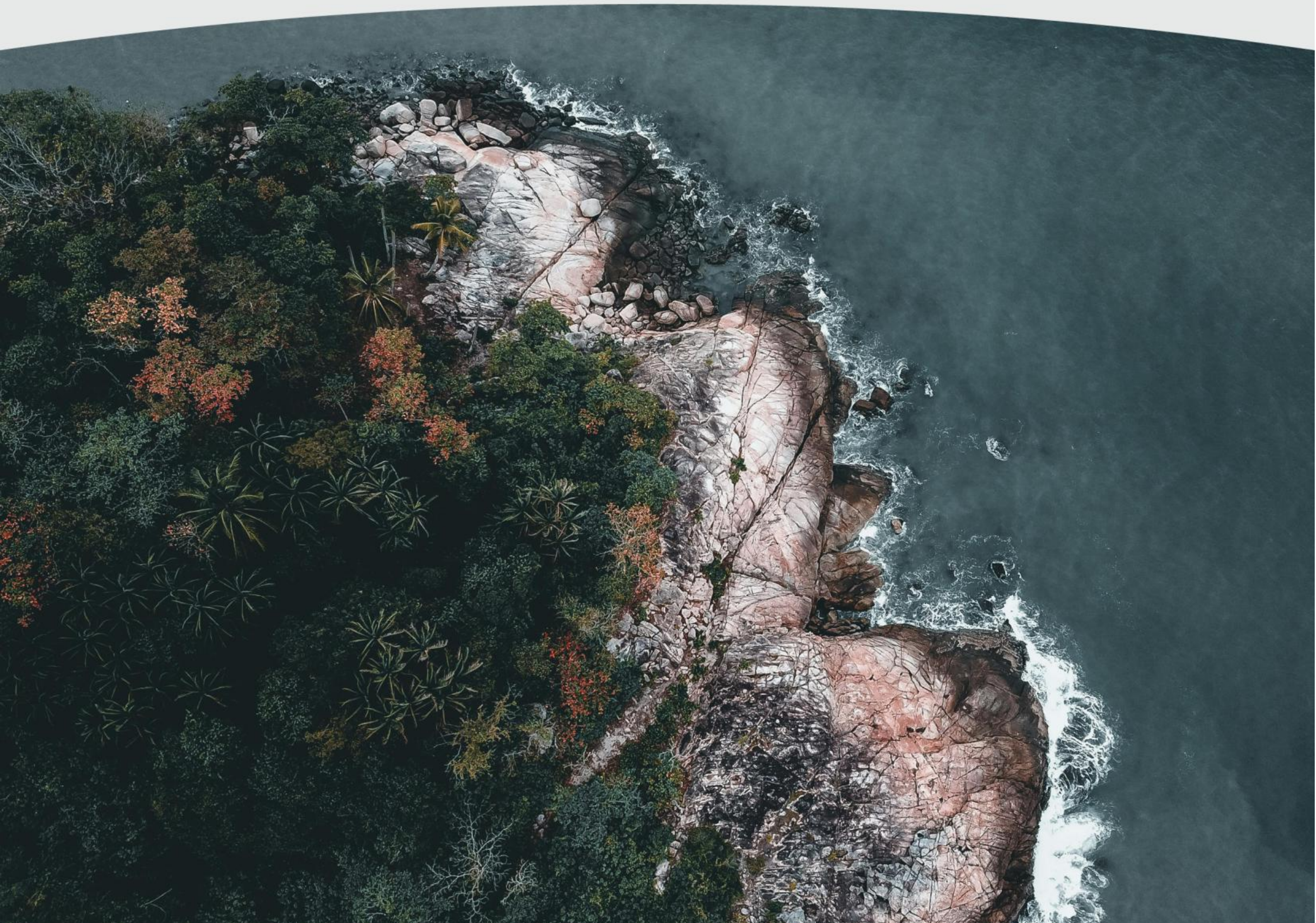
CDP Technical Note

Biofuels

CDP Corporate Questionnaire



Version

Version	Revision date	Revision summary
1.0	May 2022	• First published version
2.0	January 25, 2023	• Minor updates to align with 2023 CDP questionnaires.
3.0	June 28, 2024	• Question numbers updated to align with the CDP Corporate Questionnaire 2024
4.0	September 4, 2024	• Updates to section: Reporting on biomass and biofuel use in Module 8 to align with 2024 Corporate Questionnaire.

Contents

Glossary

Bioenergy – Energy derived from any form of biomass or biofuels.

Biomass – Biomass is any organic matter, i.e. biological material, available on a renewable basis. This includes feedstock derived from animals or plants, such as wood and agricultural crops, and organic waste from municipal and industrial sources. Biomass fuels should be sustainably sourced and certified where possible, and include:

- Solid biofuels – solid fuels derived from biomass. Includes feedstock derived from animals or plants, such as wood and agricultural crops, and organic waste from municipal and industrial sources.
- Liquid biofuels – liquid fuels derived from biomass such as ethanol and biodiesel.
- Biogases – a mixture of methane (CH4) and carbon dioxide (CO2) used as fuel and produced by bacterial degradation of organic matter or through gasification of biomass.

Greenhouse gas (GHG) – In line with Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) and amendment issued by the Greenhouse Gas Protocol on May 2013 the basket of greenhouse gases (GHGs) consists of:

- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Hydrofluorocarbon family of gases (HFCs)
- Perfluorocarbon family of gases (PFCs)
- Sulfur hexafluoride (SF6)
- Nitrogen trifluoride (NF3).

Nitrogen trifluoride (NF3) is now considered a potent contributor to climate change and is therefore mandated to be included in national inventories under the UNFCCC. NF3 should also be included in GHG inventories under the GHG Protocol Corporate Standard, and the GHG Protocol Corporate Value Chain (Scope 3) Standard.

Land use – Land use is based on the functional dimension of land for different human purposes or economic activities. Typical categories for land use are dwellings, industrial use, transport, recreational use or nature protection areas. Additional land use metrics can relate to the climate-related arrangements, activities, and inputs regarding these categories that organizations engage in, and can include land use change and land use management metrics.

Land-use change (LUC) – Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land use change may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus give rise to radiative forcing and/or other impacts on climate, locally or globally.

