

Bioethica

Vol 7, No 1 (2021)

Bioethica



Sustainable Biofuel Policies: Challenges and ethical considerations

Zinovia Tsitrouli

doi: [10.12681/bioeth.26541](https://doi.org/10.12681/bioeth.26541)

Copyright © 2021, Zinovia Tsitrouli



This work is licensed under a [Creative Commons Attribution 4.0](https://creativecommons.org/licenses/by/4.0/).

To cite this article:

Tsitrouli, Z. (2021). Sustainable Biofuel Policies: Challenges and ethical considerations. *Bioethica*, 7(1), 46–63.
<https://doi.org/10.12681/bioeth.26541>

Πρωτότυπη Εργασία

Sustainable Biofuel Policies: Challenges and ethical considerations

Zinovia Tsitrouli^{1,2}

¹ Trainee Lawyer.

² MSc Bioeconomy: Biotechnology and Law, International Hellenic University, Thessaloniki, Greece.



ztsitrouli@ihu.edu.gr

Abstract

Over the last few decades, after the emergence of biofuels at commercial scale in the 1970s, several policies, at domestic or international level, have promoted these alternative fuels, citing mainly three supporting reasons: their potential to fight energy insecurity, ability to alleviate climate change through decreasing carbon dioxide in the atmosphere -compared to conventional fuels- and capacity to promote agriculture and rural development. But, ever since the beginning of their expansion, it became clear that biofuels are not as sustainable as originally thought. And since policies and national legislative frameworks are the main instruments guiding biofuels' development, this article aims to focus on answering the question whether current biofuel policies are efficient in ensuring sustainability, while promoting biofuels. If this is found not to be the case, then an attempt will be made in order to examine the relative existing gaps, to discuss the potential conflicting interests and ultimately to proceed with recommending adequate alterations in legislations. Ethical dimensions will also be discussed, which could provide some insightful considerations for upcoming biofuel legislations.

Keywords: Biofuels, sustainability, policies, environmental ethics.

Πολιτικές για βιώσιμα βιοκαύσιμα: Προκλήσεις και ηθικές προεκτάσεις

Ζινοβία Τσιτρούλη^{1,2}

¹ Ασκούμενη Δικηγόρος.

² Μεταπτυχιακή Φοιτήτρια MSc Βιοοικονομίας: Βιοτεχνολογίας και Δικαίου, Διεθνές Πανεπιστήμιο της Ελλάδας.

Περίληψη

Τις τελευταίες δεκαετίες, μετά την εμφάνιση των βιοκαυσίμων τη δεκαετία του 1970 σε εμπορική κλίμακα, αρκετές πολιτικές, σε εθνικό ή διεθνές επίπεδο, προώθησαν αυτά τα εναλλακτικά καύσιμα, αναφέροντας κυρίως τις εξής αιτιολογίες: τη δυνατότητά τους να καταπολεμήσουν την ενεργειακή «ανασφάλεια», να συνεισφέρουν ως μία λύση στην κλιματική αλλαγή μέσω της μείωσης του διοξειδίου του άνθρακα στην ατμόσφαιρα - σε σύγκριση με τα συμβατικά καύσιμα - και να προωθήσουν τη γεωργία και την αγροτική ανάπτυξη. Όμως, σύντομα κατέστη σαφές ότι τα βιοκαύσιμα δεν είναι τόσο βιώσιμα όσο αρχικά υποστηριζόταν. Δεδομένου, λοιπόν, ότι η ανάπτυξη των βιοκαυσίμων προωθείται κυρίως μέσω εθνικών νομοθεσιών και συναφών πολιτικών, το παρόν άρθρο προσπαθεί να απαντήσει στο ερώτημα εάν οι τρέχουσες πολιτικές για τα βιοκαύσιμα είναι αποτελεσματικές στο να διασφαλίζουν εξίσου τη βιώσιμη ανάπτυξη. Σε δεύτερο επίπεδο θα ακολουθήσει μία απόπειρα προσέγγισης των κενών στις νομοθεσίες καθώς και των πιθανών αντικρουόμενων συμφερόντων, έτσι ώστε τελικά να προταθούν κάποιες απαραίτητες τροποποιήσεις. Τέλος, μέρος της συζήτησης θα αποτελέσουν και σχετικές ηθικές διαστάσεις, οι οποίες θα μπορούσαν να συμβάλλουν στην αναθεώρηση και δημιουργία πιο αποτελεσματικών πολιτικών για τα βιοκαύσιμα.

Λέξεις κλειδιά: Βιοκαύσιμα, βιωσιμότητα, πολιτικές, περιβαλλοντική ηθική.

I. Introduction

Biofuels are perceived as a promising and pioneering solution to safeguard energy security, reduce the dependence on fossil fuels and lower GHG emissions in the atmosphere, since they have been found to be carbon neutral under specific circumstances (when the carbon dioxide (CO₂) emitted during their combustion is equal or less to the atmospheric CO₂ that had been previously used from plants (biofuel feedstock) to photosynthesize). Because of this, we can understand why biofuels have been severely promoted through national - and more rarely international- policies, during the last decades.

However, ever since the beginning of their expansion, it became clear that they are not as sustainable as originally thought. And since policies and national legislative frameworks are the main instruments guiding biofuels development, the aim of this article is to focus on answering the question *whether current biofuel policies are efficient in ensuring sustainability, while promoting biofuels*. If this is found not to be the case, then the relative gaps will be explored and adequate measures will be recommended, while ethical aspects will also be introduced in our discussion.

II. Biofuels

Biofuels, perceived as a promising solution to the continuously increasing demand and upcoming depletion of fossil fuels,¹ are fuels produced from organic material (biomass) including plants, animal waste and algae,² are

classified as biofuels. Biofuels include products originating not only from biomass but also its residues and are mainly produced from photosynthetic organisms such as plants, photosynthetic bacteria and micro-/macro- algae. The primary products of biofuels may be in either gas, liquid, or solid form, however the term is commonly used by scholars in its narrower sense, referring merely to liquid biofuels for transportation.

Biofuels can be primarily divided into two categories: primary and secondary biofuels.³ *Primary biofuels* include, among others, firewood, wood chips, forest residues and animal waste, and are used untreated, mainly for heating, cooking, or electricity production; they account for a considerable amount of the energy produced in developing countries. Secondary biofuels result after biomass is processed, and can be classified into three generations (in recent years a fourth generation of biofuels has emerged, which includes biofuels produced by synthetic biology).⁴ Secondary biofuels are among others: biogas, biodiesel, bioethanol, biomethanol, synthetic biofuels. According to their properties, biofuels can be used as transport fuels either alone or blended with conventional fuels.⁵

Secondary biofuels are, as mentioned above, categorized in four generations, based on the type of raw material and the technologies used for their production. As far as the material used is concerned, first generation biofuels are

¹ BP Statistical Review of World Energy, 2016. Retrieved from <http://large.stanford.edu/courses/2016/ph240/stanchi2/docs/bp-2016.pdf>.

² Selin NE, Lehman C. biofuel | Definition, Types, & Pros and Cons. Encyclopædia Britannica, 2018. Retrieved from <https://www.britannica.com/technology/biofuel>.

³ Biofuels. Retrieved from Ballotpedia website: <https://ballotpedia.org/Biofuels#:~:text=Biofuels%20are%20categorized%20either%20as>.

⁴ Moravvej Z, Makarem MA, Rahimpour MR. The fourth generation of biofuel. Second and Third Generation of Feedstocks, 2019: 557-597. <https://doi.org/10.1016/b978-0-12-815162-4.00020-3>.

