LEVIATHAN (1909); Garrett Hardin, *The Tragedy of the Commons,* 162 SCI. 1243 (1968); Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089 (1972).

whaling evidence refutes legal-centralism and strongly supports the proposition that property rights may arise anarchically out of social custom."[155] I assert that biofuel law and policy have developed out a milieu of social customs and legal norms aimed at wealth-maximizing efforts that have placed little emphasis on environmental stewardship and sustainability principles.

Realigning the law of biofuels with environmental and human rights concerns would reduce land use conflicts arising from land grabs, food security, and environmental pollution from greenhouse gas emissions of biofuels. Considering indigenous customs and local land use norms would broaden the range of laws available to govern biofuel use and production. While an expanded governance system would add complexity to energy production dynamics, a multilayered governance system for biofuel use would work to incentivize the use of second generation biofuels and minimize the environmental and social harms associated with conventional agriculture-based biofuels.

A. The Whaling Industry as an Analogue

The whaling industry is an early example of how human greed for energy depleted a natural resource, whales. Anti-whaling laws and customs were implemented and enforced to save many species of whales from near extinction. Ellickson noted that from 1750 to 1870, whales served as a valuable source of oil, bone, and other products.[156] Early disputes involving whaling where resolved based on customs and social norms.[157] From the first significant international whaling grounds of Greenland, the Dutch, English, and Americans led early whaling expeditions as whaling developed into a full-fledged industry.[158] As whaling expanded, rules of capture became subject to internationally binding norms.[159] Charlotte Epstein has examined the material forces that pushed the rise and dominance of the whaling industry in the first

155. Ellickson, *supra* note 154.

156. *Id.*; *see* Swift v. Gifford, 23 Fed. Cas. 558 (D. Mass 1872) (No. 13,696); *see also* Taber v. Jenny, 23 Fed. Cas. 605 (D. Mass 1856) (No. 13,720).

157. Ghen v. Rich, 8 F. 159 (1881).

158. Clifford Ashley, THE YANKEE WHALER 2329 (1938); Elmo Paul Hohman, THE AMERICAN WHALEMAN: A STUDY OF LIFE AND LABOR IN THE WHALING INDUSTRY 5–22 (1928).

159. Fennings v. Lord Grenville, 1 Taut. 241, 127 Eng. Rep. 825, 828 (Ct. Comm. Pleas 1808) (nothing in dictum that the fast-fish "usage in Greenland is regarded as binding on persons of all nations."); *see also* Ellickson, *supra* note 154, at 85, n. 6.

half of the twentieth century.[160] She considered the political economy of whaling and the various ways whale resources were consumed.[161] While it would seem that this early pro-whaling period could be explained by the economic gains of this activity, Epstein highlights the co-constitutivity of discursive and material practices.[162] Not until a new discourse emerged that cast whales in a new light did actors rethink their interests.[163] Her argument combines constructivism and rationalism: "it is precisely because discursive and material interests are so deeply entwined that discourses cannot flourish without the appropriate material conditions."[164] In the latter half of the twentieth century, anti-whaling efforts emerged because the whaling industry was declining and environmentalism became increasingly influential. As a result, NGOs were established and influenced relations between state and non-state actors within the International Whaling Commission (IWC).[165] There were so few cases addressing whaling because the industry initially was adverse to litigation and loss and relied on the use of customs for such. While this example of whaling is not completely proximate to the use of land for biofuels, this example shows how customs and norms were used for competing food and energy resources.

B. The Emergence of Biofuels

German inventor Nikolaus August Otto was among the first innovators of ethanol.[166] Rudolf Diesel, the German inventor of the diesel engine, designed his engine to operate on peanut oil,[167] and later Henry Ford designed the Model T car to operate on hemp-derived biofuel.[168] Meanwhile, use of biofuels diminished as petroleum reserves

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160. *See generally* Charlotte Epstein, THE POWER OF WORDS IN INTERNATIONAL RELATIONS: BIRTH OF AN ANTI-WHALING DISCOURSE (2008)

161. *Id.*

162. *Id.* at 51.

163. *Id.* at 50.

164. *Id.*

165. *Id.*

166. Rafael Luque et al., *Biofuels: a technological perspective,* 1 ENERGY & ENVT'L SCIENCE 542, 544 (2008).

167. Kahraman Bozbas, *Biodiesel as an alternative motor fuel: Production and policies in the European Union*, RENEWABLE & SUSTAINABLE ENERGY REVS. 542, 543 (2005).

168. *See* James Holbery & Dan Houston, *Natural-fiber-reinforced polymer composites in automotive applications*, 58 J. MINERALS, METALS & SOC'Y 80 (2006), http://link.springer.com/article/10.1007/s11837-006-0234-2.

were discovered in Pennsylvania and Texas.[169] Global discovery of petroleum peaked in the 1960s and has steadily fallen over time.[170] Globally, the growth of biofuels coincided with the Asian financial collapse and the worldwide economic slump in 2008.[171] Earlier, the growth of biofuels was precipitated by the OPEC oil crisis in the 1970s.[172] The need for cooking oil and demand for biofuels led to the spike in biofuel production in 2001 in Indonesia and Malaysia.[173] Palm oil itself is not indigenous to either Indonesia or Southeast Asia as it was brought to region from West Africa during colonial times.[174]

A well-managed biofuel production system is feasible. John Blewitt notes the potential economic, health, and societal improvements because of renewables. [175] Renewable energy can be economically beneficial, improve energy security, reduce local pollutant emissions, create jobs, and improve health. Reforestation and bioenergy plantations can lead to restoration of degraded land, manage water runoff, retain the soil carbon, reduce loss of natural habitats, enhance biodiversity, conserve soil and water, and benefit rural economies when properly designed and implemented.[176] According to the World Watch Institute, because of higher world agricultural prices, "biofuels could economically benefit a number of developing countries, which instead of using foreign currency to import oil could develop their own domestic biofuel industries to purchase fuel from their own farmers."[177] In May 2011, the International Energy Agency (IEA) laid out a detailed plan to increase the use of biofuels from around two percent of global transport fuel to twenty-seven percent by the year 2050.[178] According to the IEA plan, biofuels could

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169. Leland J. Cseke et al., Plants as Sources of Energy, in Recent Advances in Plant Biotechnology 164 (A. Kirakosyan, P.B. Kaufman eds., 2009).