About this tech note

This technical note provides an overview of biofuels and their impacts, to support disclosure through the CDP Corporate Questionnaire.

Whilst there are no universally agreed approaches to the sustainable production and use of biomass and biofuels, this technical note provides organizations with information to understand the potential impacts of biofuels, so that they may take steps toward more sustainable biofuel production and consumption.

Transparent and comprehensive reporting of biofuel use presents additional data needs. Organizations must:

a) Understand how biofuels are defined;
b) Be aware of their potential impacts;
c) Understand how these impacts can and should be managed to ensure sustainable sourcing, processing and use of biofuels; and
d) Be aware of related international, regional or local policy and certification schemes.

This technical note gives some background to these areas but does not aim to be prescriptive. Ultimately, it is up to responders to decide what data is feasible to gather, what environmental impacts they will report on, and how they will manage the sustainability of their biofuels.

If you have any questions, comments or suggestions about the content of this document please contact your regional CDP contact.

1. Types of biofuels

There are two main biofuel types – primary (unprocessed) and secondary (processed) biofuels.

Primary biofuels are used in their natural form (as harvested) and are directly combusted usually to supply cooking, space heating and/or electricity production needs. Examples of primary biofuels include woody biomass (firewood, wood chips, pellets, forest/crop residues) and municipal/animal by-products (sewage sludge, manure).

Secondary biofuels are produced from biomass. They may be a solid, liquid or gas, and are used for a wider range of applications, including transport and high-temperature industrial processes. Secondary biofuels can be classified into different generations of biofuels, based on key characteristics such as the type of biomass used, the biomass preparation and processing procedure, the biofuel technical specification and how the biofuel is used (Jeswani et al., 2020). The four generations of secondary biofuels are:

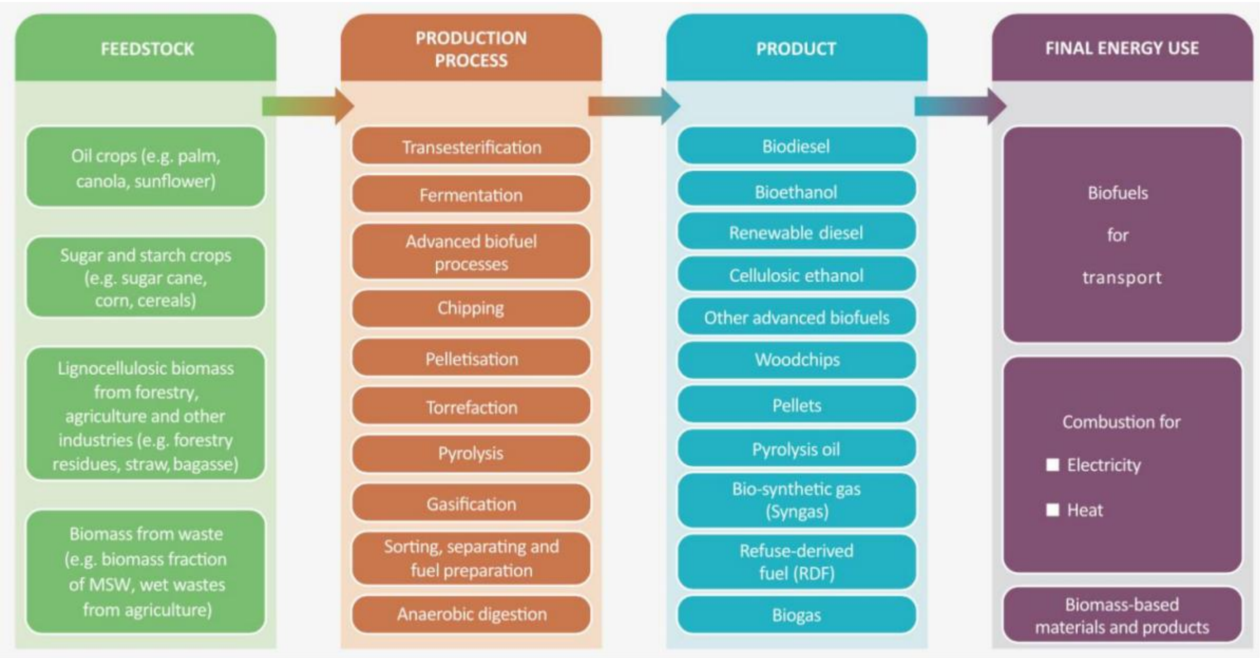
- First-generation biofuels, also known as conventional biofuels, are generated from crops using well-established processes (e.g., fermentation and distillation). As they are produced from food crops, these biofuels are in direct competition with food sources and supply. Biodiesel and bioethanol produced using food crops as feedstocks are two examples of first-generation biofuels. The feedstocks that are typically used for biodiesel include vegetable/olive/sunflower oil and animal fat, while bioethanol is produced by the fermentation of starches from wheat, corn, sugar cane, potatoes and molasses.
- Second-generation biofuels, also known as advanced biofuels, are generated using forest residues (lignocellulosic materials), agricultural or municipal waste, nonedible crops specially grown on the land that is not suitable for growing food crops, or from the nonedible part of ordinary crops. Examples of second-generation biofuels based on crops include bioethanol generated from lignocellulosic materials like straw and grass, as well as biodiesel produced using oil plants such as miscanthus, cassava and jatropha. A

common example based on waste products is landfill-derived biogas. Many processing and/or production procedures of second-generation biofuels are in early stages (e.g., research and development, piloting and demonstration phases) and are not widely available for use.

- Third-generation biofuels are produced from microalgae. Examples of third-generation biofuels include bioethanol from microalgae and seaweeds, and biohydrogen from green microalgae and microbes. Like second-generation biofuels, the processing and/or production procedures of third-generation biofuels are in early stages (e.g., research and development, piloting and demonstration phases) and are not widely available for use.
- Fourth-generation biofuels are the most advanced biofuels currently being developed. This category of biofuels is produced using non-arable land and does not require destruction of biomass. The biomass for fourth-generation biofuels includes genetically modified microorganisms for use in biohydrogen production processes. Genetic and metabolic modifications in microorganisms capable of biofuel production decrease the number of steps involved in the absorption and transformation of solar energy into the biofuels and allow capture of CO_2 to minimize emissions into the environment (Aro, 2016).