⁵ Callegari A, Bolognesi S, Cecconet D, Capodaglio AG. Production technologies, current role, and future prospects of biofuels feedstocks: A state-of-the-art review. Critical Reviews in Environmental Science and Technology, 2019, 50(4), 384-436.

produced from edible parts of crops -ethanol from sugars and starch, biodiesel from oilseed crops. In the second generation, lignocellulosic biomass from non-food crops is used (such as tree plantations or woody waste from forests) and also inedible parts of food plants.⁶ A third generation of biofuels, using algae as their feedstock, has appeared over the last ten years and seemed as the most promising alternative, since in this case, higher yields and a lower GHG footprint were observed, compared to the previous generations' feedstock.⁷ An even more promising solution seems to come with the fourth generation of biofuels, which use the tools of novel synthetic biology, however these can only be found at basic research level.⁸

Biofuels have -undoubtedly- numerous advantages as their use could remarkably reduce GHG emissions, while significant production at national level, could be proven beneficial for that specific country's economy and could help in the effort to ensure energy sovereignty (along with energy security). Their transportability and easy-to-store feature are also important assets, compared to photovoltaic and wind-power energy sources, which are widely developed but are immovable and not storable. However, biomass sources used to produce biofuels, have to be evaluated bearing in mind the biomass chemical composition, the availability of croplands, the use of pesticides, the cultivation practices, the potential impacts on water resources, soil and biodiversity, as well as an economic and energy balance evaluation has to

be conducted,⁹ before arguing that biofuels can only have beneficial effects.

III. The sustainable biofuels governance challenge

Sustainability, a word more than frequently encountered in environmental conversations, a concept applied to business, energy, and agriculture -among other fields, is something that we still struggle to define. What does it mean for something to be sustainable and how is sustainability relevant in the biofuels' field? *Sustainability does not have a global definition*; on the contrary, it is interpreted differently,¹⁰ with some describing it as a "*shared ethical belief*",¹¹ while others, focus on the three pillars of sustainability (economic, social and environmental), at times adding even more dimensions.^{12,13,14}

Producing biofuels sustainably can occur only when taking into consideration the three pillars of sustainability and thus, via practices that avoid environmental, economic and social repercussions. In other words, sustainable

⁶ EASAC. The current status of biofuels in the European Union, their environmental impacts and future prospects, 2012. Retrieved from https://easac.eu/fileadmin/PDF_s/reports_statements/Easac_12_Biofuels_Complete.pdf.

⁷ Callegari A, Bolognesi S, Cecconet D, Capodaglio AG, *op.cit.*

⁸ Aro EM. From first generation biofuels to advanced solar biofuels. *Ambio*, 2015, 45(S1), 24-31. <https://doi.org/10.1007/s13280-015-0730-0>.

⁹ Naik SN, Goud VV, Rout PK, Dalai A K. Production of first and second generation biofuels: A comprehensive review. *Renewable and Sustainable Energy Reviews*, 2010 14(2), 578-597. <https://doi.org/10.1016/j.rser.2009.10.003>.

¹⁰ Bond AJ, Morrison-Saunders A. Re-evaluating Sustainability Assessment: Aligning the vision and the practice. *Environmental Impact Assessment Review*, 2011, 31(1), 1-7. <https://doi.org/10.1016/j.eiar.2010.01.007>.

¹¹ Seager TP, Melton J, Taylor Eighmy T. Working towards sustainable science and engineering: introduction to the special issue on highway infrastructure. *Resources, Conservation and Recycling*, 2004, 42(3), 205-207. <https://doi.org/10.1016/j.resconrec.2004.04.001>.

¹² O'Connor M. The "Four Spheres" framework for sustainability. *Ecological Complexity*, 2006 3(4), 285-292. <https://doi.org/10.1016/j.ecocom.2007.02.002>.

¹³ Nurse, K. Culture as the fourth pillar of sustainable development. *Small States: Economic Review and Basic Statistics*, 2006, 11, 28-40.

¹⁴ Vos RO. Defining sustainability: a conceptual orientation. *Journal of Chemical Technology & Biotechnology*, 2007, 82(4), 334-339. <https://doi.org/10.1002/jctb.1675>.

biofuels have to be ecologically sound, economically profitable and socially just simultaneously. Having being introduced as a solution to some of humanity's biggest problems and aiming to reduce GHG emissions while providing energy security, biofuels have already been scrutinized as not being "a green alternative to fossil fuels" due to various environmental side-effects.

Practically, and since sustainable biomass could have different meanings among governments, societies and individuals, this requires a relative weighting among the socioeconomic and environmental impacts. This prioritization differs among different countries and societies but also over time, the reason being their different approaches, needs and objectives.¹⁵ For example, a developing country seeking economic prosperity could "sacrifice" the social and environmental pillar for this purpose.¹⁶

The following question arises: Can we ensure that the biofuels' production process does not cause harmful consequences? For irreversible impacts to be avoided, it is necessary to identify which practices must be applied starting from the land and resources used to produce feedstocks, along with an assessment of the process until biofuels' consumption. The production and consumption processes must be regulated so as to meet the sustainability requirements set in each case. Since, as it has been already highlighted, sustainability is ambiguous and means different things in different contexts, it becomes obvious that

science cannot provide us with a universal solution for sustainable biofuels; specialists can only research and present the potential consequences of each different option.

Biofuels' compliance with sustainability can become a reality, when this is set as the minimum requirement in national legislations, relevant guidelines, certification standards and international policies.¹⁷ For governments, international organizations or even societies to be able to define and regulate 'sustainable biofuels', the before-mentioned scientific knowledge will play a pivotal role: after having being informed for the different pathways and resultant aftermaths, they can ultimately make informed choices for their policies/legislations/regulations depending on their preferences and priorities. In this way, biofuels will eventually serve their role as "green energy" without the consequent harmful repercussions with which some of the biofuels' generations are associated currently.

IV. Are existing policies and regulatory frameworks promoting truly sustainable biofuels?

Policy has a central role in the viable and just development of biofuels, since biofuels are an industry at developing stage, with ongoing research surrounding the -currently immature- technology and which, without the governmental support via policies, could not have managed to increase in production and consumption as dramatically.¹⁸ Biofuels are currently almost completely managed at domestic level with national policies playing a key role in their

¹⁵ Dale VH, Kline KL, Kaffka SR, Langeveld, JWA. A landscape perspective on sustainability of agricultural systems. *Landscape Ecology*, 2012, 28(6), 1111-1123. <https://doi.org/10.1007/s10980-012-9814-4>.

¹⁶ This has happened in the case of China, where since 1978 and while targeting economic prosperity, the social and environmental pillars took a hit with land and air pollution, poor animal welfare and a plethora of health issues being the direct effect of economic growth-based decisions.

¹⁷ Englund O. On sustainability of biomass for energy and the governance thereof, 2016. <https://doi.org/10.13140/RG.2.1.2689.4323>.

¹⁸ Su Y, Zhang P, Su Y. An overview of biofuels policies and industrialization in the major biofuel producing countries. *Renewable and Sustainable Energy Reviews*, 2015, 50, 991-1003. <https://doi.org/10.1016/j.rser.2015.04.032>.

consumption and production, being the ones mainly affecting the international circulation of biofuels, while an international universal regime does not exist and a relevant international approach is currently rather limited.