170. Colin J. Campbell & Jean H. Laherrère, *The End of Cheap Oil*, SCIENTIFIC AMERICAN, 80–81 (Mar. 1998).

171. Fischer, *supra* note 11. Palm oil itself is not indigenous to either Indonesia or Southeast Asia as it was brought to region from West Africa during colonial times. Epstein, *supra* note 160.

172. Coca, *supra* note 104.

173. *Id.*

174. *Id.*

175. John Blewitt, UNDERSTANDING SUSTAINABLE DEVELOPMENT 50 (2009).

176. Coca, *supra* note 104, at 61.

177. *Id.* at 60. George Monbiot notes a downside to this enthusiasm, stating that the growth of palm oil plantations has displaced many indigenous peoples and destroyed much forest land in Indonesia and Malaysia. *Id.* Greenpeace has campaigned for a total and the palm oil production for these reasons and because industry is basically "cooking the planet." *Id.*

178. Fairley, *supra* at note 94.

displace enough petroleum to avoid the equivalent of 2.1 gigatons of carbon dioxide emission each year if produced sustainably — about as much as net carbon dioxide absorbed by the oceans.[179]

At the same time, a cautionary approach to biofuels is imperative because not all types of biofuel sources are the same based on their life cycle analyses and their environmental and social impacts. The FAO report finds that "the impact of biofuels on greenhouse gas emissions varies widely, depending on where and how the various feedstock crops are produced."[180] Certain regions may prove to be more optimal for growth and cultivation of crops for energy production. Parts of East Asia, where rainfall is plentiful, would be better situated for biofuel crops than lands of sub-Saharan Africa, where water is scarcer and the soil is not as nutrient-rich. The decision to grow bioenergy crops would be a decision for individual countries in concert with long-term regional and international development objectives. Globalization necessitates an international policy response to tackle market failures based on the increasing integration of world markets.[181] Unilateral measures by individual countries may only have minimal effect on trade-driven market failures.[182]

Improved agricultural techniques would go hand-in-hand with sustainable development ideals. Jeffrey Sachs provides an example of this ideal: "an agricultural extension officer teaches the farm household how to manage the soil nutrients in the new and improved manner by planting special nitrogen-fixing trees that replenish the vital nitrogen nutrients of the soil and multiply the benefits by using improved grains."[183] The arguments of biofuel critics can be alleviated with sustainable agricultural and energy methods. Brazil's use of the husks of the sugar plants for ethanol is an example of meeting demands for food and energy.[184] The use of ethanol from sugar cane is recognized as

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179. *Id.* (noting its sustainable development in all its policies and operations and expects the same from its suppliers).

180. FAO, *supra* note 82.

181. THE EARTHSCAN READER ON INTERNATIONAL TRADE AND SUSTAINABLE DEVELOPMENT, 85–86 (Kevin P. Gallagher & Jacob Weksman eds., 2002).

182. *Id.* To mitigate issues like the ratio of crop genetic diversity and the displacement of renewable natural raw materials from pollution intensive synthetic substitutes, multilateral initiatives are essential. *Id.*

183. SACHS, *supra* note 87, at 53.

184. José Goldemberg, *The Brazilian biofuels industry*, BIOTECHNOLOGY FOR BIOFUELS, (2008), http://www.biotechnologyforbiofuels.com/content/1/1/6.

decreasing greenhouse gas emissions and improving air quality.[185] Brazil has taken the biofuel production process one step further by using the sugar cane plant's cellulose-rich bagasse and straw, which allow "all of the plant's biomass to be used in the biofuel production process."[186] However, because this process requires large quantities of water and creates polluting byproducts, "doubts persist as to the economic viability of using all of the sugar cane plant in biofuel production."[187]

"Technological innovations and improvements in the agricultural and industrial phases of the production process can lead to greater efficiency."[188] In the agricultural phase, "strong sugar cane yield and a high index of TRS (total recoverable sugar) lead to a high yield of ethanol per unit of planted area."[189] The industry must also battle the fermentation of sugars from cellulosic feedstocks because sugar bagasse consists of two-thirds carbohydrates with the remainder as lignin and other materials.[190]

Physician and anti-nuclear activist Helen Caldicott writes that renewable energy "is quick to build, abundant and cheap to harvest; it is safe, flexible, secure and climate-friendly."[191] Biofuels show tremendous promise, but the development and deployment of sustainable technology and production practices will determine biofuels' overall beneficial use.[192] The next section examines the failures of existing law surrounding conventional and advanced biofuels.

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185. *Id.* "By 2004, ethanol in Brazil was priced competitively with gasoline, so biofuel based on sugar cane was more cost effective than other crops, including corn, wheat and sugar beet." *Id.* Brazil's sugar-based biofuel is "a global energy commodity that is fully competitive with motor gasoline and appropriate for replication in many countries." *Id.*

186. Carla Almeida, *Sugarcane ethanol: Brazil's biofuel success*, SCI. AND DEV. NETWORK, (Dec. 6, 2007), http://www.scidev.net/en/features/sugarcane-ethanol-brazils-biofuel-success.html. One tone of bagasse produces 186 liters of ethanol. *Id.*

187. Nadia Ahmad, *The International Sugar Trade and Sustainable Development: Curtailing the Sugar Rush*, 39 N.C. J. INT'L L. & COM. REG. 675, 686 (2014).

188. *Id.*

189. *Id.*

190. Cynthia Bryant & William Y. Yassumoto, *Bagasse-based ethanol from Brazil gearing up for export market*, 111 INT'L SUGAR J. 1331 (2009) (discussing how during cellulosic conversion process, a loss of carbohydrates signals a lower ethanol yield).

191. Blewitt, *supra* note 180, at 50.

192. Nadia Ahmad, *High Speed Public Policy for Algae-Based Biofuel as a Viable Energy Alternative: Sustainable Collaboration, Technology, and Political Will,* Conference Proceedings, World Renewable Energy Forum, May 27, 2012, http://ases.conference-services.net/resources/252/2859/pdf/SOLAR2012_0527_full%20paper.pdf.

IV. FAILURE OF THE LAW OF CONVENTIONAL AND ADVANCED BIOFUELS

> Biofuels such as ethanol require enormous amounts of cropland and end up displacing either food crops or natural wilderness, neither of which is good. The current cultivated land is what's needed to provide food for about 6 billion people. The energy used by a car is much greater than a person. A person might use 3,000 calories in a day, but a car would use 300,000. Cars take a lot more energy than people do.
>
> - Elon Musk, Founder of Tesla Motors[193]

Shortcomings within biofuel law and policy inhibit the sustainable growth of biomass and biofuel resources. These gaps are related to deficiencies in technology, learning, and institutions. These gaps are also related to the variability in tax structures required to incentivize biofuel development and consumption. This section addresses how failures within these dynamic systems impact social, environmental, and economic factors for the deployment of biofuels.