An overview of biomass types, biofuel production processes, products and uses is provided in Figure 1. Note that these are examples and not intended as an exhaustive list.

Figure 1. Bioenergy pathways (OECD/IEA, 2017)



2. Public policy

Public policy is an important driver for biofuel demand and sustainability requirements. In the International Energy Agency's (IEA) (2021) forecasts to 2026, government policies are the largest single driver of demand growth. The policy landscape for biofuels continues to change rapidly, for example the setting of blending targets, where biofuels are blended with fossil fuels at set proportions. This drives market interest in biofuels at a local to international level and can lead to the wider impacts discussed throughout this technical note.

Sustainability requirements for biomass and biofuels are formulated by specific government bodies in regulatory frameworks, for example the Revised Renewable Energy Directive 2018/2001/EU (EU RED). In addition, multistakeholder partnership initiatives like IEA Bioenergy play a key role in facilitating the development of sustainable biofuel (bioenergy) policy.

3. Impacts of biofuels

A key driver in the development and use of biofuels is their potential to replace the use of fossil fuels and thereby mitigate GHG emissions, especially in hard-to-abate sectors. According to the International Energy Agency (IEA) report *Renewables 2023, Analysis and forecast to 2028*, global demand for biofuels is set to expand 38 billion liters over 2023-2028, a near 30% increase from the last five-year period, a 23% rise to 200 billion liters by 2028, with renewable diesel and ethanol accounting for two thirds of this growth, and biodiesel and biojet fuel making up the remainder. Factors such as government policies, overall demand for fuels, as well as costs in the transport and energy sectors will drive where and how growth in biofuel demand will occur, and which biofuels see the fastest growth. By understanding the potential impacts that biofuels can have, organizations can seek to produce and source biofuels in a more sustainable way, and thereby help to minimize their negative environmental impacts.

Biofuels are commonly treated as carbon neutral. During photosynthesis, plants and algae remove carbon (as CO2) from the atmosphere and store it in their biomass. This biomass can then be used to produce biofuels, and when combusted the carbon dioxide is released back into the atmosphere (Searchinger et al., 2022). While it is true that the carbon dioxide released during the combustion of biofuels can be absorbed by plants during photosynthesis, the claim of carbon neutrality overlooks important factors. These include the environmental impact of land-use changes, such as deforestation, and the energy inputs required throughout the biofuel production process (Løkke et al., 2021). This is particularly the case when land use for the production of biofuels replaces land use with a high carbon value (e.g. forests) or land used for food production, and will become an increasing challenge given that future demand is likely to exceed the supply of biomass that can be produced sustainably (Committee on Climate Change, 2018). Aside from land use, indirect emissions and other environmental impacts from biofuels production can be sizeable and undermine the GHG emissions benefits from any reduction in fossil fuel consumption.

It is challenging to draw overarching conclusions about the environmental impacts of biofuels. Crucial in determining the scale of these impacts are the technology used, the location, scale, and pace of production, the land category used for biofuel production, the governance systems regulating biofuels, and the business models and practices adopted. All of these will vary on a case-by-case basis. However, common areas of environmental impact can be drawn together. The following section provides context on the most significant areas of environmental impact from biofuel production. It is not an exhaustive list and some further example areas of concern are listed in Table 1.

Table 1. Example issues associated with biofuel feedstock productions (adapted from CBI, 2019)

Impact type	Issue	Description	Type of emergent risk
Direct and Indirect LUC	Direct and/or indirect land use change	Potential for increase in greenhouse gas missions	Mitigation benefit of biofuels reduced or negated

Other land impacts	Biofuel production affects biodiversity	Competition for land reduces natural forest and biodiversity	Emerging risk of biodiversity loss due to mitigation-driven land use change
	Fertilizer application	Potential for increased emissions of N2O	Offsets some benefits of other mitigation measures
	Invasive properties of biofuel crops	Potential to become an invasive species	Unintended consequences that damage agriculture and/or biodiversity
Water availability and quality	Biofuel production affects water resources	Competition for water affects biodiversity and food cropping	Emergent risk of biodiversity loss and food insecurity due to mitigation-driven water stress
Socioeconomic impacts	Food/fuel competition for land	Competition for land drives up food prices	Emergent risk of food insecurity due to mitigation-driven land use change
	Biomass burning causes air pollution	Burning of biomass such as palm/sugarcane emits tropospheric ozone and small particulate matter	Emergent risk of greenhouse gas-mitigation-driven plant and human health damage caused by tropospheric ozone and particulate matter
	Socioeconomic impacts of biomass production	Potential for biomass production to compete with existing land uses	Poorly implemented governance and production weakens rural incomes and resilience

3.1. Direct and indirect land use change

LUC and deforestation are significant sources of GHG emissions, contributing roughly 11% of global emissions (FAO 2022). The primary drivers of LUC and deforestation are increasing demand for food, energy and transportation worldwide. Considering the steps required to cultivate, harvest, process and transport biomass prior to using it for energy, biofuels have been identified as a significant driver of LUC and deforestation. For example, increasing demand for bioethanol from sugarcane in Brazil has led to a continuous expansion of land used for sugarcane cultivation (Jeswani et al., 2021).

Biofuels can lead to emissions both through direct land use change (dLUC) and indirect land use change (iLUC). dLUC refers to the replacement of an original land use category with a biomass crop for biofuel production. In this case, biomass production is in direct competition with the existing land use. Measuring emissions from dLUC is relatively straightforward, and the scale of emissions will depend on the existing use of land and ecosystem. When carbon-rich ecosystems (e.g. wetlands or forests) are converted for biofuels purposes, the emissions from dLUC during the process can be more than one hundred times larger than the emissions from an equivalent use of fossil fuels (Creutzig et al. 2015). This highlights how significant dLUC emissions can be for biofuels. By growing certain biofuel crops on degraded lands or lands with carbon-poor soils, dLUC emissions can be minimized or even lead to slightly net negative emissions and iLUC, and in some cases sequester emissions/ result in negative emissions. For example, perennial lignocellulosic crops (e.g., eucalyptus, poplar, willow or grasses) can be grown on poor quality land and have less intensive management requirements than soybean or maize *(*FAO, 2008*)*.