An analysis and comparison of current national policies in the US, Brazil [Brazil is the world's second largest biofuels' producer and has led -along with the US- the production of ethanol fuel, together producing 84% of the world's ethanol¹⁹ as of 2019] and China [who has actively entered the biofuels field, especially with ethanol production] as well as the supranational policy of the EU, is important in order to answer the question whether current policies promote sustainable biofuels and what are the relevant gaps.

Starting with a general remark, we should pinpoint the fact that among these policies, two types of biofuels are the ones mainly regulated, and thus predominantly used and produced: bioethanol and biodiesel. In the attempt to assess the policies, we will begin from the EU policy, in which, sustainability has been an ongoing and principal concern related to biofuels, with several changes having been made in the small period of active -mandatory- legislation (starting with the 2009 *Red Directive* milestone, which really changed the status quo). Nowadays the sustainability requirements for biofuels may be the stricter existing globally, with limits being implemented to raw material, which *must* originate from *renewable sources*, while the main aim is for feedstock from lands with high biodiversity or carbon stock to eventually be completely eliminated.²⁰ Simultaneously, standards have been set for the reduction of CO₂ levels, compared to fossil fuels. Because of this

stringent and innovative environmental legislation, the EU is being considered as a normative power²¹ in environmental protection internationally.

In this direction -of the EU forming international sustainability standards for biofuels- we could add the following argument: sustainability requirements set at EU level for alternative fuels available in the European market, *apply equally* to biofuels and bioliquids *produced within the EU and to the ones imported from third countries*. This situation has been judged as beneficial for countries outside the EU, so as their biofuels will improve in terms of sustainability; on the other hand, this prerequisite has also been considered as a barrier for, mainly ethanol-producing countries to import in the EU. With regards to Brazil, however, *Stattman, 2020*²² argues that, the main problem could potentially arise with imports of Brazilian soybeans -and not ethanol- aimed for biofuel production, which are grown in highly biodiverse lands in the Brazilian savannah, and which would not fulfill the sustainability requirements to be imported in the EU.

When it comes to the feedstock used for production, it seems like all the policies have been focusing on providing fiscal incentives for biofuels being produced from edible feedstock in the past, while in the recent years there has been a shift and these financial aids have been reconsidered and/or eliminated especially for conventional biofuels, while relevant subsidies or tax exemptions existing for *advanced biofuels*, have either stayed in place or been introduced. Till 2010, a large-scale production of second-

¹⁹ Alternative Fuels Data Center: Maps and Data - Global Ethanol Production, 2019 Retrieved from Energy.gov website: <https://afdc.energy.gov/data/10331>.

²⁰ Renewable Energy - Recast to 2030 (RED II), 2018. Retrieved from EU Science Hub - European Commission website: <https://ec.europa.eu/jrc/en/jec/renewable-energy-recast-2030-red-ii>.

²¹ The term "normative power" for EU originated in 2002. Manners I. Normative Power Europe: A Contradiction in Terms? JCMS: Journal of Common Market Studies, 2002, 40(2), 235-258. <https://doi.org/10.1111/1468-5965.00353>.

²² Stattman SL. Biofuel governance in Brazil and the EU, 2019 (PhD Thesis). <https://doi.org/10.18174/472916>, Retrieved from <https://research.wur.nl/en/publications/biofuel-governance-in-brazil-and-the-eu>.

generation biofuels had not been possible,²³ and, while this situation has changed in recent years, it is still a reality that biofuels originating from lignocellulosic material do not make up the largest amount of biofuels currently used and produced.²⁴ As stated in the *OECD-FAO Agricultural Outlook 2020-2029*, advanced feedstock is not expected to take a great part in biofuels production by 2029, while sugarcane and maize will continue dominating in ethanol production.

Besides the EU, which nowadays has implemented limitations for traditional biofuels due to sustainability concerns, the US has also really pushed the transition from grains, sugarcane and vegetable oils to second-generation feedstock. This happened through financing the development of second-generation technologies and setting notable targets for biofuel production from cellulosic sources - it was in the *RFS2*²⁵ that *advanced biofuels* were proclaimed as the way to achieve a decrease in GHG emissions. When it comes to Brazil, national biofuel policies have not changed with regards to the type of raw material used for biofuels, but the main focus has been on the amelioration of conversion techniques for sugarcane and soy as feedstock.²⁶ On the contrary, China has suspended fiscal incentives and tax exemptions for edible crop-originating ethanol, maintaining subsidies and other

favorable economic provisions only for other types of bioethanol.²⁷

Overall, concerning the economic incentives for advanced biofuels production, governments, according to the *2019 Study* from IRENA (International Renewable Energy Agency) titled: “*Advanced biofuels: What holds them back*”, offer economic incentive most frequently to fuel producers and not feedstock suppliers - because if they did support suppliers directly they would risk prices and quantity of raw material to increase because of the demand - but in this way, merely an indirect support for farmers is not sufficient to make them adopt new crops and practices.²⁸

That being said, we need to bear in mind that direct subsidies for farmers have also been part of the policies, since one of the most important drivers for biofuels development has been policy-makers’ intention to support rural areas, a fact which confirms the existence of strong links between the *biofuel industry and agriculture*. It seems that an abolition of biofuels policies supporting feedstock grown in land (either edible or non-edible, so second-generation feedstock included), would possibly jeopardize, up to a point, support to farmers, and even cause some political consequences. Subsidies aimed at rural communities have also been criticized on the basis that, because of them, biofuels are “*an expensive form of GHG emissions reduction*”.²⁹ In that sense, agriculture-centered provisions and fiscal

²³Sorda G, Banse M, Kemfert C. An overview of biofuel policies across the world. *Energy Policy*, 2010, 38(11), 6977-6988. <https://doi.org/10.1016/j.enpol.2010.06.066>

²⁴Biofuels | OECD-FAO Agricultural Outlook 2020-2029 | OECD iLibrary. Retrieved from <https://www.oecd-ilibrary.org/sites/3aeb7be3-en/index.html?itemId=/content/component/3aeb7be3-en#section-d1e21123>.

²⁵ Found in: <https://www.epa.gov/renewable-fuel-standard-program/renewable-fuel-standard-rfs2-final-rule-additional-resources>.

²⁶ Stattman SL, *op.cit.*

²⁷ Morone P, Strzałkowski A, Tani A. Biofuel transitions: An overview of regulations and standards for a more sustainable framework. *Biofuels for a More Sustainable Future*, 2020, 21-46. <https://doi.org/10.1016/b978-0-12-815581-3.00002-6>.

²⁸ Advanced biofuels: What holds them back? Retrieved from <https://www.irena.org/publications/2019/Nov/Advanced-biofuels-What-holds-them-back>.

