UPM BIOFORE
BEYOND FOSSILS

AGRIsoma

# CLIMATE POSITIVE FUELS

## for transport decarbonization

CONCEPT PAPER
2019

# Climate positive fuels for transport decarbonization

Author: Liisa Ranta, UPM Biofuels

# Contents

# 1. The Need

## Climate crisis will not wait – carbon needs to be removed from the atmosphere: Biosequestration of carbon into soils and vegetation is a readily scalable solution.

Currently more carbon is being emitted globally to the atmosphere than is bound to plants, soils and oceans – resulting in too high concentrations of carbon in the atmosphere. Increase of atmospheric greenhouse gases such as carbon dioxide causes climate change.

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 °C. The report from Intergovernmental Panel on Climate Change (IPCC) says the 1.5 °C goal is technically and economically feasible but limiting warming to 1.5 °C requires major and immediate transformation in all sectors. According to the report, with the current rate of greenhouse gas emissions, the planet could pass the 1.5 °C increase as early as 2030, and no later than mid-century. Therefore, in addition to large emissions cuts in the next decade, net $CO_2$ emissions will need to be reduced to zero by mid-century. Dr Rattan Lal, a Nobel Peace Prize Soil Scientist awarded for his work with IPCC, has published papers on how the world's agricultural soils could potentially absorb 13% of the carbon dioxide in the atmosphere - equivalent to the amount released in the last 30 years.

We need to focus efforts not only on reducing emissions, but also removing and storing carbon from the atmosphere. Carbon removal is necessary for both moving to net-zero emissions and for producing net-negative emissions.

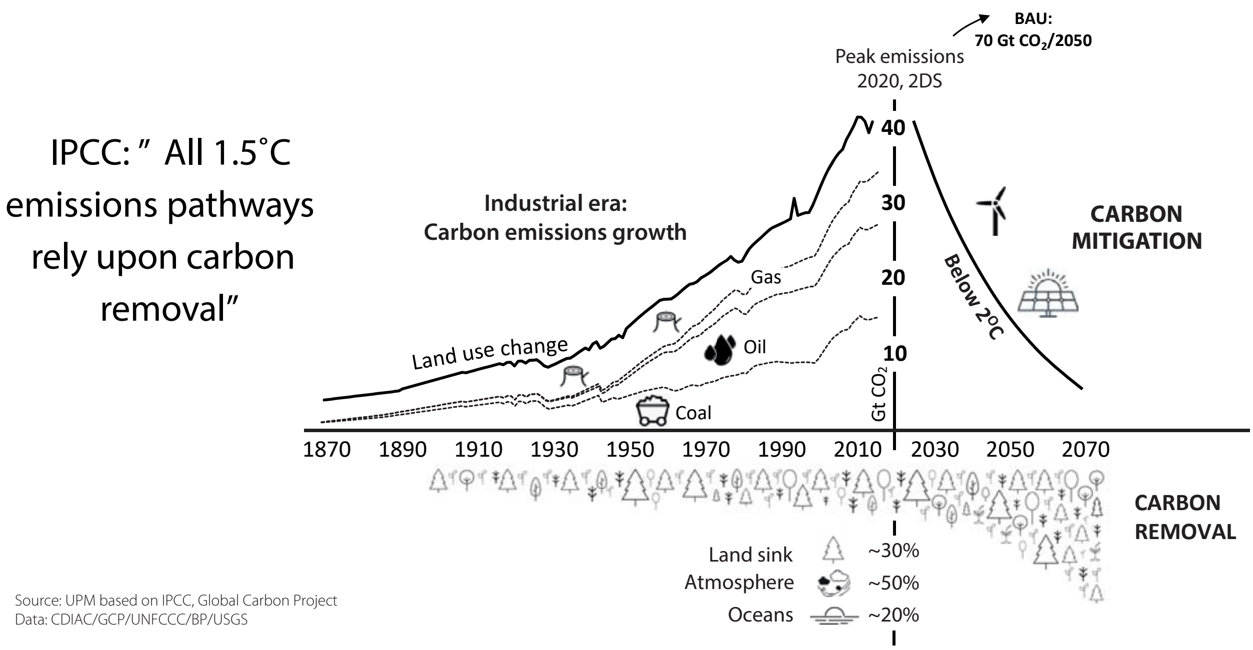
Atmospheric $CO_2$ removal by biosequestration through plants is a solution for decarbonization with positive co-benefits for soil fertility, productivity, and water and nutrient retention. These improvements ensure more resistant agroecosystems and will help farmers deal with increasing climate variability. Additional biosequestration in soils is also a promising 'negative emissions' opportunity to mitigate climate change – it has been calculated that a 0.4% annual increase in soil carbon stocks could compensate for the increase in human-caused $CO_2$ emissions. /1,2/.