Even when there are net GHG savings from biofuels, the dLUC emissions associated with them may mean that there is a period of upfront increased emissions which can take years to neutralize, termed a “carbon debt” (Creutzig et al., 2015). Depending on the previous ecosystem, the time before this carbon debt is repaid can range from years to centuries (Chum et al., 2011). Important in determining the size of the carbon debt are land type, temporal carbon replacement times, crop type, and land conversion techniques. For example, peat swamp forests need drainage which can exacerbate GHG emissions in the short term and can take many centuries to reach net negative emissions.

iLUC refers to any 'bioenergy activity that may lead to the displacement of agricultural or forest activities into other locations, driven by market-mediated effects' (Jia et al., 2021). As an indirect impact of biomass crops being grown, other land elsewhere must be converted to cropland or pasture to replace the production displaced by the biomass crops. iLUC emissions are potentially more significant for first- than second- generation biofuels (Ahlgren and Di Lucia, 2014; Valin et al., 2015). As first-generation biofuels are based on crops used as fuel or animal feed, some degree of competition and thus displacement is unavoidable. By their nature, iLUC emissions are harder to measure. The most common methods are based on modelling, the results of which are always influenced by modelling assumptions and value-judgements made by the modelers (Chum et al., 2011; Creutzig et al., 2015). Despite these issues, GHG emissions from iLUC due to biofuels can be significant, and are a factor to consider when sourcing biofuels.

3.2. Other land impacts

When land used for biomass production is managed well, it has the potential to sequester carbon, thus replacing any carbon emitted due to the processing and combustion of that biomass (IEA Bioenergy, 2020). However, focusing on the climate mitigation can lead to other impacts being overlooked, including biodiversity loss, water table change, and soil erosion. Some large-scale biomass crops like palm oil can harm both biodiversity and increase soil erosion, especially in the case of non-native monocultures (Dauber, J. et al., 2010). The intensification of timber production for the sole purpose of woody pellets manufacture can degrade forest quality and negatively affect carbon sequestration rates, however the use of residues/byproducts from the timber industry can be a sustainable method of woody pellet production (Mäkelä et al., 2023). A biomass crop can itself act as an invasive species and put pressure on local biodiversity (Barney et al., 2010). The conversion of deep-rooted vegetation to shallow-rooted biomass crops can intensify soil erosion and sedimentation processes (Dupuy et al., 2005). However, growing biomass crops such as perennials (e.g. herbaceous giant grasses) on degraded land can have positive impacts both by providing additional habitats and improving soil quality (IEA 2022).

3.3. Water availability and quality

Biomass production directly impacts water resources and water quality. The impact can be positive or negative, but as with the other types of environmental impact from biofuels this is dependent on case-specific factors like local freshwater reserves, the quality of water needed, and competition for water resources (Creutzig et al., 2015; Jeswani et al., 2020). When integrated into existing land uses, biomass production can provide co-benefits. For example, where perennial crops are used to restore degraded lands, this can have beneficial impacts at the regional level through better water retention and precipitation (Creutzig et al., 2015). However, biomass production can also exacerbate water stress. First-generation biofuels in particular tend to have relatively high water requirements (Jeswani et al., 2020). For example, sugar cane, oil palm and maize crops used for biofuel production have relatively high water requirements to generate economically viable yields. In general, crops requiring irrigation will have greater impacts on water resources.

Aside from the direct use of water, biomass production may impact water resources in other ways. Nutrient runoff from fertilizer use, such as nitrogen and phosphorus, accumulates in water bodies and/or infiltrates into groundwater and damages water quality. Biofuels can have a large detrimental impact, as for example maize crops have also the highest application rates of both fertilizers and pesticides per unit of hectare (FAO, 2008). The potential impacts are also wide-ranging: thermal regime alterations from changes in land use may affect streams' oxygen and metabolic processes – including nutrient and carbon cycling – and have significant detrimental impacts on freshwater biodiversity *(*Butman and Raymond, 2011; Demars et al., 2011; Carlson et al., 2014*)*.

3.4. Socioeconomic impacts

Widespread adoption and use of biofuels will impact economic systems and institutions (Creutzig et al., 2015). Fundamentally, the use of land for biofuels represents an alternative use for land, leading to trade-offs at both the local and national levels. If well managed and properly implemented, development of biofuels can provide benefits such as diversified income to rural areas and energy security to national governments. Poor governance can instead undermine socioeconomic objectives, if for example biofuel production displaces food production.

If implemented well, biofuel projects can benefit rural regions and their inhabitants. Demand for biofuel feedstocks can supplement and diversify farmers' and foresters' incomes and provide additional employment in these regions (Creutzig et al., 2015). This may be especially beneficial for agricultural and forestry residues that would otherwise be discarded. Growing feedstocks for biofuels can also help restore degraded (Creutzig et al., 2015) or otherwise contaminated (CCC, 2018) land and minimize competition with food production.

If implementation is not managed carefully, biofuel projects can have the opposite effect. Poorly implemented agricultural expansion for biomass production is associated with disrupted livelihoods and land degradation. If biofuel projects act as an additional land-use rather than integrating into existing uses, it may lead to existing smallholders, tenants, and herders losing access to productive land (Creutzig et al., 2015). Further, competition for productive, arable land may weaken food security and exacerbate the climate change vulnerabilities of rural communities.

4. Sustainable biofuels

To mitigate any potential negative impacts, biofuels must be produced sustainably. The wide variety of feedstocks and production methods make it difficult to provide a single broadly agreed definition of what constitutes sustainable biomass and sustainable biofuel derived from it. More research is needed to determine which crops and management practices can best minimize impacts and maximize benefits; and no global consensus exists as to what minimum conditions need to be satisfied for biomass to be considered as sustainable. This section identifies certification as the preferred option to demonstrate the sustainability of biofuels that organizations are producing, or sourcing, and offers some guidance on best practice when certification is not available.

