



Beyond net zero emission in agriculture EEB pathway for a net-zero agriculture and agriculture-related land emission

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According to the United Nations (UN) emission gap [report 2019](#), in order to meet the Paris agreement target to limit global warming to 1.5°C, the European Union (EU) is required to cut greenhouse gas emissions by at least 65% by 2030. However, reducing direct carbon emissions from transport and industry will not be enough on its own. In the [Impact Assessment](#) (IA) accompanying the European Commission (EC) communication “Stepping up Europe’s 2030 climate ambition”, the EC recognised that the climate and energy policy framework work best when it is internally coherent and act jointly with other sectoral policies.

According to [Poore et al \(2018\)](#), our food system is responsible for 26% of GHG emission worldwide. Our food and agriculture system are not only contributing to climate change, but also the deterioration of ecosystems and unprecedented levels of species loss¹. We are facing an extinction crisis with natural resources on which farmers rely on under threat². European farmers are lurching from crisis to crisis with an aging farming population which struggles to attract new young farmers³.

The key question is how do we address these multiple challenges of our food systems: feeding the world/Europe while mitigating and adapting to climate change, restoring biodiversity, and ensuring farmers wellbeing? A major part of the answer lies in addressing these interdependent challenges together; to do otherwise invites adverse consequences and unintended trade-offs. The United Nations (UN) Sustainable Development acknowledges interdependencies of the [17](#) social, environmental, and economic goals and encourages actions that promote synergies among them. The EU’s Green Deal and its Farm to Fork strategy is one of the first attempts to address this interdependency in EU policy. However, the EU’s agricultural policy has been heavily criticized by the [scientific community](#) and [civil society](#) for its lack of alignment with EU Green Deal ambitions. As a direct result, many Sustainable Developments Goals will not be achieved by 2030⁴, such as the goals to stabilize and adapt to climate change and to restore biodiversity are highly unlikely to be reached.

¹ <https://www.chathamhouse.org/2021/02/food-system-impacts-biodiversity-loss>

² <http://www.fao.org/state-of-biodiversity-for-food-agriculture/en/>

³ <https://op.europa.eu/en/publication-detail/-/publication/1c660bec-0500-11ea-8c1f-01aa75ed71a1/language-en/format-PDF>

⁴ <https://www.sciencedirect.com/science/article/pii/S1877343517302385>

Therefore, the EU must initiate a paradigm shift, not only in the way we produce and consume food but also in how we manage our land and natural resources. While technological innovation such as precision farming or feed additives offer some short-term targeted solutions on a single issue, they do not provide the required step change to address the multiple environmental crises that Europe is facing today. The European Commission's IA does not exploit co-benefits nor potential trade-offs, between mitigation, biodiversity, and farmer wellbeing. The IA does not consider diet changes to reduce emissions in agriculture, and therefore does not exploit the knock-on effects of food system changes to transition to a climate-friendly agricultural sector (Mensseen et al. 2020). This study thus intends to address this gap and provide an EEB pathway for an EU27 net-zero agriculture to the 2050 horizon characterised by a full transition towards agroecology (see [Poux and Aubert,2018](#)) accompanied by dietary changes as developed in [Costa et al.,2021](#).

Scope and main assumptions of EEB pathway for a net-zero agriculture and agricultural land related emission

The European Environmental Bureau pathway (EEB pathway) presents technically and scientifically feasible targets that translates our vision for the future of European agriculture. EEB pathway builds on the work carried by the FAO, 2018, the scenario developed by the IDDRI and an ambitious level of dietary changes as proposed by Costa et al.,2021 and use the ARISE (AgRIculture and food SystEm interactive) model⁵ for pulling them together.

Farming production assumptions

EEB pathway builds on the work carried by the FAO, 2018: [The future of food and agriculture – Alternative pathways to 2050](#), more specifically on “The Towards sustainability scenario” and the scenario developed by the [IDDRI](#) (Poux and Aubert,2018): ‘An agroecological Europe in 2050: multifunctional agriculture for healthy eating which provides systematic links between agricultural production, production methods and land use.

The full transition of European farming system to agroecological practices is therefore translated in the following hypotheses: optimum use of local resources such as nutrients, full implementation of integrated pest management (such as crop rotation and diversification) and phasing out the use of pesticides, a shift towards extensive livestock production and a decrease in crop yields. Additionally, certain agricultural practices which provide important environmental co-benefits, such as biodiversity restoration, soil improvement or water management, are simulated to measure their respective impact on climate. The considered agricultural practices include hedges on cropland and grassland, no or low tillage and use of cover crops, as suggested by [Aertsens et al.\(2013\)](#). The potential role of agroforestry is also explored and based on the estimate from [Kay et al. \(2019\)](#).

Two additional constraints to the existing scenario were imposed in the EEB pathway: maintenance of the current grassland and cropland area, and rewetting of organic soils under agricultural management (in other words, restoration of peatlands).