Limiting global warming requires major and immediate transformation in all sectors.

0.4% annual increase in soil carbon stocks could compensate for increase in anthropogenic $CO_2$ emissions.

Transition towards a low carbon bioeconomy will need sustainable land-based feedstocks that enable atmospheric carbon dioxide removal.

Fossil fuels in transport need to be replaced by renewables. Advanced biofuels from sustainable feedstocks are a fast track to decarbonize transport which accounts for 25% of greenhouse gas emissions in Europe. The feedstock availability for advanced biofuels has limitations, therefore the transition towards a low carbon bioeconomy will need sustainable land-based feedstocks that enable atmospheric $CO_2$ removal leading to a climate positive effect.




Source: UPM based on IPCC, Global Carbon Project
Data: CDIAC/GCP/UNFCCC/BP/USGS

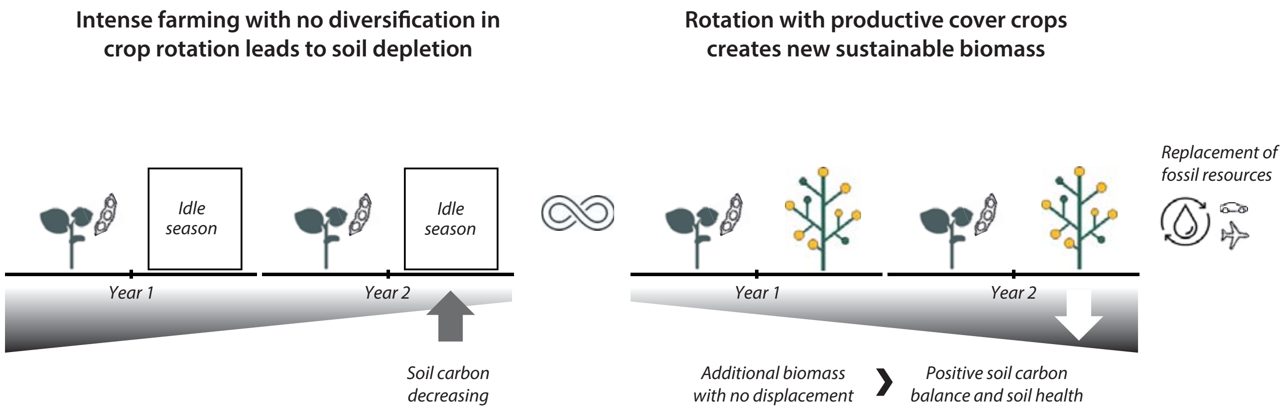
# 2. Climate positive fuels concept

## 2.1 Brief

In general, three main biological solutions for mitigation of the increase in atmospheric greenhouse gases have been identified

1. **Increase soil carbon levels** to biosequester carbon through plants and make the soils healthier in order to increase soil carbon sinks.
2. **Increase additional biomass growth through plants** with additional protein to release the pressure of deforestation created by global demand for protein and undesired land use change in order to increase biomass carbon sinks and supply of additional biomass.
3. **Create renewable solutions and renewable products** to replace the use of fossil resources, in harmony with feeding the world, including processes to capture carbon in order to decrease the use of fossil resources.

Climate positive fuels is a concept, which tackles all from these three angles of climate change mitigation using agricultural practices. It follows nature´s own principles for the carbon cycle and utilizes the most effective way to biosequester carbon from the atmosphere (photosynthesis), combining the local benefits from increased productivity and ecosystem well-being with global impact on climate change, and additional protein as shown in the figure below.