When sourcing biofuels there are several steps organizations can take to minimize any negative impacts (Birath and Defranceschi, 2009). In the first instance, priority should be given to the minimization of fossil fuel use before replacement with biofuels. This action has the greatest emissions reduction potential, and avoids the potential negative impacts associated with biofuels production. Organizations should put in place a biofuels strategy, which includes long-term targets on the use of biofuels and definitions of what they consider sustainable biofuel. Organizations should assess the local and regional context to determine what biofuels are most appropriate for their needs. Factors influencing their decisions could include market availability, preferences for local production, and other sustainability considerations. Finally, any sustainability-related requirements should be included in biofuel supplier contracts where possible.

4.1. Certification

Achieving certification is a key action to demonstrate the sustainability of biofuels. It provides consumers an option to understand the sustainability criteria met by their biofuels where the monitoring of the biofuels supply chain is challenging, and the ability to show third party assurance that the biofuels they use meet sustainability standards. Certification is usually completed by a third party to ensure that the product, process, system, or service conforms to a certain standard. For example, an accredited certification body may verify that a particular operation complies with the standard of a specific framework. A variety of voluntary sustainability standards has become operational for the production, processing and trade of biomass and agricultural products since the early 1990s. With the increasing number and use of sustainability standards, the reputation and credibility of a standard has become a key consideration. The International Social and Environmental Accreditation and Labelling (ISEAL) is the global membership organization for credible sustainability standards. Their Credibility Principles provide the foundation, and Codes of Good Practice define the technical requirements to develop and improve sustainability systems (ISEAL). The members of ISEAL are committed to developing their standards through a multi-stakeholder process, making sure that they measurably contribute to sustainability objectives, and that producers and supply chain of the final product are regularly audited for compliance.

Biomass certification has become a major instrument to demonstrate compliance with sustainability criteria set by governments. In the EU, to count towards national renewable energy targets, biofuels must comply with EU RED sustainability criteria. The compliance can be demonstrated through approved voluntary sustainability standards (in particular for biofuels produced beyond EU borders), which is crucial for commodities that have complex value chains across different countries, such as palm oil. While recognition of a certification scheme by a certain government should generally be regarded as a sign of credibility, some argue that in case of EU RED, the bar for sustainability impacts is set too low and blurs the line between standards with a genuine positive impact and those that effectively certify "business as usual" (ISEAL). CDP therefore encourages organizations to select the certification schemes that are ISEAL members, as these standards undergo rigorous checks including multistakeholder engagement, and as such tend to be the strongest. However, it should be noted that no standard covers all environmental and social concerns completely (Schlamann et al., 2013).

Table 1 contains a non-exhaustive list of relevant certification schemes for biomass and biofuels, based on their international orientation and focus on biomass for energy. The schemes incorporate approved best practice standards for the industry and factor in GHG emissions, environment (which can include soil, water and waste) and biodiversity. The table identifies the schemes developed by ISEAL members, including those that are also ISEAL Code Compliant and have therefore successfully undergone independent evaluations against the ISEAL Codes of Good Practice in Standards-Setting, Assurance and Impacts. For further information, the CBI Bioenergy criteria (2019) and NRDC Biofuel Sustainability Performance Guidelines (2014) also have in-depth assessment of several best practice standards.

Table 1 Summary of biomass and biofuel certification schemes (Adapted from Department for Transport, 2021).

Certification scheme	Geographical scope	Biomass covered	Chain of custody covered	Does the scheme include GHG criteria?	Does the scheme include environmental criteria?	Does the scheme include biodiversity criteria?	Subject to audit?	ISEAL member? (*Indicates ISEAL Code Compliant)
Better biomass (formerly NTA 8080)	Global	Multi-feedstock	Whole supply chain	Yes	Yes (except for highly biodiverse grasslands)	Yes	Yes	No
Biomass biofuels voluntary scheme (2BSvs)	Global	Multi-feedstock	Whole supply chain	Yes	Yes	Yes	Yes	No
Bonsucro EU (formerly Better Sugar Cane Initiative (BSI))	Global	Sugar cane	Whole supply chain	Yes	Yes	Yes	Yes	Yes*
FSC (Forest Stewardship Council)	Global	Forestry biomass	Whole supply chain	No	Yes	Yes	Yes	Yes*
Global GAP	Global	Agricultural biomass	Biomass production	Yes	Yes	Yes	Yes	Yes
International sustainability and carbon certification (ISCC)	Global	Multi-feedstock	Whole supply chain	Yes	Yes	Yes	Yes	Yes
Programme for the Endorsement of Forest Certification (PEFC)	Global	Forestry biomass	Whole supply chain	No	Yes	Yes	Yes	No
Red tractor farm assurance combinable crops and sugar beet scheme (Red tractor)	UK and EU-27	Agricultural biomass	Farm to first gathering point	No	Yes	Yes	Yes	No
REDcert	UK, EU-27 and selected countries	Multi-feedstock	Whole supply chain	Yes	Yes	Yes	Yes	No
Roundtable on sustainable biomaterials (RSB) EU RED Fuel Certification	Global	Multi-feedstock	Whole supply chain	Yes	Yes	Yes	Yes	Yes*
Roundtable for Sustainable Palm Oil (RSPO)	Global (focus on palm oil regions)	Palm Oil	Whole Supply chain	Yes	Yes	Yes	Yes	Yes*
Roundtable on Responsible Soy (RTRS)	Global (focus on soy regions)	Soy	Whole Supply Chain	Yes	Yes	Yes	Yes	Yes
Sustainable Agriculture Network	Global	Agricultural Biomass	Biomass production	Optional	Yes	Yes	Yes	Yes
Sustainable Biomass Program (SBP)	Global	Woody biomass – industrial applications	Whole Supply Chain	No	Yes	Yes	Yes	Yes
Sustainable Forestry Initiative (SFI)	Canada & USA	Forestry Biomass	Whole Supply Chain	Yes	Yes	Yes	Yes	No

4.2. Uncertified biomass

Although CDP encourages third-party certification, this might not be possible in all cases. Especially with emerging technologies, relevant standards may not be available, or they might not be applicable for other reasons. Costs and other market factors also play a role. In the absence of third-party certification, any claims on the sustainability of biomass should be made with caution.

