



How can sustainable farming in the EU benefit from plant-based and novel sources of protein?

EU food systems are facing unprecedented challenges. Increasing their resilience and sustainability will require changes in production methods accompanied by a shift towards more plant-based foods in European diets and reduced livestock production.

This policy brief, informed by consultations and workshops with stakeholders¹, outlines the main benefits and concerns surrounding a shift towards plant-based diets and further production and consumption of novel sources of proteins. It explores the role of EU policy in maximising the benefits and responding to the identified concerns, and specifically, in supporting further uptake of sustainable farming practices, such as agroecology.

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EU food systems are driving biodiversity loss, environmental pollution and are responsible for almost one-third (31%²) of the total greenhouse gas emissions in the EU ([EP 2023](#)). They also contribute to rising levels of cardiovascular disease, cancer and diabetes ([FAO 2023](#)).

Increasing the resilience of EU's food systems will require action both on the production and consumption sides. Agriculture has been identified

¹ Stakeholders included farmer and land manager organisations, environmental and consumer NGOs, research institutes, think tanks and regional authorities.

² Including production, processing, distribution, consumption and food waste disposal.

as one of the sectors most sensitive to climate change risks, with droughts, floods and heat waves expected to increase in frequency and intensity over the coming decades. At the same time, agriculture is one of the main drivers of biodiversity loss ([IPBES 2019](#)) with agricultural activities being responsible for environmental pollution and representing around 13% of EU's total GHG emissions ([Bognar et al 2023](#)). Of these, two-thirds of agriculture's GHG emissions in the EU derive from livestock production. The livestock sector is addressing its emissions through improvements in breeding and feeding, but these interventions are not supporting the step-change required on the road to 2050 ([UNEP 2023](#)). Reducing the size of the EU livestock sector in the near future is widely regarded by scientists and researchers as necessary to achieve both climate, biodiversity and pollution-related targets ([Poux and Aubert 2018](#), [Levasseur 2023](#)). However, livestock in sustainably managed grazing systems can have substantial benefits including maintaining socio-cultural landscapes and traditions, habitats for biodiversity and contributing to economies in rural areas ([Röös et al 2016](#)).

Continuing to produce in a business-as-usual scenario will prove increasingly difficult for the sector in the coming decades due to the impacts of climate change. Heat stress, forage quality, water scarcity and disease are challenging the maintenance of the current level of production and the quality of animal-sourced foods, potentially increasing costs ([Godde et al 2021](#)). Improved animal welfare standards can also result in higher costs per unit for livestock farmers in the future ([Fernandes et al 2021](#)).

Current levels of livestock production go hand in hand with patterns of consumption in the EU. EU diets are not aligned with the current dietary recommendations set by Member States and projections from the European Commission show that substantial reductions in total meat and dairy consumption are not expected to take place in the coming decade ([EC 2023](#)). EU citizens consume on average 67 kg of meat annually (47% of which is pigmeat, 35% poultry), while recommendations by Member States average about 23 kg of meat per person annually ([Buckwell and Nadeu 2018](#)), with gender and age differences in meat consumption ([Verkuijl et al 2022](#)). In addition, many Member States have recently revised their dietary guidelines to consider environmental impacts, further reducing these numbers (e.g. Germany, Nordic countries). Increasing the share of plant-based foods in diets can lead to a reduction in individual and public health issues ([WHO 2021](#)).

Increasing the share of plant-based foods while reducing that of animal-sourced foods in EU diets is repeatedly mentioned as a necessary step to increase the sustainability of food systems and their contribution to climate change ([IPBES 2019](#), [IPCC 2019](#)). It is also a necessary step to switch to sustainable farming systems such as agroecology or regenerative farming in addition to reducing food waste rates ([Poux and Aubert 2018](#)). Agroecological systems, for instance, do not rely on synthetic inputs (i.e. fertilisers, plant protection products), improve soil health, and reduce plant proteins for animal feed while maintaining extensive grassland systems. This would allow jointly addressing the challenges of mitigating and adapting to climate change, protecting biodiversity, reducing environmental pollution and ensuring a sustainable food system in the EU. Evidence shows that a food system largely relying on plant-based diets could result in increased food security ([Springmann et al. 2018](#)).