The maintenance of grasslands and croplands reflects the debate around two schools of thought: a land sharing approach – which aims to integrate the provision of environmental goods within farming systems, but may reduce agricultural yield – and, a land sparing approach – which aims to increase agricultural yields in order to reduce the demand for farmland. The land sparing approach goes beyond the farming system and argues that the land sharing approach would require a larger area of farmland to meet food production targets. It suggests, instead increasing yield on already converted lands, thereby reducing the pressure on natural habitat by ultimately returning former farmland back to natural area. As highlighted by [Meessen et al, 2020](#), the current focus of EU climate policy in agriculture – relying almost exclusively on promises stemming from technological solutions such as precision farming, nitrification inhibitors, and feeding strategies

⁵ The ARISE model was made initially available as part of the [EU Calculator's transition pathway explorer](#) and it is currently being developed as a separate independent and sectoral model (2021. Baudry G., R. Slade. *Designing a sustainable future for the European bioenergy system by 2050: The agri-food system calculator*. Presentation at the [29th EUBCE conference](#).) We therefore thank the authors (Imperial College London) for providing us with the early access model. ARISE will be publicly available this fall 2021

– will provide limited co-benefit and will not improve farmers' resilience in the face of more frequent extreme weather events. Ultimately, technofix solutions due to their high investment may lock in farmers in their production model. Therefore, EEB pathway showcases that the transition to agroecology of the EU farming sector and the maintenance of grasslands and croplands accompanied by a change of consumer diet will meet the food needs of European citizens and therefore highly limit carbon leakage to third countries. Moreover, it will provide other positive improvement such as resilience and room for farmers to adapt to extreme weather events.

As highlighted by the [European Court of Auditor \(2021\)](#), cultivated organic soil, otherwise known as drained peatlands, while covering only 2% of agricultural land, are responsible for 20% of the EU-27 agricultural emission. [Tanneberger et al. \(2021\)](#) explored two potential pathways for rewetting peatland in Germany and showed that little economic harm is done given the potential climate and environmental benefits. Conservatively, we assume that the restoration of cultivated organic soil will lead to zero GHG emissions, however, well managed, they could even act as a carbon sink⁶.

In EEB pathway, the shift towards no synthetic inputs, the maintenance of grasslands and croplands with a high proportion of agro-ecological infrastructure (such as hedges) thus makes it possible to directly address the restoration of biodiversity, the quality of natural resources, and a reduction of greenhouse gas emissions.

Food consumption assumptions

Achieving global food security within planetary boundaries could feed 10 billion people if our global food system transitions towards sustainability ([Gerten et al., 2020](#); [Springmann et al., 2018](#)). However, income growth and human development have shown an increase of calory intake beyond our biophysical requirements, notably from animal products. The prospect of maintaining our current diet along with an increase of animal product consumption in the rest of world will lead to an increase of emission from the agricultural sector and further transgress planet boundaries (see [Costa et al., 2021](#)).

Baudry et al. (2021)⁷ found the impact of dietary changes to be crucial to achieve full mitigation potential of our food system. "If the policy response was blind or passive to the evolution of the lifestyle patterns, the sustainability of the food and agriculture system would be sub-optimal at best. And it would neither lead to, nor achieve significant GHG mitigation, nor lead to exploit the land carbon sequestration potential in the worst case."

EEB pathway assumes an ambitious level of dietary changes as proposed by [Costa et al., 2021](#) in the [EU calculator](#). We impose the widespread adoption of a healthy diet following the global dietary guidelines based on [Springmann et al., \(2018\)](#). This means that meat consumption is maintained at 80g per day, of which 28g per day is red meat. Sugars and sweeteners are kept at below 5% of the calorie intake; and fruits and vegetable consumption to be over 600g/day. Figure 1. EU 27 change of diet illustrates the dietary changes at EU level, separated by main food category.

⁶ <https://onlinelibrary.wiley.com/doi/full/10.1002/adsu.202000146>

⁷ Baudry G. et al (2021). " Exploring the future of the European agriculture systems between food, energy and greenhouse gas emissions: the AgRI-food SystEm interactive model (ARISE)" presentation at the [SWEEET](#) seminar on the 8th of June 2021.