## 2.2 Definition of Climate positive fuels and feedstocks

A fuel is deemed a climate positive fuel when produced from feedstocks that are cultivated within existing agricultural systems and therefore do not require additional farmland for their cultivation. These feedstocks are introduced as an additional high biomass cover crop to an existing main crop rotation, during seasons where the land is not typically in productive use. These feedstocks enhance farmland productivity as they increase the soil's organic carbon balance, adopt sustainable soil management practices that reverse soil carbon depletion and produce additional protein output per unit of agricultural land, while causing no displacement of local or global food and feed production.

This integrated agricultural crop-feedstock production system is defined as Climate positive farming and is built around the following agricultural sustainability pillars:

1. **Additionality:** The biomass and protein produced from such feedstock is additional to the output provided by the existing cropping systems. The additional protein reduces the overall pressure on global demand for vegetable protein. Therefore, cultivation within such systems can be deemed no ILUC, as it causes no need to displace food or feed. Further more, in these Climate positive farming systems, as the biomass/food/feed supply continues to increase, the pressure to clear land is further relieved, leading to a reverse effect on ILUC.

2. **Positive soil carbon balance:** the introduction of these feedstocks must first demonstrate an increase in soil carbon content of the system, or

Additional high biomass cover crop is introduced to an existing main crop rotation.

Additional biomass and protein causing no displacement in local or global food and feed production.

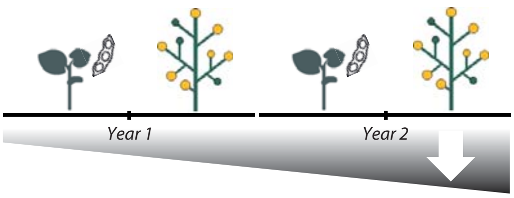
Farmland productivity is increased and positive soil carbon balance achieved.

biosequestration, following increased crop biomass or addition of external organic carbon inputs (organic fertilizers, biochar and soil amendments such as cellulosic residues or biosludge) to enhance endogenous soil organic pools. A positive soil carbon balance will result in:

a. Reduced soil erosion
b. Higher nutrient retention and recycling
c. Improved water quality and conservation
d. Higher rates of carbon biosequestration
e. Increased yields
f. Additional income for the growers as a result of higher soil productivity
g. Enhanced biodiversity

Second, these feedstocks must also demonstrate the adoption of sustainable soil management practices that further reduce soil organic matter depletion and/or accelerated atmospheric carbon release (volatisation), such as adoption of reduced or no tillage and increased soil coverage by post-harvest crop residue to minimize topsoil carbon loss (erosion).

**CLIMATE POSITIVE FARMING**




*Additional biomass with no displacement* › *Positive soil carbon balance and soil health*

**MANAGEMENT PRACTICES**

*Introduction of an additional cover crop to the existing crop rotation, in areas and during seasons where the land is not typically in productive use*

***Production system internal carbon inputs into soil, e.g:***

- *Cover cropping*
- *High biomass crop development*
- *Diversification of crop rotation / crop planning*

***Production system external carbon input into soils***

- *Biosludge, manure etc.*

***Minimizing soil disturbance***

- *Minimum or no tillage*

**BENEFITS**

- *Reduced soil erosion*
- *Higher nutrient retention and recycling*
- *Improved water quality and conservation*
- *Higher rates of carbon biosequestration*
- *Increased yields and productivity*
- *Increased biodiversity*
- *Additional income for the growers as a result of higher soil productivity*
- *Additional protein*
- *Climate change mitigation*

## 2.3 Biosequestration and soil benefits

### 2.3.1 Mechanism of biosequestration

Biosequestration is a natural process where $CO_2$ is removed from the atmosphere through plant matter (roots, leaves, stem) and stored in the soil carbon pool in the form of soil organic carbon. The process is mainly run through photosynthesis, where plants naturally absorb carbon from the air. With help from sunlight and water, they convert carbon into carbohydrates. Then plants then pump some of these carbohydrates down through their roots to feed microorganisms, which use that carbon to build soil. The amount of soil organic carbon results from the balance between photosynthesis and carbon losses through respiration and decomposition /3/.

$CO_2$ is removed from the atmosphere through plants and stored in the soil carbon pool in a form of soil organic carbon.

### 2.3.2 Benefits of biosequestration of atmospheric carbon

Unlike in the atmosphere where too much carbon is creating problems, more carbon in the soil makes it healthier and more able to hold more water and nutrients /4/.