Self-assessment against certain sustainability criteria is a practice accepted by some regulators, for example the UK's Non-Domestic Renewable Heat Incentive Ofgem (2021), but an independent audit is still required in most cases. While self-assessment is an accepted approach to demonstrate sustainability of the biomass, the criteria should be comprehensive, and an independent audit should be done to ensure the credibility of any associated claims. For examples of comprehensive sustainability criteria, boxes 1 and 2 list the principles and criteria from two independent and global, multistakeholder-led standards on sustainable biomass, RSB and RSPO.

Box 1: Examples of Sustainable Biomass principles: Roundtable on Sustainable Biomaterials (RSB)

The RSB Principles & Criteria bases its certification of sustainable biomaterials on the following criteria:

1. Legality – Operations follow all applicable laws and regulations.

2. Planning, Monitoring & Continuous Improvement – Sustainable operations are planned, implemented, and continuously improved through an open, transparent, and consultative impact assessment and management process and an economic viability analysis.

3. Greenhouse Gas Emissions – Biofuels contribute to climate change mitigation by significantly reducing life cycle GHG emissions as compared to fossil fuels

4. Human and Labor Rights – Operations do not violate human rights or labor rights, and promote decent work and the well-being of workers.

5. Rural and Social Development – In regions of poverty, operations contribute to the social and economic development of local, rural and indigenous people and communities

6. Local Food Security – Operations ensure the human right to adequate food and improve food security in food insecure regions

7. Conservation – Operations avoid negative impacts on biodiversity, ecosystems, and conservation values

8. Soil – Operations implement practices that seek to reverse soil degradation and/or maintain soil health.

9. Water – Operations maintain or enhance the quality and quantity of surface and groundwater resources, and respect prior formal or customary water rights.

10. Air Quality – Air pollution shall be minimized along the whole supply chain.

11. Use of Technology, Inputs, and Management of Waste – The use of technologies shall seek to maximize production efficiency and social and environmental performance, and minimize the risk of

Box 2: Examples of Sustainable Biomass principles: The Roundtable on Sustainable Palm Oil (RSPO)

The RSPO Principles and Criteria are applicable for sustainable palm oil production worldwide and cover the most significant environmental and social impacts of palm oil production and the immediate inputs to production, such as seed, chemicals and water, and social impacts related to on-farm labour and community relations.

1. Behave ethically and transparently
2. Operate legally and respect rights
3. Optimize productivity, efficiency, positive impacts and resilience
4. Respect community and human rights and deliver benefits
5. Support smallholder inclusion
6. Respect workers' rights and conditions

5. Reporting on biomass and biofuel use

The tables in this section show questions from the CDP Corporate Questionnaire that request information relating to biomass/biofuels, including those that request details of production or consumption of biomass/biofuels that are considered sustainable. Note that these are questions that specifically request datapoints relating to biomass/biofuels, and there may be other questions where an organization may choose to report information relating to their use of biomass/biofuels where relevant.

CDP maintains that only sustainably sourced biomass can be considered a renewable source of energy, which is reflected in the definition: "Biomass: any organic matter, i.e. biological material, available on a renewable basis." Biofuels should be sustainably sourced and certified where possible. We have revised "biomass" to "sustainable biomass" in all our questions to make this more explicit. When reporting the use of ssustainable biomass (in questions 7.55.2, 7.30.7, 7.30.8, 7.46, 7.30.14, 7.30.18, and 5.7), organizations should provide the criteria used to classify the biomass as sustainable (e.g. details of certification). The option "Other biomass" is also available for these questions to enable transparency and data collection on all types of biomass currently used by organizations. Organizations that cannot classify biofuels they use as sustainable should report their biofuels as "Other biomass".

4.1. Module 5 Business Strategy and Module 7 Environmental Performance - Climate Change

Question number	Question text	Relevance of biomass/fuels to this question
5.7	Break down, by source, your organization's CAPEX in the reporting year and CAPEX planned over the next 5 years.	Organizations in the Electric Utilities sector should report their current & planned CAPEX for biomass/fuel power generation sources in this question, disaggregated by whether the biomass/fuel is sustainable or not.
7.6	What were your organization's gross global Scope 1 emissions in metric tons CO2e?	Non-CO_2 emissions from biomass/fuel combustion should be reported in this question.
7.12	Are carbon dioxide emissions from biogenic carbon relevant to your organization?	Organizations should respond "Yes" to this question if biomass/fuel combustion is relevant to their organization.
7.12.1	Provide the emissions from biogenic carbon relevant to your organization in metric tons CO2.	CO_2 emissions from biomass/fuel combustion should be reported in this question.
7.13	Is biogenic carbon pertaining to your direct operations relevant to your current CDP climate change disclosure?	Organizations in the agricultural sectors (Agricultural Commodities, Food, Beverage & Tobacco, and Paper & Forestry) should respond "Yes" to this question if biomass/fuel combustion is relevant to their organization.

Question number	Question text	Relevance of biomass/fuels to this question
7.13.1	Account for biogenic carbon data pertaining to your direct operations and identify any exclusions.	Granular information on CO_2 emissions from biomass/fuel combustion and associated emissions calculation methodologies is requested in this question for organizations in the agricultural sectors (Agricultural Commodities, Food, Beverage & Tobacco, and Paper & Forestry)
7.19	Break down your organization's total gross global Scope 1 emissions by sector production activity in metric tons CO2e.	Non-CO_2 emissions from biomass/fuel combustion within the Cement, Chemicals, Coal, Electric Utility, Metals & Mining, Oil & Gas, Steel, Transport OEM and Transport Services sector boundary should be reported in this question.
7.25	Disclose the percentage of your organization's Scope 3, Category 1 emissions by purchased chemical feedstock.	Organizations in the Chemicals sector should report the percentage of their organization's Scope 3, Category 1 emissions that are biomass/fuel related in this question.
7.30.7	State how much fuel in MWh your organization has consumed (excluding feedstocks) by fuel type.	Biomass/fuel consumption data should be reported in this question in MWh, disaggregated by whether the biomass/fuel is sustainable or not.
7.30.8	State how much fuel in MWh your organization has consumed (excluding feedstocks) by fuel for cement production activities.	Biomass/fuel consumption data within the Cement sector boundary should be reported in this question in MWh, disaggregated by whether the biomass/fuel is sustainable or not.
7.30.14	Provide details on the electricity, heat, steam, and/or cooling amounts that were accounted for at a zero or near-zero emission factor in the market-based Scope 2 figure reported in 7.7.	Organizations that purchase or acquire renewable electricity, heat, steam, and/or cooling generated from biomass/fuel should provide details of those purchases in this question.
7.30.17(RE100 only)	Provide details of your organization's renewable electricity purchases in the reporting year by country	RE100 member organizations that purchase or acquire renewable electricity generated from biomass/fuel should provide details of those purchases in this question.
7.30.18(RE100 only)	Provide details of your organization's low-carbon heat, steam, and cooling purchases in the reporting year by country/area.	RE100 member organizations that purchase or acquire renewable heat, steam, or cooling generated from biomass/fuel should provide details of those purchases in this question.
7.30.19 (RE100 only)	Provide details of your organization's renewable electricity generation by country/area in the reporting year.	RE100 member organizations that generate renewable electricity from biomass/fuel should provide details of those purchases in this question
7.31.1	Disclose details on your organization's consumption of fuels as feedstocks for chemical production activities.	Organizations in the Chemicals sector should report the total consumption, CO_2 emission factor, and heating value of biomass/fuel feedstocks in this question.