A. Technology Gap and the Renewable Volume Obligation

Even as the innovation for large scale biofuel production increases, vehicles must be designed to utilize biofuels. Future engines would have to be compatible with biofuels. Considering that it takes approximately five years for a car to travel from drawing table to production line, the design changes would have to be anticipated or in some instances, or would have to "guess" the future capacity of the car for biofuel consumption.[194] If future car manufacturers did not account for changes to incorporate biofuel use now, it would take several years for production supply to meet biofuel demand. Moreover, if biofuels will be the primary and preferred source for energy in the future, other modes of transportation would also have to be compatible with biofuel use. Jets and airplanes are already using biofuel as a power source.[195]

193. *Elon Musk Talks About Biofuels vs. Electric Cars*, (Feb. 19, 2008), https://ragtops.wordpress.com/2008/02/19/elon-musk-talks-about-biofuel-vs-electric-cars/.

194. Neal E. Boudette, *Ford Promises Fleets of Driverless Cars Within Five Years*, N.Y. Times, Aug. 16, 2016, https://www.nytimes.com/2016/08/17/business/ford-promises-fleets-of-driverless-cars-within-five-years.html?_r=0

195. Bettina Wassener, *Airlines Weigh the Advantages of Using More Biofuel*, N.Y. TIMES, Oct. 9, 2011, at 1.

On the other hand, light-rail systems, trains, ferries, boats, ships, buses, and buildings do not operate on biofuels. In order for biofuel to succeed, designs and infrastructures of the future have to be compatible with biofuel use.

The Renewable Fuel Standard is a nationwide policy that "requires a certain volume of renewable fuel to replace or reduce the quantity of petroleum-based transportation fuel, heating oil or jet fuel.[196] Along with infrastructure changes, Congress and biofuel producers have grappled with the meaning of Renewable Volume Obligations (RVOs) and Renewable Identification Numbers (RINs), which are the mechanisms that the EPA utilizes to implement the RFS."[197] Under the RFS, the four renewable fuel categories are biomass-based diesel, cellulosic biofuel, advanced biofuel, and total renewable fuel.[198] The Energy Independence and Security Act of 2007 required key changes to the RFS program, such as:

> Boosting the long-term goals to 36 billion gallons of renewable fuel
>
> Extending yearly volume requirements out to 2022
>
> Adding explicit definitions for renewable fuels to qualify (e.g., renewable biomass, GHG emissions)
>
> Creating grandfathering allowances for volumes from certain existing facilities
>
> Including specific types of waiver authorities.[199]

These changes in energy policy may not have fully appreciated the extent to which suppliers, producers, and distributors have control of their supply chain. Approximately ten percent of the motor fuel sold as gasoline in the United States is ethanol.[200] Congress foresaw that not

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196. U.S. EIA, *RINs and RVOs are used to implement the Renewable Fuel Standard*, (June 3, 2013), http://www.eia.gov/todayinenergy/detail.cfm?id=11511. The RFS program is administered by the EPA in coordination with the U.S. Department of Agriculture and the Department of Energy. The Energy Policy Act of 2005, which amended the Clean Air Act, created the RFS program. The Energy Independence and Security Act of 2007 amended the CAA through an expansion of the RFS program. EPA, *Program Overview for Renewable Fuel Standard Program*, https://www.epa.gov/renewable-fuel-standard-program/program-overview-renewable-fuel-standard-program.

197. *RINs and RVOs are used to implement the Renewable Fuel Standard*, U.S. ENERGY INFORMATION ADMIN. (June 3, 2013), http://www.eia.gov/todayinenergy/detail.php?id=11511.

198. *Renewable Fuel Annual Standards*, EPA, https://www.epa.gov/renewable-fuel-standard-program/renewable-fuel-annual-standards (last visited Apr. 5, 2017).

199. Karl Schulz, *Evaluating the Energy Independence and Security Act of 2007: Inclusions, Exclusions, and Problems with Implementation*, 38 ENVTL. L. REP. NEWS & ANALYSIS 10763 (2008).

200. *Energy Efficiency & Renewable Energy, Ethanol Fuel Basics*, U.S. DEPARTMENT OF ENERGY, http://www.afdc.energy.gov/fuels/ethanol_fuel_basics.html (last visited Apr. 5, 2017).

every obligated party would actually blend biofuels to the mandated Renewable Volume Obligation, so it directed the EPA to "provide for the generation of an appropriate amount of credits by any person that refines, blends, or imports gasoline that contains a quantity of renewable fuel that is greater than the quantity required."[201] An entity "may use the credits, or transfer all or a portion of the credits to another person, for the purpose of complying[;]" therefore, obligated parties who are not themselves able to blend have to route to compliance by purchasing credits from those who blend beyond their obligation.[202] A RIN is created by the biofuel producer at no cost and is assigned to each batch of biofuel the producer sells.[203] Any person registered pursuant to 40 C.F.R. § 80.1450 is able to own a separated RIN.[204] Separated RINs are able to be transferred multiple times.[205]

Oil refiners' resistance to the blending of biofuels with petroleum is evident in lawsuits by the American Petroleum Institute (API), the national trade association representing America's oil and natural gas industry, against the EPA.[206] API argues that the government is pressuring oil refiners to achieve the regulation's goal of higher

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> Ethanol is a renewable fuel made from various plant materials collectively known as "biomass." Nearly 97% of U.S. gasoline contains ethanol, typically E10 (10% ethanol, 90% gasoline), to oxygenate the fuel and reduce air pollution. Ethanol is also available as E85 (or flex fuel), which can be used in flexible fuel vehicles, designed to operate on any blend of gasoline and ethanol up to 83%. Another blend, E15, has been approved for use in newer vehicles, and is slowly becoming available.

Id.

201. Bob Neufeld & Rebecca Lynne Fey, *Winners and Losers: The EPA's Unfair Implementation of Renewable Fuel Standards*, 60 S.D. L. REV. 258, 264–66 (2015).