In healthier soil, plants are better able to:

- o grow, becoming more productive with an increased rate of photosynthesis (which in turn pulls in more carbon)
- o develop stronger and longer root systems, making the plant more efficient in the uptake of water and nutrients and helping it store more carbon
- o pump carbohydrates down through their roots to feed microorganisms that in turn use carbon to build healthier soil

Additionally, biosequestration of carbon in agricultural soils can help to improve soil structure, reduce erosion, increase soil moisture retention and plant-available water, and improve nutrient storing capacity /5,6/. Additional biosequestration of carbon in soils is also a promising 'negative emissions' opportunity to mitigate climate change – it has been calculated that a 0.4% annual increase in soil carbon stocks could compensate for an increase of human-caused $CO_2$ emissions /2/.

As a direct result from such cropping systems, farmers have multiple co-benefits /7/, including:

- o seamless incorporation of the crops into farming operations and existing grain management systems
- o improved soil quality leading to productivity increases
- o reduced soil erosion
- o enhanced biodiversity
- o improved landscape appearance and GHG mitigation/carbon storage
- o additional income by developing winter/offseason cropping systems
- o more climate change resilient soils

Improved soil structure, reduced erosion, increased moisture and nutrient retention.

Enhanced soil biodiversity, additional income, more climate resilient soils.

### 2.3.3 Practices to improve biosequestration of carbon

There are many ways to increase carbon in soils. Most commonly listed practices are /8,9/:

Production system internal carbon input into soils

- o permanent vegetation cover throughout the year
- o high biomass producing plants
- o biomass left on soil after harvest
- o deep rooted crops and crops with high root biomass are favoured (roots contribute 2.3 times more to soil organic carbon than the same amount of above ground biomass)

Ability of soil micro-organisms to build carbon into soils

- o microbe carbon pump

Production system external carbon input into soils

- o organic amendments such as manure, biochar, biosludge

Soil disturbance

- o in general it is recognized that minimum soil disturbing practices, such as minimum or no tillage, help to increase soil carbon levels

## 2.4 Increasing farming system productivity with no land use change or crop displacement

In Climate positive farming the existing farming system productivity is increased by introducing a cover crop to the existing crop rotation with no displacement of other crops locally or globally. This can be done in novel cropping systems that allow an increase in overall land productivity by integrated cropping systems (e.g. cover crops and sequential cropping). The biomass and protein from such a cover crop is additional to the existing activities and services provided by the current cropping systems on the same land.

Farming system productivity is increased by introducing a cover crop to existing crop rotation with no displacement.

This means that more efficient use of existing land is achieved, leading to higher yields per hectare. Simultaneously, there are no market mediated responses triggering demand for additional land, which would lead to land use change. In concert additional protein reduces overall pressure on the global demand for vegetable protein. Therefore, the cultivation within such systems can be considered no ILUC, as they are causing no displacement. On the contrary it can be stated that Climate positive farming systems release the pressure to clear land, as the biomass/food/feed supply through the cover crop is increased, leading to a reverse effect on ILUC.

The pressure to clear the land is released leading to a reverse effect on ILUC.

## 2.5 Summary of Climate positive farming

Climate positive farming is a tool to mitigate carbon cycle imbalance as it

1. Is a way to capture atmospheric carbon and store it in soil through agricultural land management to improve soil health and biosequester carbon.
2. Can be done in areas and during seasons where the land is not typically in productive use and therefore fights land use change with increased yields of biomass and new volume of protein to meet global demand.
3. Offers new sustainable renewable feedstocks to be used for Climate positive fuels.

Key criteria and benefits of the concept are summarized in the table below.

