AGRICULTURE AND FOOD PRODUCTION – IN THE BEGINNING OF THE TRANSFORMATION

Executive summary and recommendations

In the existing and upcoming EU policies on agriculture and food, we recommend emphasising sustainable production practices that increase nature-based carbon sinks and allow further emission reductions in the sector. Several agricultural practices, technologies, and dietary shifts provide sector-specific carbon sequestration and emission reduction potential. Our recommendation is to view the land use need in a holistic way where in addition to agriculture and food production other future land use needs including renewable energy; particularly onshore wind and solar energy, biofuels and biomaterials, biodiversity protection, and ecosystem conservation are taken into consideration (see CLC Position paper on land use and nature based carbon removals). Sustainable transformation of the whole food system is necessary to feed the growing global population, mitigate climate change, and ensure the future availability of these scarce land use resources. Creating sustainable food system requires immediate investments in sustainable food production technologies and farming practices that increase carbon sinks and reduce unnecessary land use requirements as well as emissions. In this paper, we highlight the potential in the agricultural sector regarding carbon sequestration and efficient land use. Successful implementation requires technology and innovation development, financial support, and policies at the EU level.

Policy recommendations:

- Re-structure incentives in the agricultural sector in the EU to better financially support sustainable food production, and thus help increase the affordability, accessibility and availability of healthy, nutritious and environmentally friendly food.
- Market-based solutions can help create financially and sustainably viable agricultural system. Efficient carbon pricing and transparent marketplace for carbon sinks are needed to supporting farmers and society to decarbonize the food system.
- Support technology and research development in the agricultural sector (e.g. vertical farming, plant-based protein, cell-based agriculture) to assist actors in the supply chain of sustainable food production.
- The new CAP implementation period for 2025 onwards should support and promote increasing carbon sinks and storages, help reduce emissions in the agricultural sector and reduce the land use requirements. It is particularly important to ensure alignment with EU Sustainable Finance Taxonomy in the future.

1 Scope of the problem

Keeping the average global temperature increase within 1,5°C requires drastic emission reductions and increase of carbon sinks and storages. Currently we also stand at a crossroads where we require more land for food production to feed the growing global population, whereas at the same time we, at an accelerating rate, lose suitable arable land for land degradation and erosion. Currently the global food system results 21–37% of the global greenhouse gases (GHG) (IPCC, Special report on Land use) and thus holds a crucial role in climate mitigation regarding emission reductions and carbon sequestration potential.