202. *Id.* "The refiner then multiplies the percentage RFS for each biofuel times its combined petroleum gasoline and diesel fuel production and arrives at the RVO of each biofuel. The refiner is legally obligated for blending the RVO for each biofuel." *See generally* 40 C.F.R. § 80.1405 (2014); 40 C.F.R. § 80.1407 (2014); 42 U.S.C. § 7545(o)(5)(A)(i) (2012); § 7545(o)(5)(A)(ii); § 7545(o)(5)(B).

203. Neufeld & Fey, *supra* note 201 (citing *Regulation of Fuels and Fuel Additives: Renewable Fuel Standard Program*, 72 Fed. Reg. 23,900, 23,904 (May 1, 2007) (codified at 40 C.F.R. pt. 80)). "A RIN can be separated from the biofuel to which it is assigned only by an obligated party or unobligated blender owning the biofuel." *Id.*

204. *Id.* § 80.1428(b)(2) (2014). "[E]ach party that is an obligated party . . . and is obligated to meet the Renewable Volume Obligations . . . must demonstrate . . . that it has retired for compliance purposes a sufficient number of RINs . . . ." *Id.* § 80.1427(a)(1) (2014).

205. *Id.* § 80.1428(b)(3). "A registered unobligated party that blends biofuel into petroleum fuel produced by an obligated refiner owns the separated RINs. The unobligated party can sell these RINs, and the refiner that does not or cannot control or own its production at the blending point must buy RINs to demonstrate compliance."

206. Chris Prentice, *Factbox: U.S. EPA Faces Lawsuits Over its Biofuels Plan*, REUTERS, Feb. 12, 2016, at 1.

production of cellulosic biofuel.[207] The court in *API v. EPA,* 706 F.3d 474 (2013), referred to this conundrum as an "asymmetry in incentives" and "recognized the oil industry merely becomes a 'captive consumer,' forced to pay for the shortfalls of the cellulosic biofuel industry."[208] The court rejected the EPA's 2012 biofuel projection but permitted a statutorily mandated predictive methodology that will continue to create what Shinkles refers to as a "captive consumer paradox."[209] The court held that the "Clean Air Act requires minimum applicable volumes to be calculated utilizing 'outcome-neutral methodology' rather than an 'aspirational' methodology."[210] The decision noted that the EPA could not establish a technology-forcing standard for cellulosic biofuel and even if it could, the EPA had created an impermissibly designed standard.[211]

B. Learning Gap and the Renewable Fuel Standard

For biofuel consumption to increase, consumer patterns would also have to be altered to accept new technologies and choices. Marketing and policy initiatives would have to be implemented to urge consumers to make use of biofuel alternatives. Studies already suggest that demand exceeds current supply of biofuels and that this trend will continue.[212] So, the desire to use biofuels exists at the same time governmental mandates support the switch to more biofuel use. Bob Neufeld and Rebecca Lynne Fey consider the learning problems that arise based on the establishment of RINs, noting that those charged with a task must command resources necessary to its accomplish-

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207. John W. Shinkles, *A Captive Consumer Paradox: The D.C. Circuit's Attempt to Bring Symmetry to Clean Air Act Incentives for Cellulosic Biofuel Production American Petroleum Institute v. EPA*, 20 J. ENVTL. & SUSTAINABILITY L. 204, 220–22 (2014).

208. American Petroleum Institute v. U.S. Environmental Protection Agency, 706 F.3d 474 (2013); Shinkles, *supra* note 207.

209. *Id.*

210. *Id.*

211. Meredith Pressfield, *Cellulosic Biofuel: Dead on Arrival?,* 41 ECOLOGY L.Q. 461, 475–78 (2014); API, 706 F.3d at 479–80. In January 2013, the EPA proposed a fourteen-million-gallon mandate for cellulosic biofuel. Regulation of Fuels and Fuel Additives: 2013 Renewable Fuel Standards, 78 Fed. Reg. 9282, 9284 (proposed Feb. 7, 2013). After the API decision, the EPA lowered the mandate to six million gallons. Pressfield, *supra* note 185. In 2007, Congress had "statutorily anticipated the production of 250 million gallons of cellulosic biofuel in 2012." *Id.* In 2013, the EPA's most recent required the production of six million gallons, which amount to 2.4 percent of the original mandate. *Id.*

212. *See* Claude Mandil & Adnin Shibab-Eldin, *Assessment of BiofuelsPotential and Limitations*, 17 INTERNATIONAL ENERGY FORUM (2010).

ment.[213] There are three consequences of this system that may make RFS inconsistent with the mandates of EISA: 1) significant wealth transfer from RIN buyers to RIN sellers; 2) distortion of competition; and 3) resistance to accomplishing EISA's renewable fuel volume goals resulting from the RFS2 exemption granted to a significant share of the nation's blending activity.[214]

A further learning gap exists regarding the definitions for biomass. Brent Hartman describes four categories of definitions: "(1) no sustainability element; (2) ambiguous language; (3) an environmental standard; and (4) those with a sustainability element."[215] The first category, which applies to almost half of the states' definitions, only provides a list of qualifying biomass resources.[216] Yet definitions falling into the second category fail to explicitly account for sustainability.[217] A few states offer environmental goals, but those few states that set sustainability standards for biomass fall short.[218]

C. *Institutional Gap and Sustainability Reporting for Biofuel Companies*

A larger gauge of the sustainability of an energy resource is whether it is also "affordable, easy to maintain, compatible with existing infrastructure, efficient in the use of scarce natural resources, environmentally benign, and partial to small-scale."[219] The use of cross-sectoral collaborations offers a means of monitoring the environmental externalities of first and second generation biofuels. Changes to institutional mechanisms, however, result in slow efforts at reform and do little to strengthen institutional capacity to facilitate cross-sectoral collaboration.[220] Corporate sustainability programs are

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213. Neufeld & Fey, *supra* note 201. *See also* David A. Whetten & Kim S. Cameron, DEVELOPING MANAGEMENT SKILLS 468 (8th ed. 2011). (Describing how subordinates require more authority to accomplish the tasks that have been assigned to them by managers).

214. Neufeld & Fey, *supra* note 201.

215. Brent J. Hartman, *Defining "Biomass": An Examination of State Renewable Energy Standards*, 19 TEX. WESLEYAN L. REV. 1, 8-15 (2012).

216. *Id.*

217. *Id.*

218. *Id.*

219. Anthony Akubue, *Appropriate Technology for Socioeconomic Development in Third World Countries*, J. TECH. STUDIES (2000), http://scholar.lib.vt.edu/ejournals/JOTS/Winter-Spring-2000/akabue.html.