²⁹ Mattioda RA, Tavares DR, Casela, JL, Junior OC. Social life cycle assessment of biofuel production. *Biofuels for a More Sustainable Future*, 2020, 255-271. <https://doi.org/10.1016/b978-0-12-815581-3.00009-9>.

incentives found in biofuel-promoting legislation could prove successful in supporting domestic farmers, but maybe not as efficient from an economic point of view, nor an environmental one, if we consider that, concerns for GHG emissions are relevant even for second-generation biofuels.³⁰ In Brazil, specifically, even the social parameter related to farmers support was criticized as insufficient, since current policy excludes smallholder farmers, not allowing them to participate in the biofuels development, thus aggravating social inequality and poverty.³¹

It is true that, in the last few years, motivation for biofuels expansion has not been focused only on climate change mitigation and energy security, but employment and rural development have also been introduced as significant drivers for biofuel-policy makers.³² Although it is not arguable that social considerations have gradually emerged, strategic goals and most importantly the *independence from fossil fuels*, are the ones dominating.³³ Every policy, first and foremost, tries to achieve an increase in biofuels produced domestically so as to subsequently lower fossil fuel imports; according to *Huang et al. 2013*, a decrease in demand which will result from lower conventional oil imports, will mean a simultaneous decrease in oil's price at national level and thus will generate an economic advantage for national economy and consumers,

while it will potentially lead to increasing petroleum consumption -and prices- abroad.³⁴

We can realize, in this way, that substantial domestic biofuels' demand, led by policies promoting them, is fundamentally important from an economic point of view. Even though this expansion in the recent years has been "*ideologically*" promoted for environmental protection reasons, while it also was beneficial for each country's compliance with international environmental obligations, we cannot deny that economic reasons are still what primarily makes governments actively include biofuel policies in their national agendas. In these agendas, economic development is inarguably central, taking into account that the wellbeing and wealth of their citizens is of great importance, particularly in developing nations, where industrialisation in countries like China and Brazil has led a large portion of the population to poverty. So, biofuels establishment could "fuel" the economy, while it could also contribute to meeting the continuously increased energy needs.³⁵

This potential led biofuels to be considered as a synonym to economic development, since not only is their expansion capable to create new jobs, but most crucially it is the path for energy sovereignty to be accomplished. In this way, oil imports will be reduced, independence from unstable foreign oil suppliers will cease to exist, and the national economy will not have to be faced with the increased oil prices.³⁶ At this point, we also should not avoid to mention, that biofuels have gradually become cost-competitive with conventional fuels, due to the rapidly

³⁰ Mohr A, Raman S. Lessons from first generation biofuels and implications for the sustainability appraisal of second generation biofuels. *Energy Policy*, 2013, 63, 114-122. <https://doi.org/10.1016/j.enpol.2013.08.033>.

³¹ Sakai P, Afionis S, Favretto N, Stringer LC, Ward C, Sakai M, ... Afzal N. Understanding the Implications of Alternative Bioenergy Crops to Support Smallholder Farmers in Brazil. *Sustainability*, 2020, 12(5), 2146. <https://doi.org/10.3390/su12052146>.

³² Morone P, Strzalkowski A, Tani A, *op.cit.*

³³ Lovett JC, Hards S, Clancy J, Snell C. Multiple objectives in biofuels sustainability policy. *Energy Environ. Sci*, 2011, 4(2), 261-268. <https://doi.org/10.1039/c0ee00041h>.

³⁴ Huang H, Khanna M, Önal H, Chen X. Stacking low carbon policies on the renewable fuels standard: Economic and greenhouse gas implications. *Energy Policy*, 2013, 56, 5-15. <https://doi.org/10.1016/j.enpol.2012.06.002>.

³⁵ Nuffield Council On Bioethics. *Biofuels: ethical issues*, 2011. London: Nuffield Council On Bioethics.

³⁶ Afionis S, Stringer LC. European Union leadership in biofuels regulation: Europe as a normative power? *Journal of Cleaner Production*, 2012, 32, 114-123.

evolving production technologies surrounding their development.³⁷

We can summarize our sustainability-oriented assessment for policies, emphasizing on the fact that the economic component seems to be the most respected from policymakers, in the sense that it is prioritized when compared to the other two components, and that environmental protection issues are gradually taken more seriously into consideration, but the social aspect is the one mostly neglected. Even concerning the farmers' support provisions, which have as a driver social cohesion, when large-scale farming is established, then fewer jobs are created (as we have noted above for Brazil) and definitely a switch to more environmental sustainable third- and fourth- generation biofuels, will mean that these provisions, and thus the social-inclusion intention, will cease to exist.

V. Towards a Biofuels' Ethical Framework

Approaching biofuels governance from a sustainability perspective is important, and all the three pillars (the economic, the environmental and the social) should be considered in the formation of policies. However, sustainability comes with multiple challenges, the most important being that it does not have a universal definition, as it has been continuously underlined, and the effort to bring the three aspects of sustainability to a balance, could even be impossible, while it also comes with unwanted trade-offs. We can understand that policies which have been attempting to regulate biofuels sustainably have failed, and where policies fail, ethical principles must be taken into consideration.

In the biofuels field, ethical approaches have been, for the most part, overlooked, while

economic-favorable technical "solutions" have gained the most attention, which, however, fail to provide a satisfying answer to the moral questions related to human-nature relationships.³⁸ In this way we are faced with a "disoriented" sustainability, dependent on standards which aim at altering the global market scene in order to provoke a "good behavior" rather than causing a radical change to cultural presuppositions related to the notion of "economic development" and focusing on questions related to moral obligations.³⁹ Scientists and ethicists have already tried to reflect upon this, but a robust ethical framework is yet to be developed.

The establishment of a moral framework is relevant not only in the attempt to assess the current status quo of biofuels development (led by the legal regimes regulating them), but is also necessary in the ever evolving biofuel-related technological context, where new developments and thus new regulating approaches to biofuels appear, and the related moral concerns that could potentially arise, should be comparably assessed to the moral issues that existed with pre-existing situation.⁴⁰

a. The land vs biofuels and food vs biofuels debates

Ethical principles that have been suggested and introduced till the present moment, focus on the potential problems that biofuels expansion could bear on vulnerable populations⁴¹ and

³⁷ Erickson B, Lutt E, Winters P. Can Biofuels Replace Fossil Fuels? Consequences of Microbial Interactions with Hydrocarbons, Oils, and Lipids: Production of Fuels and Chemicals, 2016, 1-19.

³⁸ Nelson MP, Vucetich, JA. Sustainability Science: Ethical Foundations and Emerging Challenges. *Nature Education Knowledge*, 2012, 3(10):12.

³⁹ Van Horn G. Ethics and Sustainability A Primer with Suggested Readings by Gavin Van Horn, 2013. Retrieved from CENTER FOR HUMANS & NATURE website: https://iseethics.files.wordpress.com/2013/09/ethics_and_sustainability_primer.pdf.

⁴⁰ Nuffield Council On Bioethics, *op.cit.*

⁴¹ Von Braun J. Biofuels and the Poor: Finding the Wins, 2007. Retrieved from <http://eeas.europa.eu/archives/docs/energy/events/biofuels/>

developing countries⁴² or the probable breaches of human rights,⁴³ and consider that the environmental consequences of biofuels have already been mostly addressed through policies.⁴⁴ Furthermore, even regarding the “land vs biofuels” debate, a case in which environmental repercussions - linked to increased GHG emissions^{45,46} and biodiversity changes when natural habitats are converted to human-dominated croplands⁴⁷ - have been found to be profound, a problem more and more addressed by relevant legislations nowadays, an anthropocentric approach still dominates; experts address it from a human perspective as “the right to land” or “the right to property”, bringing to the spotlight the imbalance of power between large investors and smallholders, with the latter being excluded from the ever-growing industrialized biofuels sector, and countries choosing to facilitate the access to land to

(foreign) investors, thus eventually violating the small farmers “right to land”.⁴⁸

On the other hand, we cannot argue against a human-centred approach when it comes to the *food vs biofuels* ethical debate. Although a huge controversy exists related to whether and in what extent biofuels indeed affect human access to food,⁴⁹ via the deprivation of croplands for biofuels-intended feedstock and the consequent augmentation of food prices,⁵⁰ multiple studies⁵¹ have been published, explaining the unintended outcomes for food security, which cannot be ignored; nor should the poverty impacts resulting from higher food prices, which could even lead to hunger,⁵² for some more vulnerable populations. The same concerns could apply to water, given the inherent interdependence between biofuels and water consumption; water is a prerequisite for biofuels growth and, on the other hand energy is necessary for its extraction and transportation. In this regard, future increased production, combined with the increase in world’s population will be a challenge for the management of water, especially if part of it will be required for energy production, when current scenarios expect future water scarcity.⁵³

sessions/s4_05_von_braun_biofuels_poor_brussels_5-7-07.pdf.