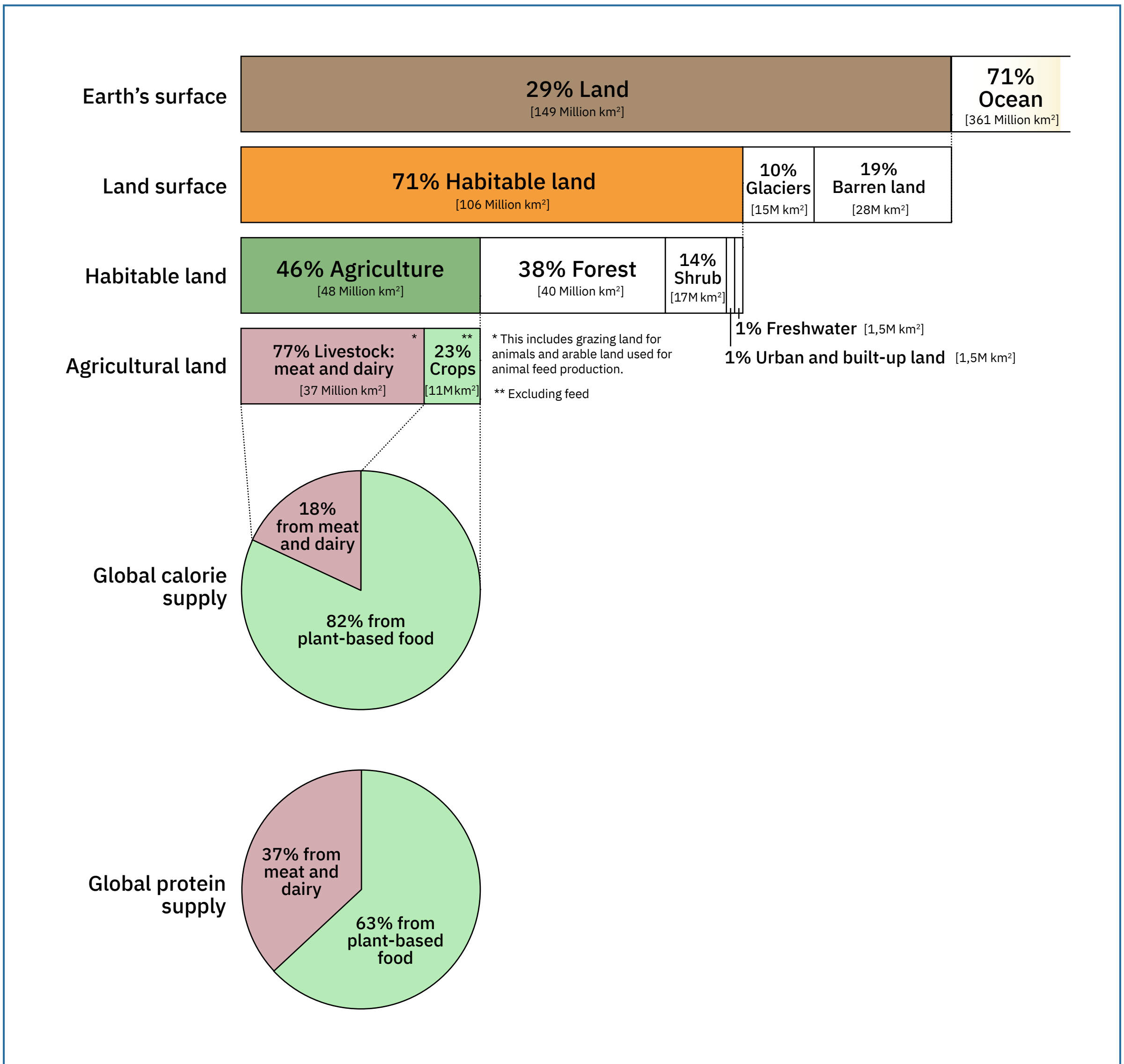
Globally croplands have been increasingly used for food and feed production, mainly due to increasing global demand for animal products and wider adaptation of the western animal-based diets.[3] With the projections of the global population reaching 9,9 billion by 2050,[4] using the western diet as a reference, this would mean approximately 70% increase of land use and more than doubling the cropland area to feed everyone.[3] The current agricultural practices and intensified animal farming are projected to result in a situation where almost half of the current arable land globally are unusable for agricultural purposes by 2050.[5] Thus, it is clear that the agricultural sector is becoming increasingly important regarding sustainable use of land, natural carbon sinks and climate mitigation. The current situation creates unprecedented pressures to transform our agricultural system to withhold and feed the growing global population in a manner that sustains global resources, ecosystems and the planetary boundaries.

As indicated in Figure 1, in the global level the current food production is highly unsustainable, where approximately 77% of global agricultural land goes to livestock production. This is exceptional amount of land, particularly considering that meat and dairy provide only 18% of the global calorie supply and 37% of global protein supply (Figure 1). In the EU, almost 40% of land is used in agricultural production, of which over 70% is used for animal feed production (Feeding the problem).

In this paper we focus on the potential of carbon sinks as well as emission reductions in the agricultural sector. We identify agricultural and production practices that can further increase carbon sequestration and storages in the agricultural sector and provide examples of technology advancements and consumption patterns that can help provide further emission reductions and reduce land use needs in the sector.