220. Unni Gopinathan et al., *Conceptual and institutional gaps: understanding how the WHO can become a more effective cross-sectoral collaborator*, GLOBALIZATION AND HEALTH 11:46 (2015), https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-015-0128-6.

a means of closing the institutional gap in accessing the social and environmental shortcoming of biofuels. Corporate sustainability is gaining momentum as a strategic business imperative that is propelled by stakeholder pressures rather than by governmental directives.[221] The guiding principle of these corporate initiatives is that sustainable business practices are crucial for long-term stakeholder value in a resource-constrained world.[222] The Dow Jones Sustainability Indices (DJSI) track the stock performance of the world's leading companies on account of economic, environmental and social criteria.[223]

The issue with sustainability initiatives is whether they have *bona fide* shareholder value, because their longer-term and intangible values are harder to measure.[224] "The shareholder value framework needs to be expanded to accommodate the value proposition of hard-to-measure initiatives, including sustainability projects."[225] "A corporation that decides to develop a corporate sustainability program should consider, among other things, how to address the issues of what, when, where, and how to report sustainability efforts and results."[226]

Another issue is technology transfer, which is the transference of a technology or technique from one context to another.[227] The transfer of technology from one research group to another can be problematic

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221. Nadia Ahmad, *Meta-regulation for environmental monitoring and corporate sustainability reporting, in* CORPORATE RESPONSIBILITY AND SUSTAINABLE DEVELOPMENT: EXPLORING THE NEXUS OF PRIVATE AND PUBLIC INTERESTS 182–83 (Lez Rayman-Bacchus & Phillip R. Walsh eds. 2015).

222. *See* Akubue, supra note 219, at 4. (Describing how sustainability factors would present opportunities and risks for businesses and should, therefore, be accounted for in the corporate longevity).

223. *Dow Jones Sustainability Indices*, http://www.sustainability-indices.com/. *See also Corporate Responsibility Report 2013,* ROBECO https://issuu.com/robeco.nl/docs/corporate-responsibility-report-201. (Describing how the DJSI were created through a partnership between RobecoSAM and S&P Dow Jones Indices. The purpose of the indices was to give investors benchmarks to incorporate sustainability considerations in portfolios and provide an engagement platform to use sustainable best practices in their business model).

224. *Sustainability Valuation: An oxymoron?* 3, PRICEWATERHOUSECOOPERS LLP, (2012), http://www.pwc.com/en_US/us/transaction-services/publications/assets/pwc-sustainability-valuation.pdf; *Dow Jones Sustainability World Index,* http://eu.spindices.com/indices/equity/dow-jones-sustainability-world-index; *Corporate Sustainability Assessment,* ROBECOSAM, http://www.sustainability-indices.com/sustainability-assessment/corporate-sustainability-assessment.jsp.

225. *See id.* (Describing how, during the period of review, RobecoSAM monitors news coverage of companies on a daily basis using media stories compiled and pre-screened by RepRisk, a media monitoring tool).

226. Jeff Civins & Mary Mendoza, *Corporate Sustainability and Social Responsibility: A Legal Perspective*, 71 TEX. B.J. 368, 372 (2008).

227. ANDREW WEBSTER, SCIENCE, TECHNOLOGY AND SOCIETY 42 (1991).

due to tacit knowledge remaining with the original researchers; that is, they have developed skills and understanding which are hidden or tacit and which, without direct contact, are difficult to transfer to other scientists working elsewhere.[228]

D. Responsible Use of Tax Incentives

It is critical for public policy not to over-incentivize biofuel production because of the short-term issues associated with scale. For the next five years, biofuels will not be produced at such a scale that would eradicate the use of oil and gas resources.[229] The transition to biofuel use should be gradual so as not to create price volatilities in other natural resources industries. For example, U.S. Senator Bill Nelson (D-Fla.) introduced S. 748: Algae-Based Renewable Fuel Promotion Act of 2011 as a bill to amend the Internal Revenue Code of 1986 to expand the definition of cellulosic biofuel to include algae-based biofuel for purposes of the cellulosic biofuel producer credit and the special allowance for cellulosic biofuel plant property.[230] Policymakers should not promote biofuel production to the detriment of other energy sources. The current framework for the RFS provides a volume mandate for the consumption of cellulosic biofuels "far exceeding those that are commercially available."[231] The EPA has authority to address this problem through yearly cellulosic biofuel waivers, but it does not properly incentivize production of cellulosic biofuels to satisfy the 2007 congressional standards.[232] As a result, the gap between traditional and advance biofuels grows.[233] Timothy Slating and Jay Kesan argue that "even if the EPA begins to exercise the full extent of its current waiver authority, all it could accomplish would be to permanently reduce the cellulosic biofuel and advanced

228. *Id.* at 44–45.

229. Ayhan Demirbas, *Biofuels Sources, Biofuel Policy, Biofuel Economy and Global Biofuel Projections*, 49 Energy Conversion and Mgmt. 2106, 2114 (2008).

230. S. 748, Algae-Based Renewable Fuel Promotion Act of 2011, https://www.congress.gov/bill/112th-congress/senate-bill/748.

231. Timothy A. Slating & Jay P. Kesan, *The Renewable Fuel Standard 3.0?: Moving Forward with the Federal Biofuel Mandate*, 20 N.Y.U. ENVT'L. L.J. 374, 477–81 (2014).

232. Clean Air Act, 42 U.S.C. § 7545(o)(7) (2010). *See generally* 2014 Proposed Renewable Fuel Standards, at 71,734; 2013 Renewable Fuel Standards, at 49,809-23; 2012 Renewable Fuel Standards, 2011 Renewable Fuel Standards, at 76,790; RFS2 Final Rule at 14,675.