⁴² Zentou H, Rosli Nurul Shafiqah, Wen H, Gomes C. The viability of biofuels in developing countries: Successes, failures and challenges. Iranian Journal of Chemistry & Chemical engineering- International English Edition, 2019, 38.

⁴³ León-Moreta M. Biofuels - A Threat to the Environment and Human Rights? An Analysis of the impact of the production of feedstock for agrofuels on the rights to water, land and food. European Journal of Legal Studies, 2011. Retrieved from <http://hdl.handle.net/1814/18600>.

⁴⁴ Gonzalez C. The Environmental Justice Implications of Biofuels. UCLA J. Int’l L. Foreign Aff., 2016, 20, 229. Retrieved from <https://digitalcommons.law.seattleu.edu/faculty/771>.

⁴⁵ Searchinger T, Heimlich R, Houghton RA, Dong F, Elobeid A, Fabiosa J, Yu TH. Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change. Science, 2008, 319(5867), 1238-1240. <https://doi.org/10.1126/science.115186>.

⁴⁶ Fargione J, Hill J, Tilman D, Polasky S, Hawthorne P. Land Clearing and the Biofuel Carbon Debt. Science, 2008, 319(5867), 1235-1238. <https://doi.org/10.1126/science.1152747>.

⁴⁷ Hansen A, Defries R, Turner W. Land use change and biodiversity, 2004, https://doi.org/10.1007/978-1-4020-2562-4_16.

⁴⁸ León-Moreta M. Biofuels, *op.cit*.

⁴⁹ Prasad S, Ingle AP. Impacts of sustainable biofuels production from biomass. Sustainable Bioenergy, 2019, 327-346. <https://doi.org/10.1016/b978-0-12-817654-2.00012-5>.

⁵⁰ Ajanovic A. Biofuels versus food production: Does biofuels production increase food prices? Energy, 2011, 36(4), 2070-2076. <https://doi.org/10.1016/j.energy.2010.05.019>.

⁵¹ Hochman G, Rajagopal D, Timilsina GR, Zilberman D. Impacts of Biofuels on Food Prices. The Impacts of Biofuels on the Economy, Environment, and Poverty, 2014, 47-64. https://doi.org/10.1007/978-1-4939-0518-8_4.

⁵² Tenenbaum DJ. Food vs. Fuel: Diversion of Crops Could Cause More Hunger. Environmental Health Perspectives, 2008, 116(6). <https://doi.org/10.1289/ehp.116-a254>.

⁵³ Lago C, Herrera I, Caldés N, Lechón Y. Nexus Bioenergy-Bioeconomy. The Role of Bioenergy in the Bioeconomy, 2019, 3-24. <https://doi.org/10.1016/b978-0-12-813056-8.00001-7>.

In spite of most scholars agreeing that policies should be reformulated, considering potential violation of the human right to food, in *Araujo Enciso, Fellmann, Pérez Dominguez & Santini, 2016*, the researchers presented results of a 10-years forward looking scenario and argued that even though a potential abolishment of biofuel policies would adversely impact biofuel prices, this would have only a negligible effect on the fluctuation of crop prices, and thus would not ensure global food security, since other competitive uses of crops would remain a reality (such as industrial use, feed production).⁵⁴

b. Who will benefit from biofuels' expansion? The threat to developing countries

The "right to food" and "the right to land" may be jeopardized by biofuel expansion, but the relevant impacts are more intense for vulnerable populations (mainly in developing countries).⁵⁵ The question whether developing countries indeed face more severe effects due to the rapid development of biofuels and the relevant national policies - in the OECD countries⁵⁶ - that support this expansion, brings to the forefront the ethical dilemma associated with the equal distribution of cost and benefits among countries. This dilemma is apposite to the biofuels context, where developing countries have been found to have a remarkable potential as important contributors to the global renewable capacity,⁵⁷ with great amounts of available lands,

while more developed ones have started to be interested in acquiring these lands, which seem as ideal for biofuels production.⁵⁸ What this means for local populations is that their access to natural resources (fresh water) may be put at risk, while land will be concentrated to large investors at the expense of locals, whose interests and well-being will be at stake, in favor of the economic development of developed states; as highlighted before, biofuels are perceived as a great economic advantage for national economies.

Additionally, even though developing countries have a comparative advantage in biofuels production, due to available and - perceived as ideal for biofuel feedstock- land, they have been faced with discriminating trade practices⁵⁹ from developed nations, and thus restrictions regarding the extent to which they can benefit from the prosperous biofuels trade. Besides that, land use changes, as a result of the exploitation of native lands on the altar of biofuels development for the prosperity of foreign nations, could have effects on the local biodiversity and climate. If we take into account that developing countries are already characterized as the most sensitive to climate change,⁶⁰ we can understand the problems that may arise.

c. On the abolishment of anthropocentrism in the biofuels' context

At this point, emphasis should be given on a specific aspect, fundamental in the ethical

⁵⁴ Araujo Enciso SR., Fellmann T, Pérez Dominguez I, Santini F. Abolishing biofuel policies: Possible impacts on agricultural price levels, price variability and global food security. *Food Policy*, 2016, 61, 9-26. <https://doi.org/10.1016/j.foodpol.2016.01.007>.

⁵⁵ León-Moreta M. Biofuels, *op.cit.*

⁵⁶ de Gorter H, Drabik D, Just DR, Kliauga EM. The impact of OECD biofuels policies on developing countries. *Agricultural Economics*, 2013, 44(4-5), 477-486. <https://doi.org/10.1111/agec.12031>.

⁵⁷ Pathak L, Shah K. Renewable energy resources, policies and gaps in BRICS countries and the global impact. *Frontiers in Energy*, 2019, 13(3), 506-521. <https://doi.org/10.1007/s11708-018-0601-z>.

⁵⁸ Bartonova E. The impacts of biofuel production in developing countries, 2012. Retrieved from Resilience website: <https://www.resilience.org/stories/2012-03-01/impacts-biofuel-production-developing-countries/>.

⁵⁹ Nuffield Council On Bioethics, *op.cit.*

⁶⁰ Global Affairs Canada - Affaires mondiales Canada. Climate change in developing countries, 2015. Retrieved from GAC website: https://www.international.gc.ca/world-monde/issues_developpement-enjeux_developpement/environnemental_protection-protection_environnement/climate-climatiques.aspx?lang=eng

approach that preceded: anthropocentrism. Ethics in the biofuels field are, for the most part, approached in a way which puts human interests in the center and assesses policies on the basis that human needs are not entirely taken into consideration or/and fulfilled. It is true that the conservation of biodiversity and the prevention of GHG emissions have also been central in the ethical discourse surrounding biofuels, with the *Nuffield Council on Bioethics*⁶¹ recognizing, in 2009, two relevant ethical principles: a) “*biofuels should be environmentally sustainable*”, b) “*biofuels should contribute to a reduction of greenhouse gas emission*”. Even when it comes to this however, which at first glance seems like a genuine concern for the Earth, things are slightly different.