Alternatives to conventional meat and dairy

In high-income countries, a share of the population is reducing meat and dairy intake by following flexitarian, vegetarian or vegan diets as a result of animal welfare concerns, environmental or climate concerns or based on health advice ([Verkuijl et al. 2022](#)). The number of people opting to reduce or eliminate animal-sourced foods from their diets is slowly increasing³. Replacing conventional animal-sourced foods by alternatives that resemble them and can be cooked in similar ways is being proposed as a way to facilitate a shift towards plant-based and reduced animal-sourced foods in diets, specifically in affluent countries.

The terminology is still not fully clear when talking about alternatives to traditional sources of animal proteins from the livestock sector and stakeholders use different combinations of words. This brief refers to two main groups, plant-based proteins and novel sources of protein, as defined below.

- **Plant-based proteins:** a generic term used to define proteins originating from plants (e.g. pulses, nuts). Pulses are the number one source of plant-based proteins. They can also be processed to obtain products that can replace meat in many recipes, and which have existed for a long time (e.g. seitan, tofu, tempeh).
- **Novel sources of protein** ('alternative proteins'): category of substitutes for traditional animal-derived proteins. According to the UNEP they include novel plant-based foods as well as other innovative protein sources (fermented proteins, insect-based protein and cultured meat) ([UNEP 2023](#)).

Novel sources of protein

The development of novel foods which are rich in proteins has accelerated over the past decades. While not all are livestock-free, they do require reduced livestock numbers for their production ([UNEP 2023](#)). Below we present three categories of novel sources of protein and discuss some of the environmental, health and socioeconomic benefits and impacts (other novel sources of protein including insect or algae novel foods are not discussed).

³ According to a [survey](#) from the Smart Protein EU-funded project 51% of EU meat eaters have reported reducing their annual meat intake.

Novel sources of protein (UNEP 2023)

Novel plant-based products combine plant protein with additives to replicate the sensorial experience of animal products. Multiple proteins can be used in these products, generally pulses.

Fermentation-derived products using biomass or precision fermentation. While the former uses microorganisms to make protein-rich food (with microorganisms being the primary ingredient), the latter uses microorganisms to produce specific functional ingredients.

Cultivated meat is directly produced from animal cells that can be obtained by biopsy from live or slaughtered animal muscles. These cells are then multiplied in vitro or in bioreactors into muscles, fat, and other types of cells in order to achieve properties similar to conventional meat products.

These novel alternatives are found in different stages of development and face challenges for scaling up. These include expanding production capacity, infrastructure limitations, legislative barriers, and reducing input and energy use ([Hefferon et al. 2023](#)). While novel plant-based foods have already been available for a few decades, the commercialisation of some of the novel sources of protein, such as cultivated meat is expected to take some time to be commercialised in the EU⁴. The production of cultivated meat is currently not financially viable and requires high amounts of energy, whether its production costs will be brought down to be competitive in relation to animal-sourced foods, or sophisticated novel plant-based alternatives that substitute meat, remains uncertain ([Hefferon et al. 2023](#)). Further upscaling and market uptake of these products, in particular of fermentation-derived products and cultivated meat will be dependent on public investment and changes in regulatory frameworks ([Collas and Benton 2024](#)).