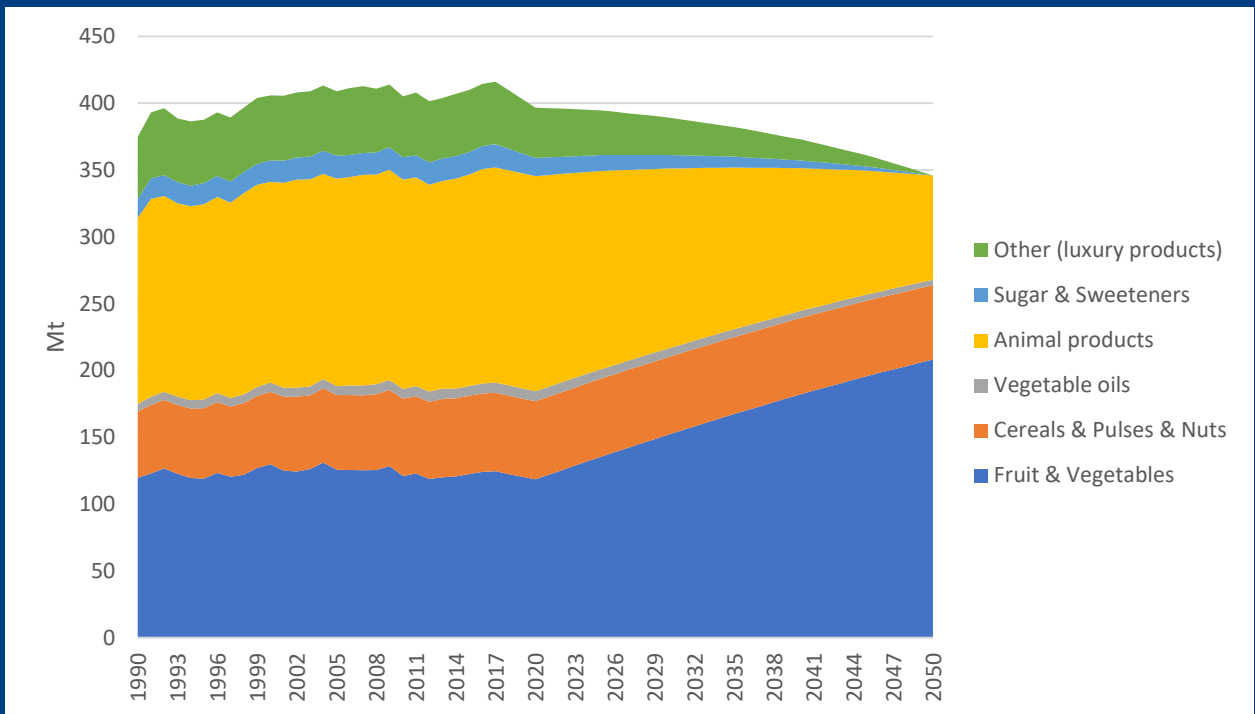


Figure 1. Total yearly EU 27 food consumption

Food waste assumptions

The FAO report (2017) on the food and agriculture recalled that given the hundreds of millions of people suffering from hunger, the fact that a third of food is wasted globally is unacceptable. Drastically reducing food waste and loss is not only an environmental matter but a key lever to achieving global food security in the face of a growing population.

In the EU's 2050 long-term strategy, "A Clean Planet for all: A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy", the halving of food waste by all EU Member States is proposed (LTS 2018).

EEB pathway conservatively assumes that the EU27 would have 50% lower food waste at the consumer level in 2050 compared to today, thus assuming the SDG target of 50% reduction by 2030 is reached but no additional progress is made thereafter. This translates to an average food waste for EU27 of 130kcal/capita/day. Post-harvest wastes and losses are also assumed to decrease by about 50% by 2050, evaluated and adapted after the FAO-2050 "towards sustainability" pathway.

EEB pathways

Figure 2 shows the GHG emission reduction for the agriculture covering non-CO₂ emissions, energy use and related land use emissions from agriculture. Orange shades reflect the reduction in emissions reduction currently reported under the 'Agriculture' UNFCCC category and addressed under the Effort Sharing Regulation (ESR). Dark green represents the emissions from organic soils. Drained organic soils emit several gases and are currently reported under the 'Agriculture' UNFCCC category for CH₄ and N₂O emissions, and under the 'Land use, land use change and forestry' (LULUCF) UNFCCC category for CO₂ emissions. In different light shades of green, we show the impact of the four agricultural practices (hedges on cropland and grassland, no or low tillage and use of cover crops). Purple and pink show emissions under the LULUCF category linked to agriculture and blue is the emission link to energy use by the agricultural sector counter under the 'Energy' UNFCCC category.

Figure 2 reflects the complexity in imagining a future for the agricultural sector as emissions are split over different UNFCCC reporting category, three different gases are emitted and the shift to agroecological practices reconnect land use and agricultural production. Additionally, the adoption from 2018 onward of the four agricultural climate practices display an S-shaped curve. Plotting the performance against the efforts (e.g. money, policy) invested most often yields an S-shaped curve for learning and adopting new practices or technologies. Thus, we assumed the widespread adoption of the agroecological standards in the EU to follow an S-shaped curve starting from new policy incentives within the CAP or other policy instruments.