Question number	Question text	Relevance of biomass/fuels to this question
7.31.2	State the percentage, by mass, of primary resource from which your chemical feedstocks derive.	Organizations in the Chemicals sector should report the percentage of total chemical feedstock consumption that is derived from biomass in this question.
7.32	Disclose details on your organization's consumption of feedstocks for steel production activities.	Organizations in the Steel sector should report the total consumption, CO_2 emission factor, and heating value of biomass/fuel feedstocks in this question.
7.46	For your electric utility activities, provide a breakdown of your total power plant capacity, generation, and related emissions during the reporting year by source.	Organizations in the Electric Utilities sector should report their power generation capacity, gross & net electricity generation, and direct emissions & emissions intensity figures from biomass/fuel power generation sources in this question, disaggregated by whether the biomass/fuel is sustainable or not.
7.54.2	Provide details of any other climate-related targets, including methane reduction targets.	Organizations should report biomass/fuel production and consumption targets in this question if they are relevant to their organization.
7.55.2	Provide details on the initiatives implemented in the reporting year in the table below.	Organizations should report biomass/fuel related initiatives in this question if they are relevant to their organization.
7.74.1	Provide details of your products and/or services that you classify as low-carbon products.	Organizations should report biomass/fuel related low carbon products/services in this question if they are relevant to their organization.
7.79.1	Provide details of the project-based carbon credits retired by your organization in the reporting period.	Organizations should report details of the biomass related project-based carbon credits retired in the reporting year if relevant to their organization.

5.2. Module 8 Environmental Performance - Forests

Question number	Question text	Relevance of biomass/fuels to this question
8.6	Does your organization produce or source palm oil derived biofuel?	This question allows organizations to understand the relevancy of palm oil derived biofuels to their organizationYou should answer this question if your organization produces or consumes biofuel derived from palm oil.
8.6.1	Provide details of how your organization produces or sources palm oil derived biofuel.	Organizations will provide insight into their associated palm derived biofuel volume and origin.
8.9.1	Provide details of third-party certification schemes used to determine the deforestation-free (DF) or deforestation- and conversion-free (DCF) status of the disclosure volume, since specified cutoff date.	This question gathers information on the proportion of your disclosure volume determined to be DF or DCF using a third-party certification scheme providing full assurance of DF/DCF. Credible third-party certification is one method organizations can use to determine that no deforestation or conversion has occurred since a specified cutoff date and assure investors and other data users that their commodity volumes are DF/DCF.
8.9.2	Provide details of third-party certification schemes not providing full DF/DCF assurance.	This question gathers information on the proportion of your disclosure volume certified through third-party certification schemes that do not provide full DF or DCF assurance, used in combination with additional control methods to determine the DF/DCF status.

References

Ahlgren, S., & Di Lucia, L. (2014). Indirect land use changes of biofuel production–a review of modelling efforts and policy developments in the European Union. *Biotechnology for biofuels*, *7*(1), 1-10. https://www.researchgate.net/publication/260608286

Aro, E. M. (2016). From first generation biofuels to advanced solar biofuels. *Ambio*, *45*(1), 24-31. Azapagic, A., Perdan, S., & Clift, R. (Eds.). (2004). Sustainable development in practice: case studies for engineers and scientists. John Wiley & Sons. https://www.researchgate.net/publication/287204121

Barney, J.N., DiTomaso, J.M. (2010). Invasive Species Biology, Ecology, Management and Risk Assessment: Evaluating and Mitigating the Invasion Risk of Biofuel Crops. In: Mascia, P., Scheffran, J., Widholm, J. (eds) Plant Biotechnology for Sustainable Production of Energy and Co-products. Biotechnology in Agriculture and Forestry, vol 66. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-13440-1_9

Birath, K., & Defranceschi, P. (2009). *Guide to sustainable biofuels procurement for transport*. ICLEI. https://www.yumpu.com/en/document/view/42941437/guide-to-sustainable-biofuels-procurement-for-transport-biofuel-cities

Butman, D., & Raymond, P. A. (2011). Significant efflux of carbon dioxide from streams and rivers in the United States. *Nature Geoscience*, *4*(12), 839-842. https://www.researchgate.net/publication/232780435

Chum, H., A. Faaij, J. Moreira, G. Berndes, P. Dhamija, H. Dong, B. Gabrielle, A. Goss Eng, W. Lucht, M. Mapako,O. Masera Cerutti, T. McIntyre, T. Minowa, K. Pingoud.(2011). Bioenergy. In*: IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*
https://www.researchgate.net/publication/285717963_Bioenergy

Committee on Climate Change (CCC). (2018). *Biomass in a low-carbon economy*. Retrieved from: https://www.theccc.org.uk/wp-content/uploads/2018/11/Biomass-in-a-low-carbon-economy-CCC-2018.pdf