At this point, we should address this fundamental question: is human welfare the sole reason which motivates concern for the conservation of healthy ecosystems, or is there an inherent value of ecosystems? The answer to this question depicts cultural presumptions that are profoundly embedded in our modern society, and which tend to give precedence to human-favorable aspects. For biofuels, the question is whether humans fundamentally care for the health of the Earth and the effects that these alternative fuels could bear on it, or whether their distress is focused merely on the fact that eventual climate and biodiversity problems could limit the potential of specific lands to perpetually produce biofuels. The fact that human needs are prioritized, potentially at the expense of natural habitats, is a conclusion which is supported by the fact that policies do jeopardize the health of ecosystems for economic development.

It ultimately turns out that the main problem we still are faced with is our inappropriate relationship with nature, when we see natural habitats purely as a means to fulfill human needs, as something distinct to humankind. Given this, the only way to ensure

that, in the case of conflict between human interests and non-human ones, policies will not benefit humans at the expense of, for instance, other organisms, is a non-anthropocentric ethics approach.⁶² While human-centered concerns for the environment only aim to secure human well-being, biocentric concerns have as a fundamental objective to also protect non-human organisms and natural habitats holistically (of which humans are a part). In anthropocentrism, humans will potentially start acting in favor of the environment and adopting some pro-environmental behaviours, while biocentrism is oriented towards true environmentalism, regarding both values and behaviors.⁶³

VI. Conclusions

A main objective for most countries promoting biofuels has been the reduction of CO₂ emissions in the environment; in these 20 years of active biofuel expansion, however, it soon became obvious that biofuels constitute as much of a risk for climate change, as a solution. Indeed, it has been observed that CO₂ levels may increase due to biofuels production and consumption, rather than be eliminated, as it happens with first generation biofuels.⁶⁴ In that sense, it seems that the initial key assumption for this immense government-driven biofuel promotion, has been formed as following: *Biofuels, emerging from renewable sources, are by default sustainable*. However, after some years of active development in the field, it became obvious that multiple criteria must be met for biofuels to be characterized as

⁶¹ Nuffield Council On Bioethics, *op.cit.*

⁶² Burchett B, Kyle L. Anthropocentrism as Environmental Ethic, 2016, (Doctoral Dissertation). <http://dx.doi.org/10.13023/ETD.2016.259>.

⁶³ Rottman J. Breaking down biocentrism: two distinct forms of moral concern for nature. *Frontiers in Psychology*, 2014, 5. <https://doi.org/10.3389/fpsyg.2014.00905>.

⁶⁴ Gasparatos A, Stromberg P, Takeuchi K. Sustainability impacts of first-generation biofuels. *Animal Frontiers*, 2013, 3(2), 12-26. <https://doi.org/10.2527/af.2013-0011>.

sustainable and that only holistic approaches, taking into consideration several aspects and throughout the “life” of biofuels -beginning from the feedstock cultivation to the final consumption- must be taken into consideration.

Policies are central in the biofuels’ discourse, since they are the ones guiding their expansion, and they should be *reformulated*, in order to regulate aspects of biofuels development that are currently associated with uncertainty; for example, scientists agree that there are still *knowledge gaps* when it comes to concerns related to the biofuel industry’s impact to biodiversity.⁶⁵ Besides incorporating provisions that will identify “ideal” areas for feedstock cultivation where the ecosystem’s diversity will not be at risk -the most suitable being existing agricultural lands, while sensitive areas such as forests, natural grasslands and peatlands must be avoided- legislations should also regulate more exhaustively the aspects related to the conflicts for land, following the European paradigm, which, however, can still be ameliorated. A parameter, which, for instance, new legislations should incorporate, is that of a potential intensification in land conflicts in the future, due to phenomena caused by climate change such as water scarcity, erosion and increased soil salinity; more extensive attention should also be given to social aspects providing clear provisions with regards to locals being displaced and losing access to their lands and potentially other resources (water), due to the biofuel industry.⁶⁶

VII. Recommendations

We will finish the current discussion, with providing some key recommendations with regards to legislation and policies reformulations, which, could be beneficial in the overall sustainability of biofuels.

1) *Economic support for research and development (R&D)* for technology for advanced biofuels should be provided, in order to identify ways in which biofuels could contribute to the restoration of degraded land, better manage drainage basins, improve efficiency of production, use less natural resources (land, water) and lower the production cost. The evolution of biotechnology is also important for promoting marine biomass as biofuel feedstock, which has been proven to be efficient in terms of sustainability.

2) *The importance of coherence among different policy domains.* Various policy domains frame biofuel development (energy, environmental and climate protection, trade), however since different interests are at stake, negotiations among stakeholders could lead to different, and even conflicting trade-offs in each policy sector. The only way to ensure that biofuels will reach the different objectives set in different policies, is for clear guidelines to be created from governments in the policy-making process and different countries to try and create biofuel-specific regimes which integrate cross-sectoral concerns. It is in this way that agriculture will still be supported -while shifting away from crop-originating biofuels-, or that GHG emissions will be eliminated -while support for the transportation sector will remain strong.

3) *The promotion of stakeholders’ active involvement.* Besides politicians and policymakers, the scientific community as well as NGOs should have an active role in the policy-making process. In this way, besides achieving a true transdisciplinary approach, individual groups’ knowledge, opinions or propositions regarding some burning issues can also provide some insight for a better biofuel strategy. Simultaneously, at an international level, such an active inclusion of different stakeholders is important in order to design suitable solutions for small farmers in (mostly) developing countries, which, as mentioned elsewhere, are often at a disadvantage.

4) *Equitable distribution of bioenergy-related costs and benefits.* Future initiatives should promote small-scale production, at local and regional levels, especially when it comes to

⁶⁵ Lago C, Herrera I, Caldés N, Lechón Y, *op.cit.*

⁶⁶ Ibidem.

developing countries, because in this way they can solve their oil dependency problem, conserve cheaper energy from locally available sources and accomplish an overall better well-being. Moreover, international cooperation should be encouraged in order for technological knowledge and skills to be shared among nations, and the more developed ones to fulfill their obligation, under the *Rio Declaration*, to support those countries at development stage. In this direction, more economic powerful states should not exploit third countries' arable lands for their national economic gain, at the expense of that country's economy and environment. Moreover, fair trade principles should be respected.

5) *The introduction of an international sustainability standard for biofuels.* As it has been previously highlighted, there are different interests and conflicts between different actors and countries. We already proposed a more active participation on the stakeholders' part, but a well-rounded global solution would be fully achieved only with the establishment of an international sustainability standard for biofuels production, which could be promoted, at UN level, for example. Such an initiative would mean that countries would have to adhere to the same criteria for assessing biofuel GHG emissions from their production to their consumption, that national policies would have to respect the same principles with regards to land-use changes and trade limitations, but also that human rights and social aspects would be considered and food and water security would be ultimately put in the center of attention, a parameter which current legislations fail to address. In this way, major biofuel producing countries, will have to abide by this international regime and not merely adhere only to their national monitoring systems.

6) *The importance of Degrowth in the effort to achieve sustainable development.* Through our conversation it became clear that even though environmental and social concerns related to biofuels development have alarmed scientists and policy-makers, after these promising alternative fuels did not prove as environmentally friendly as initially thought, states remain hesitant to entirely change their

supporting systems, since these fuels are a clear economic advantage, in the era where oil is continuously depleting and its price is incessantly increasing. It seems that human societies are driven by economic growth and that sustainable development, as currently formed, has as a main purpose economic development, at times at the expense of the other two pillars (social and environmental viability).