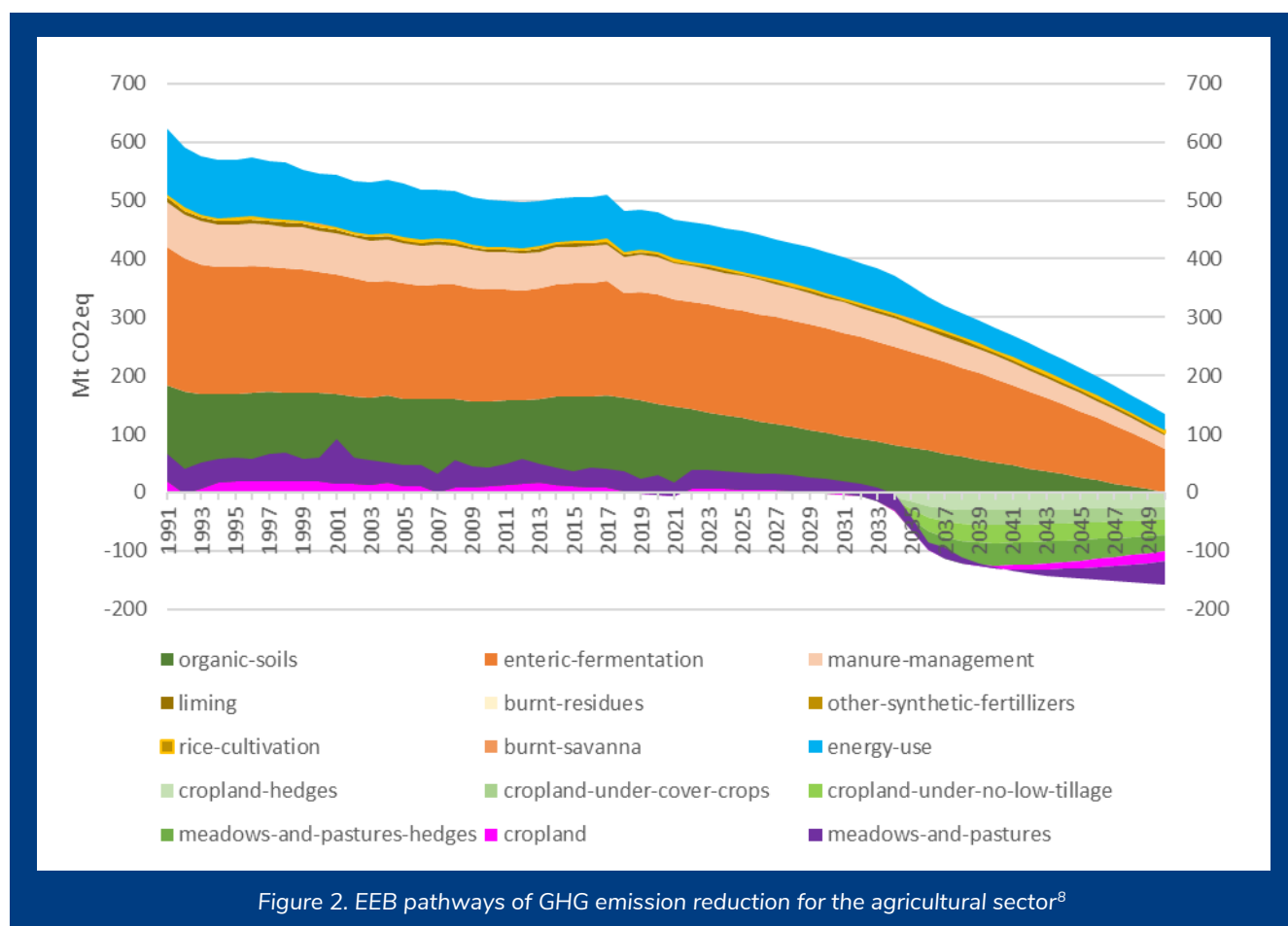


Figure 2. EEB pathways of GHG emission reduction for the agricultural sector⁸

⁸ Figure 1 displays GHG emission reduction in the agricultural sector independently from the UNFCCC category.

Figure 3 intends to display the potential of agroforestry in Europe. Contrary to [Kay et al. \(2019\)](#), from which we derive agroforestry carbon sequestration potential, in our simulation agroforestry is applied to all agricultural land and not only to areas who could benefit the most. The intention is not to provide the most accurate results but rather to illustrate the potential of agroforestry. If agroforestry was deployed to all agricultural land, it could potentially sequester about 1400 Mt CO₂ by 2050. Agroforestry not only offers an immense climate potential benefit, but also other environmental benefits such as increased natural habitat, improved soil fertility, reduced soil erosion and improved water retention (see [Tarralba et al., 2016](#)).