233. 42 U.S.C. § 7545(o)(7)(F).

biofuel mandates for 2016 and subsequent years, and thereby increase the renewable fuel gap for these years."[234]

John Cobb observes that "when biofuel tax credits operate in a relatively free-functioning market, biofuel producers capture most of the economic benefits because their supply elasticity is likely higher . . . than the demand elasticity of purchasers."[235] In other words, the long-term demand for biofuels is elastic when it is near the price of gasoline.[236] Congress sought to incentivize tax credits for the development of biofuels by biofuel producers.[237] However, the simultaneous use of a biofuel mandate and biofuel tax credits could thwart Congress's intent by preventing biofuel producers from retaining the economic benefits of the tax credits.[238] Cobb indicates that "placing the economic incidence of tax breaks on biofuel producers is a necessary condition of furthering these goals because it puts money in the pocket of those who are directly responsible for making investment and hiring decisions."[239] The Environmental Protection Agency may be able to restore the full incentive provided by the tax credits if it properly accounts for the impact of the biofuel tax credits on biofuel market conditions in setting the level of the waiver.[240] In contrast, "[f]ailure to take the tax credits into account in determining the level of mandated biofuel consumption will . . . deprive biofuel producers of the long-term economic support of the tax credits and will perversely subsidize fossil fuel consumption."[241]

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234. Slating & Kesan, *supra* note 231. *See generally* 42 U.S.C. § 7545(o).

235. John Cobb, Mitigating the Unintended Consequences of Biofuel Tax Credits, 49 HARV. J. ON LEGIS. 451, 458 (2012).

> While there may be some limitations to biofuel use in the short-term imposed by the need for infrastructure improvements (i.e., car engines that can run on biofuels and gas pumps that can deliver them), in the long term consumers and motor vehicle fuel suppliers are likely to be relatively indifferent between relying on gasoline and biofuels.

Id.

236. *Id.*

237. *Id.* ("In addition to reducing greenhouse gases and fossil fuel dependence, Congress wanted to encourage investment in improved biofuel technology, increase farm incomes, and promote rural development.")

238. Cobb, *supra* note 235.

239. *Id.*

240. *Id.* at 465–68

241. *Id.* at 472.

E. The Low Carbon Fuel Standard as an Alternative

The California Air Resources Board administers the Low Carbon Fuel Standard (LCFS), which uses a market-based cap and trade approach to decrease greenhouse gas emissions from petroleum-based transportation fuels, including gasoline and diesel.[242] The LCFS mandates petroleum-based fuel producers "to reduce the carbon intensity of their products, beginning with a quarter of a percent in 2011 culminating in a ten percent total reduction in 2020."[243] One of the unique features of the LCFS program is that "fuel providers would be required to track the life cycle global warming intensity (GWI) of their products, measured on a per-unit-energy basis, and reduce this value over time."[244] Another feature of the LCFS program is the implementation schedule, where 2010 served as a reporting year, and 2011 was formal implementation where petroleum-based fuel producers and importers were required to reduce the carbon content of their fuel by a quarter of a percent.[245] The reduction requirements increase steadily to the full ten percent reduction in 2020.[246] The California system allows for fuel providers to decide how they will reduce the carbon intensity of petroleum-based products from various alternatives, including blending low-carbon biofuels, low-carbon fuels such as hydrogen, or purchasing credits from other low-carbon fuel providers.[247] In other words, business picks the technologies and strategies that work best for them and their customers.[248] The LCFS is better than the RFS because over time the carbon intensity of petroleum based products is reduced at a more drastic rate.[249] Initially,

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242. *Low Carbon Fuel Standard*, CALIFORNIA ENERGY COMMISSION, http://www.energy.ca.gov/low_carbon_fuel_standard/.

243. *Id*. Petroleum importers, refiners and wholesalers have the options to "develop their own low carbon fuel products, or buy LCFS Credits from other companies that develop and sell low carbon alternative fuels, such as biofuels, electricity, natural gas or hydrogen." *Id.*

244. Alexander E. Farrell & Daniel Sperling, *A Low-Carbon Fuel Standard for California, Part 2: Policy Analysis*, (Aug. 2, 2007), http://www.energy.ca.gov/low_carbon_fuel_standard/UC_LCFS_study_Part_2-FINAL.pdf. The term life cycle encompasses all activities "in the production, transport, storage and use of the fuel." *Id.* A more thorough analysis includes "energy embodied in the materials used in all these activities through their own production, such as batteries in electric vehicles, tractors used for cultivating the biofuel crops, and oil refinery equipment." *Id.*

245. CALIFORNIA ENERGY COMMISSION, *supra* note 242.

246. *Id.*

247. Alex Farell & Daniel Sperling, *Getting the Carbon Out*, S.F. CHRON. (May 18, 2007), http://www.sfgate.com/opinion/openforum/article/Getting-the-carbon-out-2593360.php.

248. *Id.*

249. *Id.*

corn-based ethanol will be the fuel source to lower carbon intensity, but to meet more stringent low-carbon fuel standards, the next generation of fuels and vehicles, including plug-in hybrids, hydrogen fuel-cells, and second generation biofuels.[250] The next section describes the different types of second generation biofuels to lower dependency on petroleum-based fuels.

V. PROBLEMS AND SOLUTIONS: DILEMMA OF FOOD SECURITY AND ENERGY PRODUCTION

> Will biofuel usage require land? Absolutely, but we think the ability to use winter cover crops, degraded land, as well as using sources such as organic waste, sewage, and forest waste means that actual land usage will be limited. Just these sources can replace most of our imported oil by 2030 without touching new land.
>
> - Vinod Khosla, venture capitalist[251]

The issue of using competing agricultural, land, and labor resources for food production versus fuel development can be solved by the development of "good," rather than "bad," biofuels. The STSE solutions factor competing uses of natural resources as a measure.[252] I would argue that used cooking oils, other biomass waste, seaweed, and algae are better suited to sustainable development compared to sugar- and corn-based biofuel. By using waste and water-based plants as sources for biofuel, the issue of scarce land is almost eliminated as an argument against biofuels. Further, better efficiency in waste management techniques would allow for greater supplies of biomass waste to be converted to biofuels.

A. Used Cooking Oil

Some restaurants, fast food chains, hotels, residences, and other places are already equipped with storage containers for stockpiling used cooking oils. Through a chemical process called trans-esterification, grease is converted to fuel by the removal of glycerin and addition of methanol, making the oil a thinner product that can power

250. *Id.*

251. Elizabeth Gettelman, *Power Q&A: Vinod Khosla*, MOTHER JONES, (Apr. 21, 2008), http://www.motherjones.com/politics/2008/04/power-qa-vinod-khosla.