(Data source: FAO, OurWorldinData.org)

Figure 1. Global land use for food production and indication of global calorie and protein supply from meat and dairy. Source: FAO



2 Agricultural production practices that can provide additional carbon sequestration and storage

Regenerative agriculture concentrates on circular sustainable agricultural system emphasising renewing soil organic carbon (SOC) and creating new soil. The regenerative agriculture helps to increase carbon sequestration in agricultural soils, while also improving soil health (Rhodes, 2017). Regenerative farming can also improve biodiversity, water cycle and ecosystem services.[12] Carbon farming implies to a set of specific land management practices part of regenerative farming, where carbon dioxide (CO_2) is absorbed from the atmosphere and sequestered in plant material and soil organic matter.[8] Carbon farming as a process entails emission reductions, avoided emissions as well as carbon removals through land use management practices. This includes management of land and livestock, carbon cycle and carbon pools, as well as fluxes of CO_2, methane and nitrous oxide.

Sustainable agriculture necessitates minimum disturbance to soil including no tilling, permanent or semi-permanent soil cover, and crop rotation system.[13] The sustainable land management practices improve soil health and increase carbon sequestration by protecting soil from erosion and improving soil biota. Sustainable agriculture is practiced usually on small scale farms that use less off-farm inputs, use sustainable energy and often integrate animal and plant production.[7] **Precision farming** refers to land management practices concentrating on precise measurements and observations of farms, fields, animals, or specific crops.[16] Precision farming is expected to increase crop resilience and reduce yield loss. Precision farming can also allow agricultural practices in more marginalized lands and help reduce the need for land use change. **Agroforestry** refers to integrated farming practices that include production of agricultural crops, trees and grazing animals in the same land area. Agroforestry increases the land use efficiency, improves soil health and carbon sequestration, whilst also reduces land degradation and provides many ecological and environmental benefits.[5] Agroforestry is particularly more common in tropical forests where it also contributes to biodiversity and forest conservation while reducing pressure on natural and local forest resources.[5]

3 Food production technologies and dietary changes that can reduce land use and GHG emissions

Vertical farming indicates of production technology where food is grown in a controlled indoor environment in vertically stacked layers, often in large facilities close to urban setting and infrastructure. The environmental and social benefits from this farming method can improve regional food security, while reducing geographical, climatic and geopolitical risks of food production. In Europe, vertical farming production is increasing rapidly with new innovative ideas and technological solutions that help the sector advance even further and drastically reduce the land use need in agricultural sector.[20]

Cellular agriculture refers to a production method where meat is produced in laboratories by using only initial cells from animals (without killing them) and producing fat or muscle cells in vitro cultivation that closely replicates animal meat.[21] Cellular agriculture has primarily been concentrated on meat production (mainly beef and chicken), but cell-based milk as well as fish production are increasing in interest amongst researchers, investors and consumers. Cellular agriculture has several desirable environmental aspects, such as over 80% reduction in land use, water use and GHG emissions compared to animal-based food production (Tuominen 2022 etc). The production method requires high energy consumption due to the in vitro production technology and, therefore, sufficient renewable energy sources are crucial to ensure sustainable production.[23] As the technology and field develops and becomes more prevalent, the product cost is expected to come down and make the products commercially more viable.

Alternative protein sources have increased dramatically over the last few decades and today many plant-based 'meat alternatives' imitate the texture, flavour composition and nutritional aspects of meat. Common plant-based protein sources include soy, grains, seeds, nuts, leaves, legumes, pulses, microalgae and fungi.[25] Due to the protein efficiency ratio it takes 7kg of plant-based food to produce 1kg of meat, which results in higher efficiency for plant based food.[25] Thus, reduced meat consumption would radically alleviate land use needs for wider food production, as currently approximately 37% of the world's grain is fed to livestock.[7] Other alternative protein sources include **insects**, which provide environmentally very sustainable, healthy, and financially viable alternative source of protein.[25] **Microbial protein** also provides a highly sustainable alternative with minimal land use. The protein is derived from single- or multicell microorganisms such as microalgae, fungi and bacteria, and used in human diets as protein supplementation. Examples of microbial protein are for example of mycoprotein, microalgae and solein.