| Criteria | Ways to achieve | Benefits |
|---|---|---|
| **Land use effectiveness** | **Introduction of an additional cover crop to the existing crop rotation, in areas and during seasons where the land is not typically in productive use** | No displacement of other crops locally or globally |
| | | More efficient use of existing land leading to higher yields per hectare |
| | | No market mediated responses that lead to land use change |
| | | More biomass to local ecosystem and for climate positive fuels |
| | | More protein to fight worldwide protein deficit |
| **Correct land management practices leading to increased soil carbon sequestration and soil health** | Production system internal carbon input into soils:<br>• Cover cropping<br>• Utilization of crops with high biomass – both above and below ground<br>• Permanent vegetation cover throughout the year<br>• Biomass left on soil after harvest<br>• Deep rooted crops and crops with high root biomass | In healthier soils productivity improves<br>Improved soil structure<br>Reduced erosion<br>Enhanced soil biodiversity<br>Additional income for farmers<br>More climate resilient soils<br>Better nutrient and water retention<br>Climate change mitigation |
| | Production system external carbon input into soils<br>• manure<br>• biochar<br>• biosludge | |
| | Minimization of soil disturbance<br>• minimum or no tillage | |

Climate positive farming is an effective way to mitigate climate change.

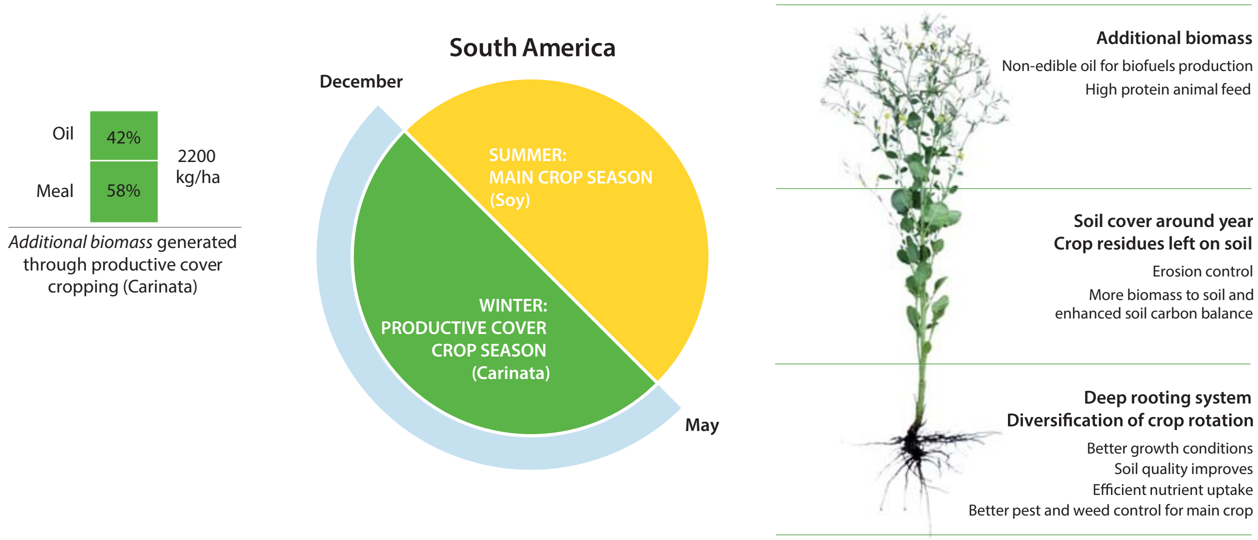
## 2.6 Example of Climate positive farming – case UPM carinata production in Uruguay

UPM is developing the Brassica carinata (Carinata) Climate positive farming system in Uruguay for the sustainable production of biofuels.

Carinata is an oleaginous crop developed for the sustainable production of biofuels that, in addition to producing inedible oil, produces protein meal for animal feed, while the residual biomass in a Climate positive farming system can increase carbon sequestration in soil.

Carinata is a crop that adjusts well to the local agricultural rotation, being additional to existing food production and offers an interesting alternative for rural producers to generate additional income in compliance with all aspects of sustainability.
Increased biomass production and correct land management practices improve soil carbon sequestration, leading to significant greenhouse gas savings.

Carinata is a crop that adjusts well to the local agricultural rotation, being additional to existing food production, and offers an interesting alternative for rural producers to generate additional income in compliance with all aspects of sustainability.




UPM Biofuels, in collaboration with rural producers, obtained the RSB (Roundtable for Sustainable Biomaterials) certification for the cultivation of Carinata in Uruguay. RSB is one of the voluntary schemes approved by the European Commission that demonstrates compliance with the sustainability criteria of the European Union's Renewable Energy Directive.