Environmental, health and socioeconomic benefits and impacts

Environmental sustainability

Novel sources of protein have significant potential to reduce the environmental footprint of protein production compared to conventional animal-based foods. These alternatives

⁴ Even globally, as of June 2023, only cultivated chicken was available commercially and only sold by two companies, in the USA and Singapore (UNEP 2023)

generally require less land and inputs, resulting in lower greenhouse gas (GHG) emissions and pollution ([UNEP 2023](#)). The potential gains, however, are contingent on the specific product and the farming system it is compared to. If increased uptake of these proteins goes hand in hand with a reduction of livestock production, large amounts of land could be freed up. Displacing one sixth of meat and dairy with plant-based and novel sources of proteins could result in the release of 21% of domestic farmed area in the EU and 9% of overseas area used for feed imports ([Collas and Benton 2024](#)). This has been highlighted as an opportunity to repurpose this land for nature restoration or to expand less intensive forms of farming such as agroecology ([Collas and Benton 2024](#), [UNEP 2023](#)).

Replacing meat and dairy consumption with unprocessed plant-based foods, such as legumes, results in savings in land use and can also enhance the productivity of arable farms by reducing the need for external inputs ([Porto Costa et al 2023](#)). In the case of water use, the footprints of novel sources of protein and traditional animal-sourced foods are highly variable according to the product ([Potter et al 2020](#)). Finally, the impacts of large-scale production processes, such as for the energy-intensive cultivated meat, remain unknown and their impact will also depend on the energy sources used; the use of renewable energy could provide substantial reductions in GHG emissions compared to traditional livestock farming. Life cycle assessments suggest that in the case of plant-based beef replacements, reductions could be around 30-50% ([Saget et al 2021](#)), while cultivated meat could cut emissions by up to 90% if produced with renewable energy ([Sinke et al 2023](#)).

An opportunity for agroecology?

An agroecological transition, including mixed farming systems, is central to the Farm to Fork Strategy of the European Green Deal and is aligned with the Biodiversity Strategy and the Sustainable Development Goals. It has also been highlighted by research institutes, stakeholders and farming groups as a path towards increased food system resilience and sustainability (e.g. [Baldock and Bradley 2023](#), [Poux and Aubert 2018](#)).

Agroecology and technological solutions for food production, such as the development of novel sources of protein, can represent contrasting food system views ([Pimbert 2022](#)). However, there are two main ways through which the novel sources of protein sector could support further uptake of agroecological practices: i) freeing up land which could then be used to expand agroecological systems, and ii) using crops cultivated using agroecological practices as input to the processed products. The former requires that increased uptake of plant-based foods and novel sources of protein will reduce demand for land for the production of feed. It also implies that at least some of the freed-up land is used to expand agroecological systems. Given the rising competition for land globally ([King et al 2023](#)), instruments and policies will be needed to encourage uptake of sustainable farming, including

mixed farming systems where desirable. In the case of the sourcing of the inputs, the contribution of agroecologically sourced crops will depend on the protein source and inputs and ingredients required to upscale the production of specific novel sources of protein.

Health, nutrition and food availability

Plant-based foods offer several health benefits when compared to animal-sourced foods, including lower saturated fats, no cholesterol, and higher fibre levels, which can reduce chronic diseases ([WHO 2021](#)). Novel sources of proteins can potentially also offer similar health benefits, in addition to reducing the risks of zoonoses and antimicrobial resistance, major global concerns highlighted by the World Health Organisation. Ensuring nutritional completeness in these products and the digestibility, nutrient profile and bioavailability of micronutrients is still being researched for these products, in particular after undergoing processing methods ([Duque-Estrada and Petersen 2023](#)).

While overall plant-based proteins can reduce the risk of cardiovascular diseases ([Crimarco et al 2020](#)), the nutritional profile and the level of food processing must be taken into account to understand the health implications of the novel sources of proteins, as well as the characteristics and level of processing of the foods they replace. Some replacements are highly processed and may contain high levels of salt and additives. For example, meat substitutes such as nuggets or sausages made from plants which have been deconstructed into chemical components, are considered ultra-processed foods and can increase the risk of cardiovascular diseases if replacing less processed foods in diets ([Rauber et al 2024](#)).