Creutzig, F., Ravindranath, N. H., Berndes, G., Bolwig, S., Bright, R., Cherubini, F., Chum, H., Corbera, E., Delucchi, M., Faaij, A., Fargione, J., Haberl, H., Heath, G., Lucon, O., Plevin, R., Popp, A., Robledo-Abad, C., Rose, S., Smith, P., … Masera, O. (2015). Bioenergy and climate change mitigation: an assessment. *GCB Bioenergy*, *7*(5), 916–944. https://research.chalmers.se/publication/222263/file/222263_Fulltext.pdf

Dauber, J., Jones, M.B. and Stout, J.C. (2010), The impact of biomass crop cultivation on temperate biodiversity. GCB Bioenergy, 2: 289-309. https://doi.org/10.1111/j.1757-1707.2010.01058.xDupuy, L., Fourcaud, T., Stokes A. (2005). A numerical investigation into factors affecting the anchorage of roots in tension. Eur J Soil Sci 56:319–327.
https://www.researchgate.net/publication/249430086_A_numerical_investigation_into_factors_affecting_the_anchorage_of_roots_in_tension

Demars, B. O., Russell Manson, J., Olafsson, J. S., Gislason, G. M., Gudmundsdottir, R., Woodward, G. U. Y., … & Friberg, N. (2011). Temperature and the metabolic balance of streams. *Freshwater Biology*, *56*(6), 1106-1121. https://www.researchgate.net/publication/230047919_Temperature_and_the_metabolic_balance_of_streams

Department for Transport. (2021). *RTFO list of recognised voluntary schemes*. GOV.UK. https://www.gov.uk/government/publications/renewable-transport-fuel-obligation-rtfo-voluntary-schemes/rtfo-list-of-recognised-voluntary-schemes.

Food and Agriculture Organization (FAO). (2008). *The state of food and agriculture 2008: Biofuels: Prospects, risks and opportunities* (Vol. 38). Food & Agriculture Organization of the United Nations. Rome, Italy. https://www.fao.org/3/i0100e/i0100e00.htm.

Food and Agriculture Organization (FAO). (2022). The State of the World's Forests 2022. Forest pathways for green recovery and building inclusive, resilient and sustainable economies. Rome, FAO. https://doi.org/10.4060/cb9360en

International Energy Agency (IEA). (2017). *Energy Technology Perspectives 2017*. IEA. https://www.iea.org/reports/energy-technology-perspectives-2017

International Energy Agency (IEA). (2021). *Renewables 2021: Analysis and forecast to 2026*. IEA. https://iea.blob.core.windows.net/assets/5ae32253-7409-4f9a-a91d-1493ffb9777a/Renewables2021-Analysisandforecastto2026.pdf

IEA Bioenergy. (2020). The use of forest biomass for climate change mitigation: dispelling some misconceptions. https://www.ieabioenergy.com/wp-content/uploads/2020/08/The-use-of-biomass-for-climate-change-mitigation-dispelling-some-misconceptions-August-2020-Rev1.pdf

IEA Bioenergy. (2022). Environmental impacts of perennial grasses on abandoned cropland in Europe. https://www.ieabioenergy.com/blog/publications/environmental-impacts-of-perennial-grasses-on-abandoned-cropland-in-europe/?utm_source=chatgpt.com

Jeswani, H. K., Chilvers, A., & Azapagic, A. (2020). Environmental sustainability of biofuels: a review. *Proceedings of the Royal Society A*, *476*(2243), 20200351.

Jia, G., E. Shevliakova, P. Artaxo, N. De Noblet-Ducoudré, R. Houghton, J. House, K. Kitajima, C. Lennard, A. Popp, A. Sirin, R. Sukumar, L. Verchot.(2019). Land–climate interactions. https://www.ipcc.ch/srccl/chapter/chapter-2/

Løkke, S., Aramendia, E., Malskær, J. (2021). A review of public opinion on liquid biofuels in the EU: Current knowledge and future challenges, Biomass and Bioenergy. https://www.sciencedirect.com/science/article/pii/S0961953421001318

Mäkelä, A., Minunno, F., Kujala, H. *et al.* (2023). Effect of forest management choices on carbon sequestration and biodiversity at national scale. *Ambio* **52**, 1737–1756. https://doi.org/10.1007/s13280-023-01899-0

Natural Resources Defense Council (NRDC). (2014). *Biofuel Sustainability Performance Guidelines*. NRDC. https://www.nrdc.org/sites/default/files/biofuels-sustainability-certification-report.pdf

Ofgem. (2021). *Non-Domestic Renewable Heat Incentive: Sustainability Self-Reporting Guidance (version 2)*. Ofgem. https://www.ofgem.gov.uk/sites/default/files/docs/2021/04/sustainability_self-reporting_guidance_final_2021.pdf.

.

Roundtable on Sustainable Biomaterials (RSB). (2016). *RSB Principles and Criteria*. Retrieved from: https://rsb.org/framework/

Roundtable on Sustainable Palm Oil (RSPO). (2020). *Principles and Criteria for the Production of Sustainable Palm Oil*. https://rspo.org/resources/?id=6025

Schlamann, I., Wieler, B., Fleckenstein, M., Walther-Thoß, J., Haase, N., & Laszlo, M. (2013). *Searching for Sustainability: Comparative Analysis of Certification Schemes for Biomass used for the Production of Biofuels*. WWF Deutschland. http://awsassets.panda.org/downloads/wwf_searching_for_sustainability_2013_2.pdf.

Searchinger, T., James, O., Dumas, P., Kastner, T. and Wirsenius, S. (2022). 'EU climate plan sacrifices carbon storage and biodiversity for bioenergy'. *Nature*, 612 (7938), pp. 27–30. doi: 10.1038/d41586-022-04133-1. https://www.researchgate.net/publication/365816467_EU_climate_plan_sacrifices_carbon_storage_and_biodiversity_for_bioenergy

Valin, H., Peters, D., van den Berg, M., Frank, S., Havlik, P., Forsell, N., Hamelinck, C., Pirker, J., Mosnier, A., Balkovic, J., Schmidt, E., Dürauer, M., & Di Fulvio, F. (2015). *The land use change impact of biofuels consumed in the EU: Quantification of area and greenhouse gas impacts*. ECOFYS Netherlands B.V. https://energy.ec.europa.eu/system/files/2016-03/Final%2520Report_GLOBIOM_publication_0.pdf