Without counting on agroforestry, the **agriculture and related land-use emissions could reach net-zero by 2050**. Agricultural emissions (as reported in the UNFCCC) **could be reduced to 110 Mt CO₂eq by 2050**, which represents a 75% cut in GHG emissions by compared to 2005 levels and **agricultural land-use emissions (cropland & grassland) would transform from a net emitter to a sink of -150 Mt CO₂eq by 2050**. On a 2030 horizon, this would mean cutting agricultural emissions by 21% compared to 2005 levels and bring agriculture-related land use emissions down to **net-zero**. If governments decided to incentivize the adoption of agroforestry, agricultural and related land use emissions could go easily beyond net-zero emissions. [Kay et al. \(2019\)](#) shows that implementing agroforestry in hotspots of environmental pressures, representing 8.9% of total EU farmland, could sequester up to 43% of EU agricultural GHG emissions. The *EEB pathway* explores the potential of agroforestry base on the same estimate than the aforementioned study but covering all EU farmland. Potentially, agroforestry could generate a sink of -1400Mt CO₂.

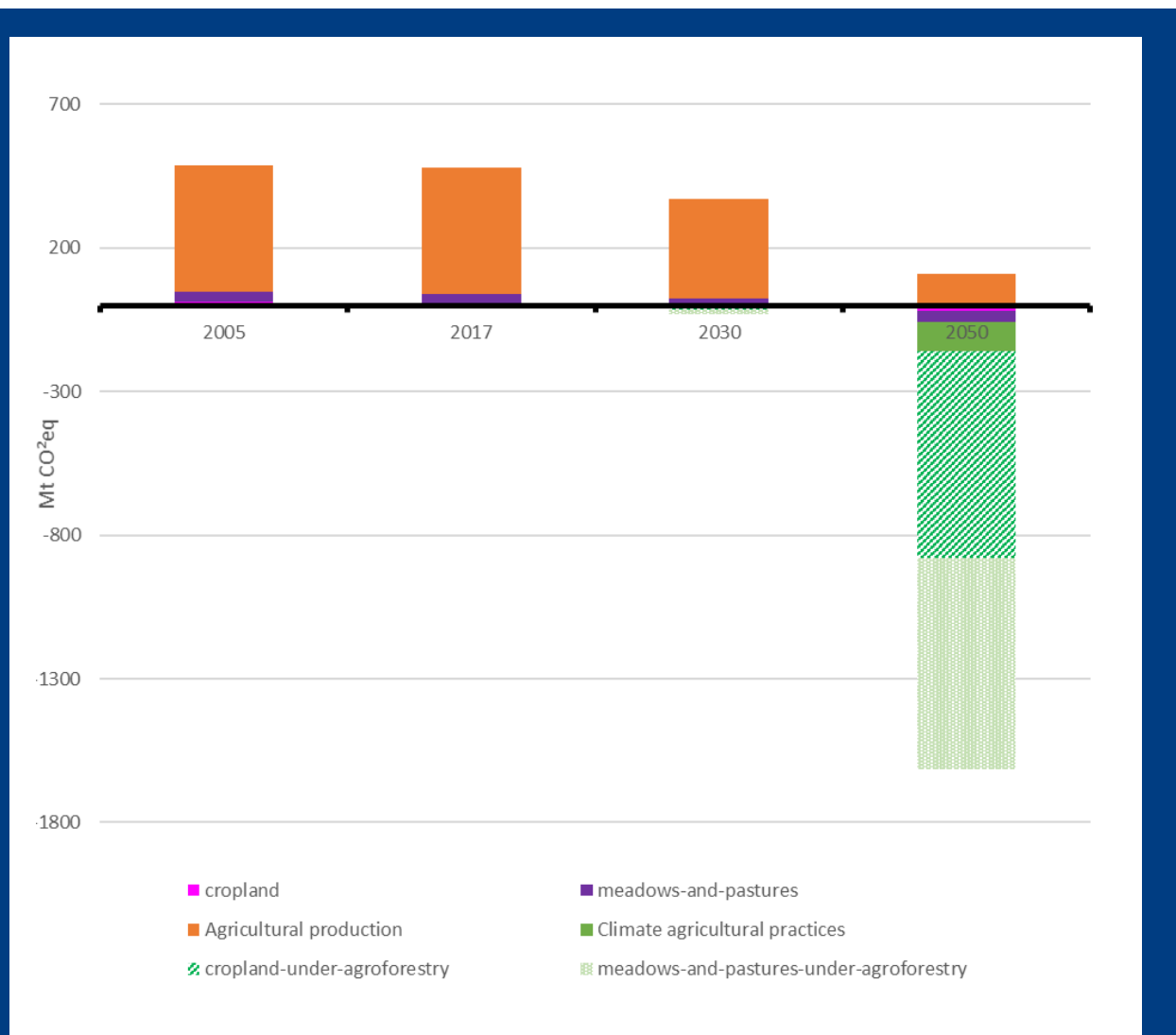


Figure 3. GHG emissions reduction for agriculture and agricultural land emission including the sink potential of agroforestry

Impact of EEB pathway

As explained above, EEB pathway intends to maintain agricultural land, and therefore no significant land use changes occur. Nevertheless, as the number of consumers adopting a more sustainable diet grow over the year, as long as the number of farmers adopting agroecology; EEB pathway would allow a reduction of European farmland of about 20% to the profit of forestry, while maintaining European food self-sufficiency.