Furthermore, UPM Biofuels has been recognized with the world's first RSB low ILUC (indirect land use change) risk certification. This certification is an additional proof of sustainability that demonstrates that UPM's carinata oil from Uruguay has a low risk of generating indirect emissions, positioning it among the most sustainable raw materials.

UPM Biofuels has been recognized by world's first RSB low ILUC (indirect land use change) risk certification.

## 2.7 Example of Climate positive farming – case Agrisoma Carinata production

In many regions of global agriculture, there is a primary cash crop and an opportunity for a cover crop that has not been realized. This “cover cropping” option requires a crop that can withstand the challenges of the winter season, which is often colder and wetter than the summer season. In many regions of the world, land is left fallow or is simply seeded with a “cover crop”, which protects the land from erosion, but offers no additional protein to decrease pressure on land conversion.

Carinata is an example of a type of crop that fits that cover crop option reducing the pressure on global demand for protein and providing biosequestration of carbon through its large root structure, and extensive above ground biomass.

Agrisoma had conducted over 10 years of non-GMO development and innovation into Carinata which combines the qualities of canola along with the resilient nature of the mustard crop. This single crop enables farmers to harvest a high protein, high oil grain which grows under the toughest conditions.

Carinata in a Climate positive farming system can provide increased biodiversity in the ecosystem through

- protection of water resources
- soils formation and protection
- nutrient storage and recycling
- contribution to climate stability
- maintenance of ecosystems

Carinata is stored, transported and handled exactly like other crops. Carinata grain can be transformed into oil and protein (meal) in any number of large scale (e.g. 1 million tonnes per year) facilities that are located in the commodity agricultural regions.

Carinata meets the needs of Climate positive farming through

- high biomass and high density root structure provide large biosquestration of atmospheric carbon
- a winter crop that doesn’t divert land from food production but increases volume of protein to reduce global pressure
- frost and drought tolerance greater than other winter cropping options

Carinata is an example of a cover crop which reduces the pressure on global demand for protein and provides biosequestration of carbon through its large root structure, and extensive above ground biomass.

The following table summarizes how UPM´s and Agrisoma´s Carinata cover cropping system responds to the criteria and achieves the benefits of Climate positive farming.

| | | | | |
|---|---|---|---|---|
| **Land use effectiveness** | **Introduction of an additional cover crop to the existing crop rotation, in areas and during seasons where the land is not typically in productive use** | ✓ | **No displacement of other crops locally or globally** | ✓ |
| | | | More efficient use of existing land leading to higher yields per hectare | ✓ |
| | | | No market mediated responses that lead to land use change | ✓ |
| | | | More biomass for the local ecosystem and for climate positive fuels | ✓ |
| | | | More protein to fight worldwide protein deficit | ✓ |
| **Correct land management practices leading to increased soil carbon sequestration and soil health** | Production system internal carbon input into soils:<br>• Cover cropping<br>• Utilization of crops with high biomass □ both above and below ground<br>• Permanent vegetation cover throughout the year<br>• Biomass left on soil after harvest<br>• Deep rooted crops and crops with high root biomass | <br>✓<br>✓<br>✓<br>✓<br>✓ | Improved soil productivity<br>Improved soil structure<br>Reduced erosion<br>Enhanced soil biodiversity<br>Additional income for farmers<br>More climate resilient soils<br>Better nutrient and water retention<br>Climate change mitigation | ✓<br>✓<br>✓<br>✓<br>✓<br>✓<br>✓<br>✓ |
| | Production system external carbon input into soils<br>• manure<br>• biochar<br>• biosludge | | | |
| | Minimization of soil disturbance<br>• minimum or no tillage | ✓ | | |

# 3. Regulative framework – EU

While the benefits of *Climate positive fuels* systems are manifest, existing renewable fuels policy should incentivize such systems. This could be achieved by clarifying the positioning of such systems in relation to food cap/low ILUC-risk/Annex IX feedstocks.

## 3.1 Food cap

Exemption from the cap on the use of food and feed materials as biofuels feedstocks.

Article 2 (Paragraph 40) of RED II which defines which feedstocks may be subject to a cap states that 'food and feed crops' mean starch-rich crops, sugar crops or oil crops produced on agricultural land as a main crop excluding residues, waste or ligno-cellulosic material and **intermediate crops, such as catch crops and cover crops, provided that the use of such intermediate crops does not trigger demand for additional land**. Feedstocks from Climate positive farming systems that add additional production are therefore exempted from the cap on the use of food and feed materials as biofuel feedstock.