In terms of the availability of the products, infrastructure and supply chain issues can hinder accessibility and affordability. Price, taste, healthiness, and convenience are primary drivers of food choice, and alternatives will try to mimic traditional animal-sourced products in appearance, taste, and cooking experience to be widely accepted without lifestyle changes ([Bryant 2022](#)). Increased consumer awareness about diet impacts on health and the environment is growing, but overcoming resistance to change is crucial, and there can be issues with consumer acceptance of some of these products ([Aschemann-Witzel et al 2020](#)).

Social and economic impacts

Livestock production plays a central role in EU agriculture and while novel sources of proteins can provide opportunities for farmers—as input providers, by producing value-added products or by partnering with tech companies—they can also create challenges. There is a concern about the impact of these products on farmers which is acknowledged both within and outside the agricultural sector. Farmer responses to the alternatives are mixed and tend to see more barriers to accepting these products than non-farmers, but they acknowledge

the many benefits that the alternative products can bring to the environment, health, safety and animal welfare ([Crawshaw and Piazza 2023](#)).

Additionally, some stakeholders have raised concerns about the alignment of novel sources of protein with the existing, mostly industrialised model of protein production, specifically in relation to technology access and ownership and potential market concentration ([IPES-Food 2022](#)). Some of the large food corporates in the meat sector have also entered the market for novel sources of protein in recent years, although the share of their investments compared to those in the mainstream livestock sector remain low ([Mylan et al 2023](#)).

A better understanding of the implications of increased uptake of novel sources of protein and reduced livestock production is overall needed to put in place policies that maximise benefits and mitigate impacts. This should include estimating the implications of a reduced livestock sector on employment in specialised regions or its impact on the supply chains of by-products from the livestock industry (e.g. leather). Assessments conducted for the displacement of specific animal-sourced products would be useful to frame the debate and offer solutions to those most affected.

Priorities for policy action

Action is needed to reduce GHG emissions from agriculture, address environmental challenges, and halt and reverse biodiversity loss. Doing this on a large scale and in the time frame of the coming decades will require aligning changes from farm to fork. Increased production and consumption of plant-based proteins and novel sources of protein, particularly in affluent parts of the world such as the EU, could offer benefits on multiple fronts. However, as outlined above, there is not an automatic link between the development of these novel sources of protein and the upscaling of sustainable farming practices in the EU. Neither is there a guarantee that these products will reduce livestock production. There are also potential impacts on sustainable livestock farms that will need to be mitigated.

There are therefore a range of roles for policy (in addition to research and private sector investments) to steer an increase in plant-based proteins for food consumption and the development of novel sources of protein towards the most socially and environmentally beneficial outcomes. A suitable policy mix is therefore needed that:

- a) Supports sustainable and agroecological farming systems, including extensive and high nature value livestock;
- b) Addresses unsustainable livestock systems, and provides just transition support;
- c) Contributes to increasing demand and take up of more plant-based diets in the EU and novel sources of proteins;

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- d) Addresses the development of the most promising novel sources of proteins from an environmental, climate, health and social perspective.

Below we elaborate further on the first three areas for policy action in relation to specific EU policies. In relation to the fourth one, several research and innovation projects have addressed the role of public R&I to support socially beneficial development of novel sources of proteins, including the need for open-access technologies and decentralised deployment. The development of the novel sources of protein sector will also require changes in the regulatory framework such as those related to definitions of products and labelling requirements.

- **Incentivising sustainable farming systems and protein diversification**

The CAP can play a central role in enabling farmers to transition towards sustainable farming systems by providing them with tools to implement sustainable farming practices in their land, aligned with increased protein diversification for direct food consumption. More than half of EU countries have adopted at least one eco-scheme associated to agroecological principles ([Krishna et al 2023](#)). These include crop rotations with leguminous crops, mixed cropping systems, use of cover crops and catch crops as well as support for low-intensity grass-based livestock systems. However, the level of requirements for some of the interventions can lack the ambition to make a substantial impact on climate, resource use or biodiversity ([Midler et al 2023](#)).