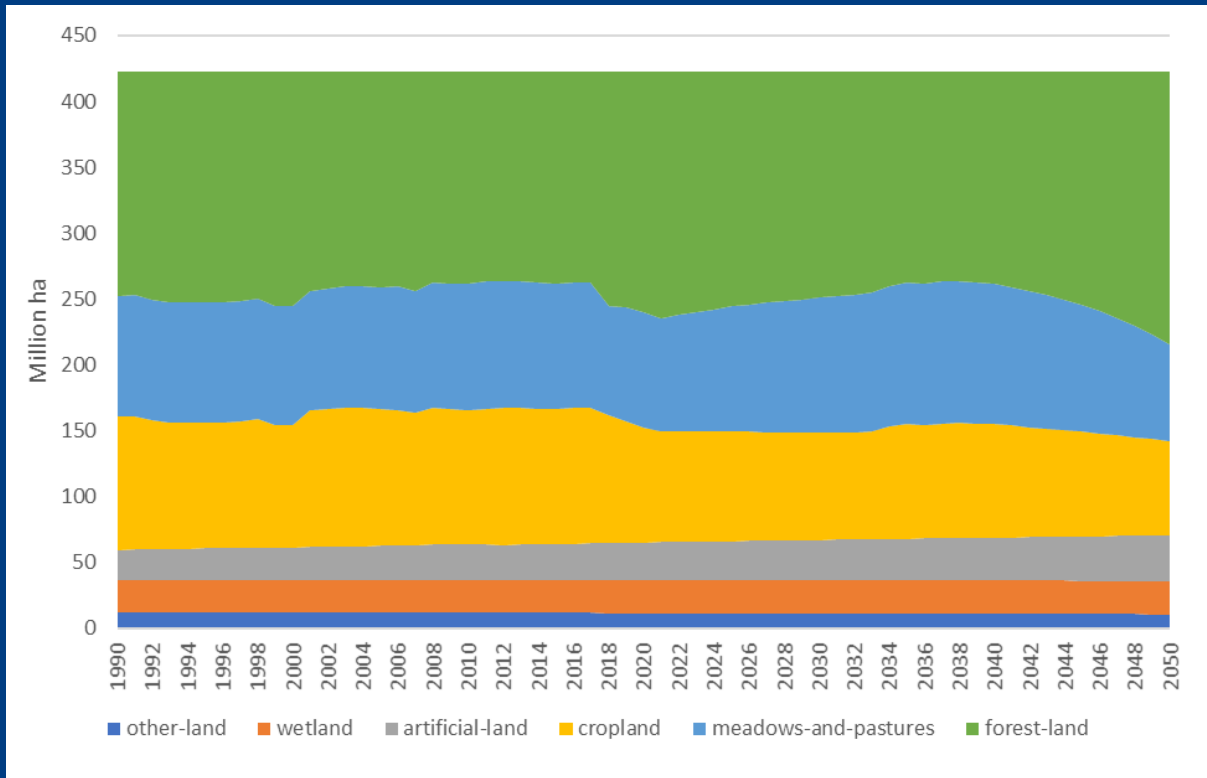


Figure 4. Land use change

The impact on livestock production is the most significant (see Figure 5). The shift to a healthier diet induces a drastic reduction of livestock demand with a reduced knock-on effect on feed production from cropland (see Figure 6). The shift to agroecology induces an extensification of livestock production with an EU domestic feed supply. Therefore, former feed imports are replaced by an EU domestic feed supply. The shift of diet and the transition towards agroecology will also solve the [EU major deficit in plant proteins](#). The expansion of bioenergy reflects the business as usual since the scope of the study is limited to the food system.

The impact on irrigated land demands remains unchanged compared to current demand (see Figure 7). However, the water allocation between crops changes significantly. The irrigated areas under oilseed, vegetable, and fruit increase, while irrigated areas for cereals decline.