Abandoning the economic growth-centered model in the modern world and implementing degrowth, the anti-consumerism movement which suggests that societies' primary goal should not be economic development (in the increasing-the-GDP sense), but overall *well-being and happiness*, might be hard to implement, but would be a pioneering solution especially for the Global South. Such a shift, which will come with a reduction in material consumption and thus energy needs, would lead to better resource management and would readjust the exploitation of natural resources, to meet the Earth's limitations. This would be a truly sustainable solution in the environmentally stressed world we live in, where overproduction and overconsumption constantly aggravate the situation. In the case of developing countries, such distancing from the Western dominant capitalist model, to resource responsibility and efficiency, would lead to economic self-sufficiency, and overall well-being.

However, it is hard to accept the shift to degrowth, in Global North societies, where anthropocentrism is the dominant belief, embedded in western cultures; a different philosophical basis is necessary in order for societies to understand and actively pursue the shift to degrowth which will be beneficial for environmental health. Deep Ecology, the notion that all living beings have an inherent value, and that humans are just another component of the ecosystem without having a superior value to the other organisms, could be used as the ideological basis behind this societal restructure, since in

that sense respecting the ecosystem is a fundamental moral value⁶⁷ and environmental health, if this philosophy is adopted, leads automatically to well-being.

Having presented the above, it is true that societies are far from achieving such a shift, and it is probable that the degrowth model will not be implemented soon (or at all). However, keeping this ideal as a guideline, legislation could progressively be reformulated in the effort to achieve a balance between human activities and the laws of nature. Ethics and cultural perceptions, inherent in human societies, are harder to change, and because of that, a reformulation in the human relation to the nature is less probable to be achieved in the next decades, even though efforts are increasing and hopes arise that human societies will eventually be restructured in accordance with deep ecology ideas. What can be achieved, however, and must in any case be pursued, is to reach the maximum "moral" result, *through* the current anthropocentric ethical guidelines. A new approach in biofuels' legislation, which takes full account of these ethical dilemmas, will certainly have more positive results, than the current situation, and could perhaps bring us closer to the desired change towards biocentrism.

References

1. Advanced biofuels: What holds them back? Retrieved from <https://www.irena.org/publications/2019/Nov/Advanced-biofuels-What-holds-them-back>.
2. Afionis S, Stringer LC. European Union leadership in biofuels regulation: Europe as a normative power? *Journal of Cleaner Production*, 2012, 32, 114-123. <https://doi.org/10.1016/j.jclepro.2012.03.034>.
3. Ajanovic A. Biofuels versus food production: Does biofuels production increase food prices? *Energy*, 2011, 36(4), 2070-2076. <https://doi.org/10.1016/j.energy.2010.05.019>.
4. Alternative Fuels Data Center: Maps and Data - Global Ethanol Production, 2019 Retrieved from Energy.gov website: <https://afdc.energy.gov/data/10331>.
5. Araujo Enciso SR., Fellmann T, Pérez Dominguez I, Santini F. Abolishing biofuel policies: Possible impacts on agricultural price levels, price variability and global food security. *Food Policy*, 2016, 61, 9-26. <https://doi.org/10.1016/j.foodpol.2016.01.007>.
6. Aro EM. From first generation biofuels to advanced solar biofuels. *Ambio*, 2015, 45(S1), 24-31. <https://doi.org/10.1007/s13280-015-0730-0>.
7. Bartonova E. The impacts of biofuel production in developing countries, 2012. Retrieved from Resilience website: <https://www.resilience.org/stories/2012-03-01/impacts-biofuel-production-developing-countries/>.
8. Biofuels | OECD-FAO Agricultural Outlook 2020-2029 | OECD iLibrary. Retrieved from <https://www.oecd-ilibrary.org/sites/3aeb7be3-en/index.html?itemId=/content/component/3aeb7be3-en#section-d1e21123>.
9. Biofuels. Retrieved from Ballotpedia website: <https://ballotpedia.org/Biofuels#:~:text=Biofuels%20are%20categorized%20either%20as>.
10. Bond AJ, Morrison-Saunders A. Re-evaluating Sustainability Assessment: Aligning the vision and the practice. *Environmental Impact Assessment Review*, 2011, 31(1), 1-7. <https://doi.org/10.1016/j.eiar.2010.01.007>.
11. BP Statistical Review of World Energy, 2016. Retrieved from <http://large.stanford.edu/courses/2016/ph240/stanchi2/docs/bp-2016.pdf>.
12. Burchett B, Kyle L. Anthropocentrism as Environmental Ethic, 2016, (Doctoral Dissertation, 2012, 32, 114-123. <https://doi.org/10.1016/j.jclepro.2012.03.034>.

⁶⁷ Dalla Casa G. Deep ecology as a philosophical basis of degrowth. Retrieved from <https://www.degrowth.info/en/catalogue-entry/deep-ecology-as-a-philosophical-basis-of-degrowth/>.

- tation).
<http://dx.doi.org/10.13023/ETD.2016.259>.
13. Callegari A, Bolognesi S, Ceconet D, Capodaglio AG. Production technologies, current role, and future prospects of biofuels feedstocks: A state-of-the-art review. *Critical Reviews in Environmental Science and Technology*, 2019, 50(4), 384-436. <https://doi.org/10.1080/10643389.2019.1629801>.
 14. Dale VH, Kline KL, Kaffka SR, Langeveld, JWA. A landscape perspective on sustainability of agricultural systems. *Landscape Ecology*, 2012, 28(6), 1111-1123. <https://doi.org/10.1007/s10980-012-9814-4>.
 15. Dalla Casa G. Deep ecology as a philosophical basis of degrowth. Retrieved from <https://www.degrowth.info/en/catalogue-entry/deep-ecology-as-a-philosophical-basis-of-degrowth>.
 16. de Gorter H, Drabik D, Just DR, Kliauga EM. The impact of OECD biofuels policies on developing countries. *Agricultural Economics*, 2013, 44(4-5), 477-486. <https://doi.org/10.1111/agec.12031>.
 17. EASAC. The current status of biofuels in the European Union, their environmental impacts and future prospects, 2012. Retrieved from https://easac.eu/fileadmin/PDF_s/reports_statements/Easac_12_Biofuels_Complete.pdf.
 18. Englund O. On sustainability of biomass for energy and the governance thereof, 2016. <https://doi.org/10.13140/RG.2.1.2689.4323>.
 19. Erickson B, Lutt E, Winters P. Can Biofuels Replace Fossil Fuels? Consequences of Microbial Interactions with Hydrocarbons, Oils, and Lipids: Production of Fuels and Chemicals, 2016, 1-19. https://doi.org/10.1007/978-3-319-31421-1_379-1.
 20. Gasparatos A, Stromberg P, Takeuchi K. Sustainability impacts of first-generation biofuels. *Animal Frontiers*, 2013, 3(2), 12-26. <https://doi.org/10.2527/af.2013-0011>.
 21. Global Affairs Canada - Affaires mondiales Canada. Climate change in developing countries, 2015. Retrieved from GAC website: https://www.international.gc.ca/world-monde/issues_developpement-enjeux_developpement/environmental_protection-protection_environnement/climate-climatiques.aspx?lang=eng.
 22. Gonzalez C. The Environmental Justice Implications of Biofuels. *UCLA J. Int'l L. Foreign Aff.*, 2016, 20, 229. Retrieved from <https://digitalcommons.law.seattleu.edu/faculty/771>.
 23. Fargione J, Hill J, Tilman D, Polasky S, Hawthorne P. Land Clearing and the Biofuel Carbon Debt. *Science*, 2008, 319(5867), 1235-1238. <https://doi.org/10.1126/science.1152747>.
 24. Hansen A, Defries R, Turner W. Land use change and biodiversity, 2004. https://doi.org/10.1007/978-1-4020-2562-4_16.
 25. Hochman G, Rajagopal D, Timilsina GR, Zilberman D. Impacts of Biofuels on Food Prices. *The Impacts of Biofuels on the Economy, Environment, and Poverty*, 2014, 47-64. https://doi.org/10.1007/978-1-4939-0518-8_4.
 26. Huang H, Khanna M, Önal H, Chen X. Stacking low carbon policies on the renewable fuels standard: Economic and greenhouse gas implications. *Energy Policy*, 2013, 56, 5-15. <https://doi.org/10.1016/j.enpol.2012.06.002>.
 27. Lago C, Herrera I, Caldés N, Lechón Y. Nexus Bioenergy-Bioeconomy. *The Role of Bioenergy in the Bioeconomy*, 2019, 3-24. <https://doi.org/10.1016/b978-0-12-813056-8.00001-7>.
 28. León-Moreta M. Biofuels - A Threat to the Environment and Human Rights? An Analysis of the impact of the production of feedstock for agrofuels on the rights to water, land and food. *European Journal of Legal Studies*, 2011. Retrieved from <http://hdl.handle.net/1814/18600>.
 29. Lovett JC, Hards S, Clancy J, Snell C. Multiple objectives in biofuels sustainability policy. *Energy Environ. Sci*, 2011, 4(2), 261-268. <https://doi.org/10.1039/c0ee00041h>.
 30. Manners I. Normative Power Europe: A Contradiction in Terms? *JCMS: Journal of Common Market Studies*, 2002, 40(2), 235-258. <https://doi.org/10.1111/1468-5965.00353>.