252. *See* Yager, *supra* note 29.

a diesel engine.[253] "Biodiesel can also be blended with petroleum diesel, and blends of the alternative fuel are now sold at 1400 gas stations across the country".[254] San Francisco was one of the first municipalities to start a citywide program for converting used cooking oil to fuel.[255] In 2009, Boston University began recycling cooking oil from on-campus dining halls for the purpose of heating thirteen of the university's buildings.[256] By doing so, Boston University adopted not only a more environmentally conscious heating policy, but also a more financially conservative one.[257] As the National Renewable Energy Laboratory has reported, reused cooking oil should release about 70 percent less greenhouse gas and cost less than conventional petroleum heating oil.[258]

A major drawback of recycling cooking oil is that the process of conversion, while simpler than other approaches, does require a level of technical expertise and thoroughness. Even though many individuals and businesses are already doing this conversion process on their own, many more still need or prefer the professional to complete the conversion to fuel.

B. *Biomass Waste Biofuel*

By 2020, nineteen million tons of oil equivalents could be derived from biomass, of which forty-six percent could be obtained from biomass wastes like farm waste, agricultural waste, municipal solid waste and other biodegradable waste streams. [259] The gases produced by this waste are called landfill gases (LFG), and they are burned as a

253. *Used cooking oil stolen—by biodiesel pirates,* MSNBC (May 20, 2008), http://www.msnbc.msn.com/id/24729484/ns/us_news-environment/t/used-cooking-oil-stolen-biodiesel-pirates/#.T2OCZPXTGuo.

254. *Id.*

255. *Id.* SFGreaseCycle aimed to cut down on the millions the City of San Francisco spent each year to dislodge fats, oils and grease clogging the sewers. The San Francisco Public Utilities Commission aims to power its fleet of buses, fire trucks and emergency vehicles with biodiesel made from local restaurants' old oil. *Id.*

256. Jared Killeen, *Boston University Turning Waste Cooking Oil into Biofuel Heating Oil*, (Oct. 5, 2009), http://www.heatingoil.com/blog/boston-university-turning-waste-cooking-oil-biofuel-heating-oil105/. BU's director of sustainability Dennis Carlberg said that the university hopes to "take what would otherwise be waste from one process and convert it into a technical nutrient–fuel in this case." *Id.*

257. *Id.*

258. *Id.*

259. *Biofuel From Waste,* BIOFUEL, http://biofuel.org.uk/biofuel-from-waste.html (last visited Mar. 26, 2017). The waste buried in a landfill site undergoes anaerobic digestion and generates gases. *Id.*

source of renewable energy.[260] Novel technologies are making the process of producing these fuels more efficient. A chemical process developed by researchers at the University of Wisconsin-Madison converts cellulose from agricultural waste into gasoline and jet fuel.[261] It produces fuel by modifying what had been considered unwanted byproducts (levulinic acid and formic acid) of the breaking down of cellulose down into sugar and will need to compete with other processes that can be adapted to work with biomass, including those that have been used to convert coal into liquid fuels.[262]

C. Algae-based Biofuel

CNN lauded algae-based biofuel as "the ultimate in renewable energy."[263] The University of California at Berkeley's Energy Biosciences Institute (EBI) reports that "it would take a decade of testing to determine if algae companies can produce affordable biofuels in mass quantities.[264]" "At present, algae-based biofuels are cost-prohibitive without the right technology. Costs per barrel of algae biofuel range from $140 a barrel to $900 per barrel."[265]

A number of organizations have invested in research into algae-based biofuels. Abu Dhabi's Algae Research Laboratory and Microbial Environmental and Chemical Engineering Laboratory (MECEL) at the Masdar Institute of Science and Technology is researching algae-based aviation and jet fuel.[266] Dubai-based LootahBiofuels partnered with Singapore-based algae oil producers AlgaOil Limited to develop raw materials for biofuels such as algae oil.[267] The King Abdulaziz City for Science and Technology (KACST), an independent scientific organization, provided funding for a project

260. *Id.*

261. Kevin Bullis, *From Waste Biomass to Jet Fuel*, TECH. REV., (Feb. 25, 2010), http://www.technologyreview.com/energy/24663/.

262. *Id.*

263. Marsha Walton, *Algae: "The Ultimate in Renewable Energy"*, CNN (Oct. 4, 2008), http://articles.cnn.com/200804-01/tech/algae.oil_1_algae-research-fossil-fuels-nrel/2?_s=PM:TECH.

264. *Id.*

265. *Id.*

266. Masdar Institute Presents Experts Details on UAE's Biofuel-from-Algae Potential, MASDAR INSTITUTE (Mar. 7, 2013), https://www.masdar.ac.ae/component/k2/item/6093-masdar-institute-presents-experts-details-on-uae-s-biofuel-from-algae-potential.

267. Imran Khan, *Bolstering a Biofuels Market in the Middle East*, RENEWABLE ENERGY WORLD (Mar. 5, 2015), http://www.renewableenergyworld.com/rea/news/article/2015/03/bolstering-a-biofuels-market-in-the-middle-east.

called Saudi Arabia Biorefinery from Algae (SABA project) "to screen lipid hyper-producer species in Saudi Arabian coastal waters."[268] These species will be the basis for next-generation algal biofuel production. "The goal of this project is to increase research and training in microalgae-based biofuel production as well as algal biomass, with an additional goal of using a biorefinery approach that can strongly enhance the Saudi Arabia economy, society and environment within the next ten years."[269]

Algae is available all over the Middle East's dry, arid regions.[270] Algae can withstand extreme temperatures, live in high-salinity ranges and can be used throughout the year, offering a long harvesting season.[271] The strains of algae used for biofuel in the Middle East are not expected to compete with the fresh water supply or with food production in the region.[272] As such, a properly designed and constructed algae growth facility will not have a disruptive impact on the marine ecosystem of the Arabian Gulf.[273] The region is highly suited to the mass production of algae due to the presence of large tracts of non-arable lands and extensive coastline; numerous oil refineries and power plants to capture carbon dioxide and desalination plants for salt reuse; favorable climatic conditions (highest annual solar irradiance); a large number of sewage and wastewater treatment plants; and the existence of highly lipid productive microalgae species in coastal waters.[274]

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268. Imran Khan, *Middle East OPEC countries see a future in algae*, ALGAE INDUSTRY (Feb. 24, 2015), http://www.algaeindustrymagazine.com/middle-east-opec-countries-see-future-algae/.