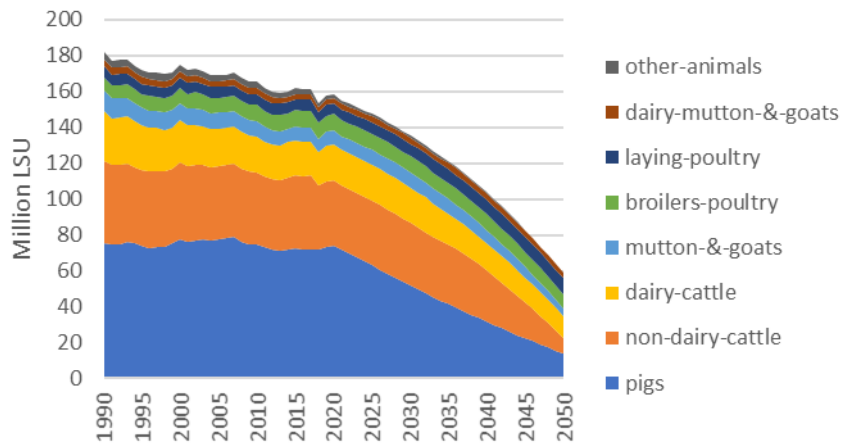


Figure 5. Impact on livestock production

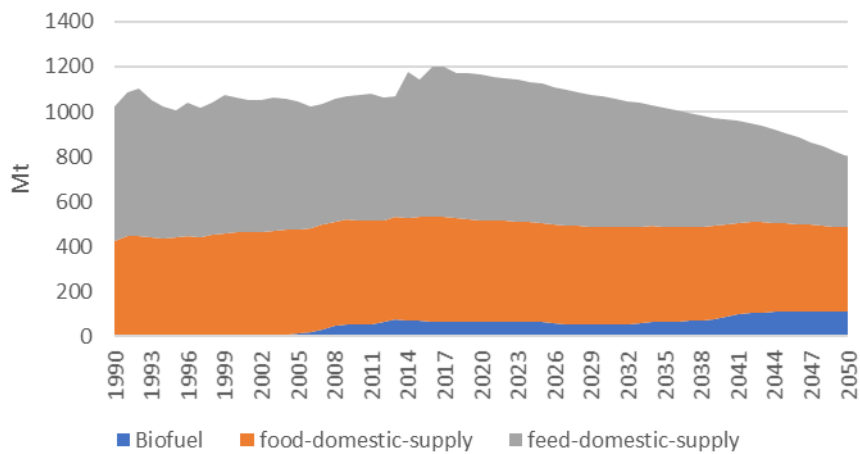


Figure 6. Impact on crop use

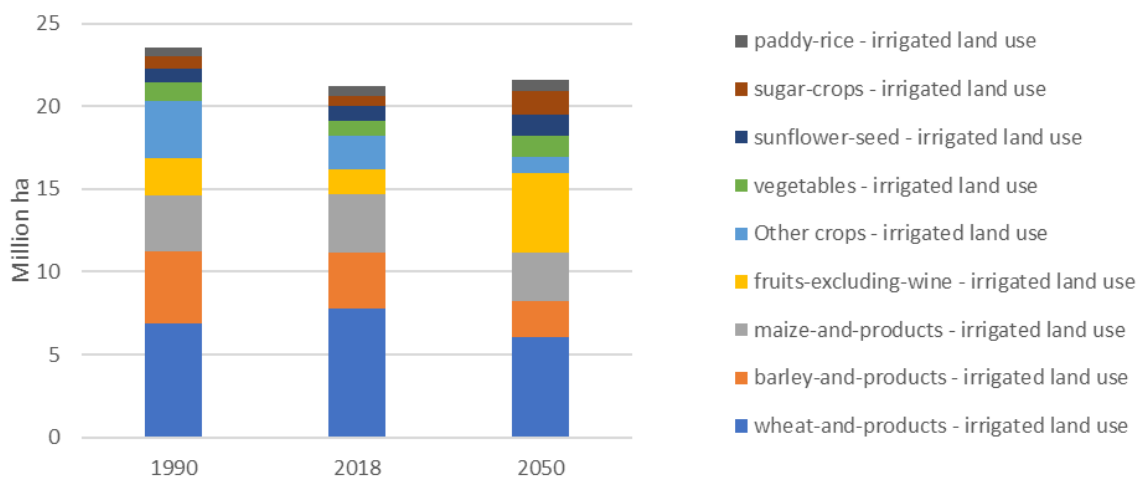


Figure 7. Impact on irrigated land demands

One of the main counter arguments opposing the shift to agroecology, is the assumption that the EU must increase food production to answer global food security. In short, the argument goes that a European shift to agroecology will starve the most vulnerable countries. However, there is increasing scientific evidence that agroecology could feed the world by 2050⁹. Ensuring food security, particularly in light of ongoing pandemic and current and future crises are important objectives to which European agriculture should contribute to, but must do so within its environmental limits. shows that the EEB pathway ensures self-sufficiency in cereals, oilseed, protein crops and vegetable and fruits. Additionally, EU27 could increase its exporting capacity in ruminant products. The shift to a flexitarian diet and the maintenance of grassland permit the EU 27 to produce more cattle that what is consumed on the EU27 domestic market.