31. Mattioda RA, Tavares DR, Casela, JL, Junior OC. Social life cycle assessment of biofuel production. *Biofuels for a More Sustainable Future*, 2020, 255-271. <https://doi.org/10.1016/b978-0-12-815581-3.00009-9>.
32. Moravvej Z, Makarem, MA, Rahimpour, MR. The fourth generation of biofuel. *Second and Third Generation of Feedstocks*, 2019: 557-597. <https://doi.org/10.1016/b978-0-12-815162-4.00020-3>.
33. Mohr A, Raman S. Lessons from first generation biofuels and implications for the sustainability appraisal of second generation biofuels. *Energy Policy*, 2013, 63, 114-122. <https://doi.org/10.1016/j.enpol.2013.08.033>.
34. Morone P, Strzałkowski A, Tani A. Biofuel transitions: An overview of regulations and standards for a more sustainable framework. *Biofuels for a More Sustainable Future*, 2020, 21-46. <https://doi.org/10.1016/b978-0-12-815581-3.00002-6>.
35. Naik SN, Goud VV, Rout PK, Dalai A K. Production of first and second generation biofuels: A comprehensive review. *Renewable and Sustainable Energy Reviews*, 2010 14(2), 578-597. <https://doi.org/10.1016/j.rser.2009.10.003>.
36. Nelson MP, Vucetich, JA. Sustainability Science: Ethical Foundations and Emerging Challenges. *Nature Education Knowledge*, 2012, 3(10):12.
37. Nuffield Council On Bioethics. *Biofuels: ethical issues*, 2011. London: Nuffield Council On Bioethics.
38. Nurse, K. Culture as the fourth pillar of sustainable development. *Small States: Economic Review and Basic Statistics*, 2006, 11, 28-40.
39. O'Connor M. The "Four Spheres" framework for sustainability. *Ecological Complexity*, 2006 3(4), 285-292. <https://doi.org/10.1016/j.ecocom.2007.02.002>.
40. Pathak L, Shah K. Renewable energy resources, policies and gaps in BRICS countries and the global impact. *Frontiers in Energy*, 2019, 13(3), 506-521. <https://doi.org/10.1007/s11708-018-0601-z>.
41. Prasad S, Ingle AP. Impacts of sustainable biofuels production from biomass. *Sustainable Bioenergy*, 2019, 327-346. <https://doi.org/10.1016/b978-0-12-817654-2.00012-5>.
42. Renewable Energy - Recast to 2030 (RED II), 2018. Retrieved from EU Science Hub - European Commission website: <https://ec.europa.eu/jrc/en/jec/renewable-energy-recast-2030-red-ii>.
43. Rottman J. Breaking down biocentrism: two distinct forms of moral concern for nature. *Frontiers in Psychology*, 2014, 5. <https://doi.org/10.3389/fpsyg.2014.00905>.
44. Sakai P, Afionis S, Favretto N, Stringer LC, Ward C, Sakai M, Afzal N. Understanding the Implications of Alternative Bioenergy Crops to Support Smallholder Farmers in Brazil. *Sustainability*, 2020, 12(5), 2146. <https://doi.org/10.3390/su12052146>.
45. Seager TP, Melton J, Taylor Eighmy T. Working towards sustainable science and engineering: introduction to the special issue on highway infrastructure. *Resources, Conservation and Recycling*, 2004, 42(3), 205-207. <https://doi.org/10.1016/j.resconrec.2004.04.001>.
46. Searchinger T, Heimlich R, Houghton RA, Dong F, Elobeid A, Fabiosa J, Yu TH. Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change. *Science*, 2008, 319(5867), 1238-1240. <https://doi.org/10.1126/science.1151861>.
47. Selin NE, Lehman C. biofuel | Definition, Types, & Pros and Cons. *Encyclopædia Britannica*, 2018. Retrieved from <https://www.britannica.com/technology/biofuel>.
48. Sorda G, Banse M, Kemfert C. An overview of biofuel policies across the world. *Energy Policy*, 2010, 38(11), 6977-6988. <https://doi.org/10.1016/j.enpol.2010.06.066>.
49. Stattman SL. *Biofuel governance in Brazil and the EU*, 2019 (PhD Thesis). <https://doi.org/10.18174/472916>, Retrieved from <https://research.wur.nl/en/publications/biofuel-governance-in-brazil-and-the-eu>.

50. Su Y, Zhang P, Su Y. An overview of biofuels policies and industrialization in the major biofuel producing countries. *Renewable and Sustainable Energy Reviews*, 2015, 50, 991-1003. <https://doi.org/10.1016/j.rser.2015.04.032>.
51. Tenenbaum DJ. Food vs. Fuel: Diversion of Crops Could Cause More Hunger. *Environmental Health Perspectives*, 2008, 116(6). <https://doi.org/10.1289/ehp.116-a254>.
52. Van Horn G. Ethics and Sustainability A Primer with Suggested Readings by Gavin Van Horn, 2013. Retrieved from CENTER FOR HUMANS & NATURE website: https://iseethics.files.wordpress.com/2013/09/ethics_and_sustainability_primer.pdf.
53. Von Braun J. Biofuels and the Poor: Finding the Win-Wins, 2007. Retrieved from http://eeas.europa.eu/archives/docs/energy/events/biofuels/sessions/s4_05_von_braun_biofuels_poor_brussels_5-7-07.pdf.
54. Vos RO. Defining sustainability: a conceptual orientation. *Journal of Chemical Technology & Biotechnology*, 2007, 82(4), 334-339. <https://doi.org/10.1002/jctb.1675>.
55. Zentou H, Rosli Nurul Shafiqah, Wen H, Gomes C. The viability of biofuels in developing countries: Successes, failures and challenges. *Iranian Journal of Chemistry & Chemical engineering- International English Edition*, 2019, 38.
56. Found in: <https://www.epa.gov/renewable-fuel-standard-program/renewable-fuel-standard-rfs2-final-rule-additional-resources>.