## 3.2 Low ILUC risk

RED II introduces the 'low ILUC-risk' concept under which biofuel feedstocks may be considered more sustainable if they are produced in systems that avoid displacement of existing agricultural production.

Recital 12 of the RED II states that: Biofuels, bioliquids or biomass fuels should be considered low indirect land-use change-risk only if the **feedstock** used for their production **is cultivated as a result of the application of duly verifiable measures to increase productivity**. In addition, these measures should ensure sustainability of feedstock in view of all requirements set out in Directive 2009/28/EC or Directive (EU) 2018/2001 in relation to renewable energy targets, allow operators to cultivate crops on areas which were previously not used for cultivation of food and feed crops or are severely degraded, or be implemented by independent small farm holders.

A Delegated Act providing additional specification of the low ILUC-risk concept has been released by the Commission. The Delegated Act introduces requirements for productivity improvements. The Commission's delegated regulation for High and Low Indirect Land-Use Change is scoped around high ILUC risk food and feed crops, but it can also give a framework for novel concepts such as Climate positive fuels.

## 3.3 Annex IX

Feedstocks should be added into Annex IX, while they not only bring into market climate positive fuels, but also contribute to soil productivity locally and cause no displacement locally or globally.

To establish a clear position in the EU regulation, feedstocks from Climate positive farming should be added into Annex IX, while they not only bring into market Climate positive fuels, but also contribute to soil productivity locally and cause no displacement locally or globally.
RED II notes that each delegated act amending the list of feedstocks shall be based on an analysis considering the points below. Justification for Climate positive farming is noted:

**i) the principles of the circular economy and the waste hierarchy established in Directive 2008/98/EC;**

- o Waste hierarchy does not play a role for feedstocks from Climate positive farming, as they are not waste but purposely grown feedstocks
- o With a Climate positive farming system, a totally new source for additional biomass is introduced, without violating principles of the circular economy

**ii) the Union sustainability criteria set out in Article 26;**

- Sustainability criteria will be fulfilled with certification from an applicable sustainability scheme. As an example, UPM´s and Agrisoma´s Carinata farming are certified with RSB's certification scheme.

**iii) the need to avoid significant distortive effects on markets for (by-) products, wastes or residues;**

- Cover crops based on Climate positive farming are not a waste/residue/by-products and there are no distortive effects on markets of those products.

**iv) the potential for delivering substantial greenhouse gas emission savings compared to fossil fuels based on life cycle assessment of emissions; and**

- The Climate positive farming concept when, for example, Carinata is placed as a sequential crop with appropriate land management practices, has significant potential for delivering substantial greenhouse gas emission savings while sequestering carbon into soil.

- Introducing a sequential crop into crop rotation with right land management practices has big potential to improve soil health, and especially improving soil organic carbon balance, leading to substantial savings in greenhouse gas emissions over the whole production chain.

**v) the need to avoid negative impacts on the environment and biodiversity**

- With certified operations, using the already existing agricultural land, negative impacts on the environment and biodiversity can be avoided. On the contrary, there can be substantial benefits for the local ecosystem: soil health (soil carbon increase), soil biodiversity (diverse microbial population), increased yields.

**vi) the need to avoid creating additional demand for land**

- With certified operations and using the already existing agricultural land during the season when it is not normally in productive use, the additional demand for land can be avoided.

- As an example, Carinata oil from UPM´s production in Uruguay is also certified with the RSB low-ILUC module that verifies the production of Carinata oil does not increase land use elsewhere.

Furthermore, RED II notes that feedstock that can be processed only with advanced technologies shall be added to Part A of Annex IX. Feedstock that can be processed into biofuels, or biogas for transport, with mature technologies shall be added to Part B of Annex IX.

- Feedstocks from Climate positive farming typically are oils – the processing of these into biofuels can be done with mature technologies.

- However, **the whole system of Climate positive farming needs transformation of the agricultural sector into climate friendly operations** which needs **deployment of new type of management practices on a large scale**. This is comparative to transformation into new processing technologies.