269. *Id.*

270. *Id.*

271. *Id.*

272. *Id.*

273. *Id.*

274. *Id.* Khan notes the market confidence based on demand in the Middle East. He observes the advancement in algal and microbial fuels in the GCC region:

> The early leaders in advanced algal and microbial fuels are therefore diversifying and targeting existing petrol, diesel and aviation markets, as well as related biofuels markets for green chemicals, polymers and power generation. The diversification of biofuels companies beyond one fuel – ethanol and biodiesel – to include a portfolio of advanced biofuels represents a wise long-term strategy to inspire investor confidence. Military, aviation, government, and petrochemical organizations all demand fungible, drop-in fuels and prefer to work with advantaged producers with scalable technologies for R&D and deployment. Algae leaders that have established pilot and demonstration scale projects, in addition to biodiesel and ethanol, are able to produce drop-in replacement fuels from microalgae, cyanobacteria and other microbes.
>
> These factors make it imperative on Middle East nations to develop a robust research, development and market deployment plan for a comprehensive microalgal biomass-based biorefinery approach for bioproduct synthesis. An integrated and gradual

D. *Seaweed-based Biofuel*

Seaweed has gained favor with petrochemical companies, including Statoil, Dupont, and ENAP, because of its fast growth compared to terrestrial crops, its high sugar content for conversion to ethanol and advanced biofuels, its absorption of more airborne carbon than land-based plants, its lack of lignin, easy harvesting compared to microalgae, no pretreatment for ethanol production, and amount of harvesting of up to six times a year in warm climates.[275] Seaweed biofuels include ethanol, methanol and biobutanol.[276] BP-Dupont's Butamax will collaborate with BAL, a leader in the field, to produce biobutanol for drop-in fuels and chemicals.[277] More than half the dry mass in seaweed is sugar, which is the new crude, according to fuel scientists.[278] Berkeley-based Bio Architecture Lab, a startup, has partnered with DuPont, the Department of Energy's ARPA E-labs, and the venture arm of Norway's Statoil to develop the chemistry that would unlock the energy in that sugar and create a fuel cheaper than alternatives. BioArchitecture Lab has already constructed three seaweed farms off the coast of Chile.[279] While the technology is ripe for seaweed-based biofuel, the real impediment is the issue of scale.[280]

Unfortunately biofuel growth will rely heavily on "agricultural commodities as opposed to cellulosic feedstocks over the coming decade and will be constrained largely by food crop production capacity."[281] Arable land for agricultural use is limited in most parts of the world, but where expansion is possible, such as in Brazil and Indonesia, "the environmental costs related to forest clearing, GHG emissions, biodiversity loss, hydrological changes, and reduced water

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> appreciation of technical, economic, social and environmental issues should be considered for the successful implementation of the microalgae-based oleo-feedstock (MBOFs) industry in the region.

Id.

275. Will Thurmond, *Top 11 Algae Biofuel and Biochemical Trends From 2011-2020*, RENEWABLE ENERGY WORLD (Mar. 29, 2011), http://www.renewableenergyworld.com/rea/news/article/2011/03/top-11-algae-biofuel-and-biochemical-trends-from-2011-2020.

276. *Id.*

277. *Id.*

278. Anne VanderMey, *4 New Ways to Solve the Energy Challenge*, FORTUNE (Jan. 5, 2012), http://fortune.com/2012/01/05/4-new-ways-to-solve-the-energy-challenge/.

279. *Id.*

280. *Id.*

281. Rosamond L. Naylor, *The Ripple Effect: Biofuels, Food Security, and the Environment,* 49 ENV'T 30, 30–43 (2007), http://iis-db.stanford.edu/pubs/22064/Naylor_et_al_Env.pdf.

and soil quality could potentially offset the benefits from biofuels."[282] While consumers indicate that they are willing to use biofuels in the future as a preferred alternative energy, most of the future biofuel production will be primarily derived from corn, sugar, and other agricultural products, the so-called "bad biofuels."

The La Jolla, Calif.-based Sapphire Energy, which has big-name backers like Bill Gates and the Rockefeller family, says it will be producing more than 100 million gallons of algae biofuel a year by 2018 and 1 billion gallons a year by 2020 – enough to meet almost 3 percent of the U.S. renewable fuel standard (RFS) of 36 billion gallons.[283] Natural resources are needed to supply this demand. Large-scale biofuel production could lead to substantial demands for fresh water, both for cropping systems and for process water needs in biofuel refineries.[284] The water and energy intensive nature of biofuel production along with the need for premium land are "surmountable challenges" i.e. "teething problems for a young technology.[285]

Jared Diamond's *Collapse: How Societies Choose to Fail or Succeed*, examines the correlation between population growth and agricultural production. Diamond writes that unsustainable practices led to environmental damage which caused agriculturally marginal lands to be abandoned. Consequences for society included food shortages, starvation, wars for resources, and overthrows of governing elite by disillusioned masses. Eventually, population decreased because of starvation, war, or disease. Consequently society lost some of the political, economic, and cultural complexity they developed at its peak.[286] While Diamond's thesis is dreary and pessimistic, it does offer a lens to peer into the future. An unsustainable energy future looms on the horizon unless we opt for the "good biofuels" of waste cooking oil, biomass waste, algae and seaweed over the forest- and agriculture-based biofuels. The scaling issues of the biomass, algae and seaweed resources are significant in terms of current global energy consumption, but fuller exploitation of these resources has major implications for energy, climate and food security.

282. *Id.*

283. Katie Howell, *Is Algae the Fuel of the Future?*, SCI. AM. (Apr. 28, 2009), http://www.scientificamerican.com/article.cfm?id=algae-biofuel-of-future.

284. Barry D. Solomon, *Biofuels and Sustainability,* 1185 ANN. N.Y. ACAD. SCI. 119, 119–134 (2010).

285. Michelle Grayson, *Biofuels,* 474 NATURE OUTLOOK S1, (June 23, 2011).

286. JARED DIAMOND, COLLAPSE: HOW SOCIETIES CHOOSE TO FAIL OR SUCCEED 6 (2011).

CONCLUSION

Advanced biofuels derived from algae, seaweed, and waste biomass have enormous growth potential. On account of existing energy infrastructure and transport mechanisms, the Global North and Global South countries can be equipped to handle this new wave of energy innovation through adequate law and governance protocol. GCC countries that have financial resources lack the regulatory governance regimes and law and policy tools to design a long-term and highly-efficient production process for second generation biofuels. Meanwhile, Global North countries, including the United States, lack political will and the technology to scale second generation biofuels to the extent energy demands insist. By considering the STSE analysis of biofuels, countries can fast track the deployment of biofuels regionally and worldwide. No energy source is without conflict or peril, but some energy sources can be attenuated to adapt to local ecosystems and become more resilient.