In addition to farming practices, the CAP's rural development fund can provide support to increase processing capacity and market barriers for some of these products including legumes and other minor crops. Certain CAP interventions contribute to maintaining livestock production in High Nature Value Areas and rural development funds can support the economic viability and business development of sustainable livestock operations, for example through aid for the processing of artisanal products. CAP spending should therefore support the economic viability of sustainable forms of livestock farming, including mixed farming systems and those respecting the carrying capacity of the land. Rural development aid can also support the processing and marketing of value-added livestock products, which can contribute to the economic viability of smaller-scale, more artisanal livestock farms. These types of measures are highly valued by farmers and are key instruments to support changes in production ([Linares Quero et al 2022](#)). Next to these, access to knowledge, education and advisory services that support less conventional production methods are still a bottleneck for many farmers. The LEADER⁵ approach in the CAP could play an important role in filling these knowledge gaps and building the necessary supply chains.

⁵ Member States have to allocate 5% of their EAFRD budget to this measure which aims to bottom-up approaches by local actors by promoting cooperation between actors, networking, engagement or experimentation.

- **Addressing unsustainable livestock systems and just transition support**

About 80% of the CAP budget is currently supporting the livestock sector, with a majority of funds dedicated to feed production through land-based payments ([Kortleve et al. 2024](#)). This has supported further intensification of the sector, with more animals in lower numbers of farmers. The CAP does not currently incentivise a reduction in or limit livestock numbers despite having climate action as one of the key objectives ([ECA 2021](#)). In addition to these de-coupled direct payments, support for livestock in the CAP is also provided through coupled payments, animal welfare interventions, subsidies for investments and market measures promoting animal products.

Improved animal welfare legislation could help accelerate the shift towards de-intensifying livestock production and increasing the sustainability of the sector. In addition, a target for agriculture in the 2040 climate targets together with a more ambitious Industrial Emissions Directive could also add pressure to reducing livestock numbers and accelerating a transition towards sustainable food systems.

However, scaling down livestock production and consumption motivated by challenges related to climate change, environmental pollution, increased animal welfare standards and a shift towards less consumption of traditional animal-sourced foods could bring about important changes to livestock farmers but also other stakeholders. Engaging with and understanding which sectors, regions and communities will be most affected is crucial to providing them with transition support and, if possible, new business opportunities ([Baldock and Buckwell 2022](#)). This could be the case for some farmers, communities, workers and companies who may see livestock numbers go down or their farming operations stop.

- **Consumption side measures to promote a shift to plant-based and novel sources of proteins**

Current policies are failing to promote a shift towards sustainable food consumption ([EEA 2022](#)). A framework that encourages dietary changes and the sourcing of sustainably produced food is needed. Some priority actions could be: i) integrating agroecologically produced plant-based foods and novel sources of protein in public procurement programmes; (ii) providing consumers with nutritional information; pricing instruments to incentivise consumer change such as reduced VAT for plant-based products and those with a lower ecological footprint. In addition, supporting actions could include changes in dietary guidelines, creating public awareness of the benefits of sustainable diets and regulating advertising.

Summary and further research

A shift towards more plant-based foods in European diets, increased uptake of sustainable farming practices and a reduced livestock sector are widely regarded by researchers as necessary steps to increase the resilience and sustainability of EU food systems. Novel sources of protein could play a role in supporting these changes, but further research is needed to help address some of the current uncertainties related to the positive and negative impacts that the upscaling of novel sources of protein can have on the environment, society and the economy, as well as its potential synergies with the necessary shifts outlined above. From our discussions with stakeholders, some research needs relate to:

- The nutritional profile and health implications of novel sources of protein – and the type of foods they could replace;
- Avenues to link sustainable farming systems, such as agroecology alongside increased production of plant-based proteins and novel sources of proteins for food;
- The market segments for which the replacement of traditional animal-sourced foods by plant-based or novel sources of proteins can offer the highest environmental, climate and health benefits while preserving livestock farming systems that provide ecosystem services and high-quality products.

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