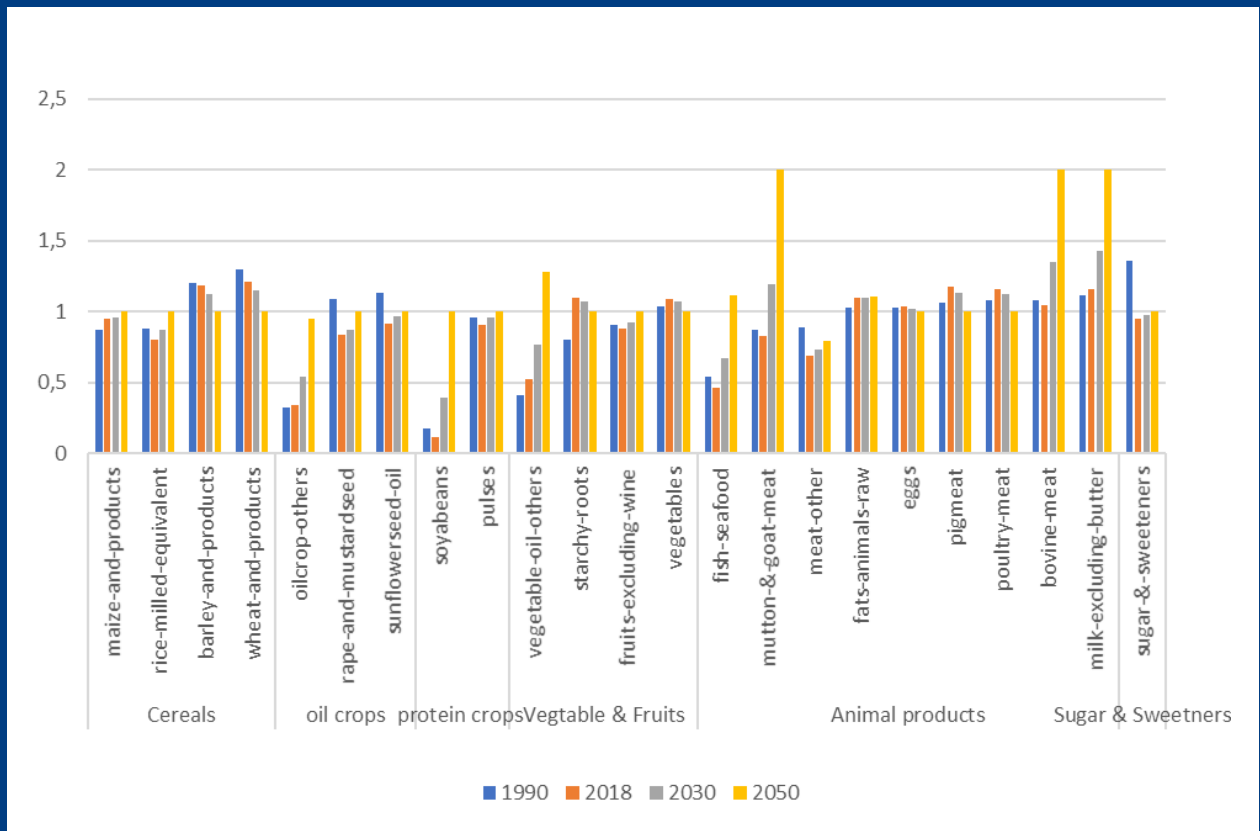


Figure 8. Self-sufficiency ratio in main agricultural products

⁹<https://www.theguardian.com/global-development-professionals-network/2016/oct/09/agroecological-farming-feed-world-africa>
<https://www.sciencedirect.com/science/article/abs/pii/S221191242100050X>
<https://www.unep.org/news-and-stories/story/agroecology-contribution-food-security>

Conclusion

The EEB pathway used in this study explores the technical feasibility to reach net-zero emissions for agriculture by mainstreaming agroecology along with a shift towards a healthier and flexitarian diet. The key results highlight that **agriculture and related land-use emissions can meet a net-zero emission target by 2050**. Agricultural emissions can be reduced to 110 Mt CO₂eq by 2050, representing a 75% cut in GHG emissions by 2050 from 2005 levels and that **agricultural-related land use emissions (cropland & grassland) would transform from being a net emitter to a sink of -150 Mt CO₂eq**. On a 2030 horizon, this would mean cutting agricultural emissions by 21% and bring agriculture-related land use emissions down to net-zero. Importantly, agroforestry could play a decisive role in meeting the Paris agreement target.

The transition toward agroecology takes full account of the interdependency between environmental and climate dimensions. While this study does not quantify other positive environment externalities, simple measures such as growing hedges will certainly benefit via creating new natural habitats.

In light of the recent [IPCC leak](#), urgent political action is needed to alleviate the food sector from social and economic barriers in order to achieve climate neutrality, from the farm to the fork. Policymakers need to provide a clear signal to farmers, and all public and private financing must be climate and environment proof. Sustainable diets must become the default and easy choice for consumers.

Continuing with business-as-usual will ultimately undermine the health of the ecosystem on which a productive and profitable agriculture depends. Farmers face the prospect of ever-increasing expenditure on inputs to substitute for eroded soils, the over-exploitation of water resources, and the loss of pollinators, to tackle the increased risk of pests and diseases, and to cope with more variable and extreme weather events due to climate change.



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