- Deployment of new management practices need political incentives to take place on a large scale. This can be achieved by adding Climate positive feedstocks into RED II Annex IX Part A.

## 3.4 Comparison of Climate positive farming feedstocks with other Annex IX feedstocks

RED II Annex IX Part A lists feedstocks eligible for the advanced biofuel mandate. Feedstocks in the list consist of non- food waste and residual materials and purposely grown lignocellulosic and cellulosic materials.

Purposely grown feedstocks comprise of lignocellulosic material and non-food cellulosic material, whose definition is:

> *(q) 'non-food cellulosic material' means feedstocks mainly composed of cellulose and hemicellulose, and having a lower lignin content than lignocellulosic material; it includes food and feed crop residues (such as straw, stover, husks and shells), grassy energy crops with a low starch content (such as ryegrass, switchgrass, mis canthus, giant cane), cover crops before and after main crops, ley crops, industrial residues (including from food and feed crops after vegetal oils, sugars, starches and protein have been extracted), and material from biowaste. Ley and cover crops have to be understood as temporary, short-term sown pastures comprising grass-legume mixture with a low starch content to get fodder for livestock and improve soil fertility for obtaining higher yields of arable main crops;*

According to the definition, cellulosic cover crops and ley crops, defined as temporary, short term pastures are included in Annex IX A. In simple terms, grass grown and harvested between food crop periods is eligible for the status in Annex IX A, since it needs advanced conversion technologies.
However, the definition does not cover other cover crops, such as cover crops producing oil and protein. Nevertheless, such cropping systems are not only climate positive, but enhance local productivity and ecosystem wellness. These systems can bring multiple benefits over grassy cover crops while promoting good agricultural practices, leaving more biomass on the soil as well as diversifying the crop rotation, leading to positive effects on climate and local the ecosystem.

Climate positive farming has multiple benefits compared to non-food cellulosic cover crops.

Annex IX part B consists of used cooking oil and animal fats, which are food industry wastes. Wastes are defined to have no emissions at point of origin (where they are formed), creating a carbon neutral cycle when used for biofuels. Purposely grown feedstocks from Climate positive farming have benefits beyond those as they are able to reduce the emissions from the atmosphere, creating a climate positive cycle when used for biofuels.

## 3.5 Proposal for regulative action

**Proposal:**

Brassica carinata* should be added to RED II Annex IX A.

**Definition:**

Feedstocks from Climate positive farming are introduced as an additional high biomass cover crop to an existing main crop rotation, during seasons where the land is not typically in productive use. These feedstocks enhance farmland productivity as they increase the soil organic carbon balance, adopt sustainable soil management practices that reverse soil carbon depletion and produce additional protein output per unit of agricultural land, while causing no displacement of local or global food and feed production.

Feedstocks from climate positive farming are produced within integrated cropping systems (e.g cover crops) that both aim to enhance soil carbon levels, increasing supply of protein, and as well the total productivity of the land.

**Criteria**

**Feedstocks from Climate positive farming are produced within integrated cropping systems (e.g. cover crops) that both aim to enhance the soil carbon levels, increasing supply of protein and the total productivity of the land.*

# 4. References


1. *Global Warming of 1.5°C, an IPCC special report on the impacts of global warm ing of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*

2. *https://www.4p1000.org/*

3. *Ontl, T. A. & Schulte, L. A. (2012) Soil Carbon Storage. Nature Education Knowl edge 3(10):35*

4. *Community Environmental Council/Carbon farming, www.cecsb.org*

5. *J.J Hutchinson, C.A. Campbell and R.L. Desjardins, "Some Perspectives on Carbon Sequestration in Agriculture", Agricultural and Forest Meteorology, Vol. 142, No. 2-4, 2007, pp. 288-302.*

6. *Lal, R., 2004. Soil carbon sequestration impacts on global climate change and food security, Science 304, 1623*

7. *Kragt ME, Dumbrell NP, Blackmore L, Motivations and barriers for Western Australian broad-acre farmers to adopt carbon farming, Environ Sci Policy 2017, p.73*

8. *Summary of Soil organic matter management in agriculture – International Symposium 29.-30. May 2018, https://www.som-management.org/*

9. *Minasny, B. et al., Soil carbon 4 per mille, Geodema, Volume 292, 2017, p. 59-86.*