4 Concluding remarks

One of the greatest future challenges, in addition to climate change, is to produce more food with less land. To be able to address these needs the whole agricultural system needs a systemic transformation. Implementing the science-based farming practices, technologies and dietary changes recommended in this paper are crucial in order to preserve the scarce land resources and cover all the different land use needs in the EU. Many sustainable land use practices also have positive impacts on biodiversity protection and these synergies should be investigated further. A holistic view to address these future challenges is needed

The impacts of agricultural production practices or food technologies highlighted in this paper are summarized below in table 1.

Table 1. Impacts of agricultural practices and food production technologies on land use needs and carbon sequestration.

Method or practice	Impact or potential
Regenerative agriculture	Increased carbon sequestration, enhance soil health, improve water cycle, biodiversity protection
Carbon farming	Increased carbon sequestration, enhance soil health
Sustainable agriculture	Increased carbon sequestration, biodiversity protection
Precision farming	Increased carbon sequestration, efficient resource use
Agroforestry	Increased carbon sequestration, biodiversity protection
Vertical farming	Reduced land use and land-based emissions, efficient resource use, improved food security
Cellular agriculture	Reduced land use and land-based emissions, reduced water and resource use, improved food security
Alternative protein	Reduced land use and land-based emissions, efficient resource use, improved food security

Impact	Method	Potential and environmental impact
Increase carbon sinks and storage	Regenerative agriculture	Increased carbon sequestration, enhance soil health, improve water cycle, biodiversity protection
	Carbon farming	Increased carbon sequestration, enhance soil health
	Sustainable agriculture	Increased carbon sequestration, biodiversity protection
	Precision farming	Increased carbon sequestration, efficient resource use
	Agroforestry	Increased carbon sequestration, biodiversity protection
Land use reductions	Vertical farming	Reduced land use and land-based emissions, efficient resource use, improved food security
	Cellular agriculture	Reduced land use and land-based emissions, reduced water and resource use, improved food security
	Alternative protein	Reduced land use and land-based emissions, efficient resource use, improved food security

According to estimations all emissions emitted today and from here on onwards, would need to be absorbed from the atmosphere by carbon sinks in aim to limit the global temperature increase even below 2C°. This requires drastic increase in carbon sinks and storages in addition to immediate emission reductions. As has been addressed in this paper, emission reduction potential exists in all part of the value chain in the food sector. In the agricultural sector the demand i.e. consumer side is expected to have larger emission reduction potential than the production side.[1] The new IPCC Sixth Assessment report furthermore identifies that with sufficient infrastructure, technologies and policies available, consumer behaviour can result up to 40–70% emission reductions by 2050.[31] This highlights the importance of the technology innovations and dietary shifts also recommended in this paper. The most beneficial impacts are expected to be achieved through a combination of the highlighted agricultural production and consumption methods and practices instead of relying solely in one solution.

To scale up sustainable agricultural practises re-structuring of incentives in the agricultural sector is needed. The incentive framework should better support sustainable food producers, and thus help increase the affordability, accessibility and availability of healthy, nutritious and environmentally friendly food.

The EU's common agricultural policy (CAP) should promote increasing carbon sinks and storages and incentivise emissions reductions in the sector. It is particularly important to ensure alignment of agricultural policies with EU Sustainable Finance Taxonomy in the future. In the longer term, the incentive framework should be developed towards market-based direction as it can help to create financially and sustainably more viable agricultural system. Efficient carbon pricing and transparent marketplace for carbon sinks would be suitable tools to start with.

Increased support of technology research and development in the agricultural sector (e.g. vertical farming, plant-based protein, cell-based agriculture) is also needed to assist actors in the supply chain of sustainable food production.

With appropriate incentives and support we believe that the highlighted options in this paper can assist in the needed green transformation of the agricultural sector in Europe.

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