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SUMMARY

Agriculture, forestry and food in a climate neutral EU

The land use sectors as part of a sustainable food system and bioeconomy

Please cite as:

Agora Agriculture (2024): Agriculture, forestry and food in a climate neutral EU. The land use sectors as part of a sustainable food system and bioeconomy. Summary.

Full Study
The full study has appeared in English under the title: Agora Agriculture (2024): Agriculture, forestry and food in a climate neutral EU. The land use sectors as part of a sustainable food system and bioeconomy.

The study is available here: https://www.agora-agriculture.org/publications/agriculture-forestry-and-food-in-a-climate-neutral-eu.

The Annex to the study is published as a separate document and provides details about the data used, the quantitative model and the additional calculations. It is available here: https://www.agora-agriculture.org/land-use-study-annex.pdf.

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CAPRI modelling was conducted by Alexander Gocht and Torbjörn Jansson with technical support from Heinz-Peter Witzke, Davit Stepanyan, Jörg Rieger, Ferike Thom and Davide Pignotti.

Acknowledgements
We thank all persons who contributed through provision of data, analysis, intensive review or debates to this study. Among them are the members of the council of Agora Agriculture, colleagues from Agora Think Tanks, scientists from different universities and other research institutes and think tanks as well as stakeholder representatives from the agricultural, forestry and food sectors and civil society organisations.

Agora Agriculture is funded by alv Foundation, European Climate Foundation, German Federal Environmental Foundation, Porticus, Robert Bosch Stiftung, Stiftung Mercator and Umweltstiftung Michael Otto.

Preface

Dear reader,

The land use sectors – agriculture and forestry – are vital for societal well-being. They provide safe, nutritious food, and have large potential to increasingly contribute to a climate neutral economy, enhance biodiversity and environmental quality, as well as prosperity in rural areas.

While pathways to climate neutrality are well defined for many economic sectors, there is currently no integrated analysis of the potential of agriculture, forestry and food to deliver on sustainability objectives within the EU. This study contributes to closing this gap by presenting a scenario for the land use sectors as part of the food system and the bioeconomy in a climate neutral EU by mid-century. It also outlines policies that incentivise and value the contributions of agriculture and forestry to societal objectives and strengthen future-oriented land use sectors.

We developed this analysis over the past two years and engaged in intensive stakeholder dialogues with scientists, policy makers, administrators and representatives from the agricultural, forestry, food and bioeconomy sectors, as well as environmental and other civil society organisations. The constructive, solutions-oriented approach of all stakeholders involved helped shape our analysis.

We hope this study serves as a useful contribution to the discussion on the future role of agriculture and forestry as part of the food system and the bioeconomy, and we look forward to continuing the exchange.

Christine Chemnitz and Harald Grethe
Directors, Agora Agriculture

Key findings at a glance

1 **Agriculture and forestry can substantially increase their contribution to achieving climate neutrality, biodiversity protection, human health and other societal sustainability objectives.** However, this potential is hindered by an insufficient policy environment. A main roadblock for creating enabling policies has been the lack of a shared vision for the future of the land use sectors.

2 **By mid-century, agriculture and agricultural peatlands in the EU can cut their greenhouse gas emissions by 60 percent – in sharp contrast to their historically stagnating emissions.** Carbon removals can be increased in agriculture and be stabilised in forests. Biodiversity loss in agricultural landscapes can be reversed, while biomass production for the bioeconomy increases. This is possible while producing sufficient food, improving animal welfare, lowering agricultural imports and increasing agricultural exports, thereby contributing to global food security.

3 **Efficient land use and a more sustainable demand for food, feed and other biomass are the key levers for realising these sustainability potentials.** This requires economic incentives for the provision of public goods, such as carbon removals and biodiversity protection, which create opportunities for farmers and forest owners. Additionally, fair food environments for consumers can support and incentivise sustainable food consumption including more plant-rich diets and less food waste.

4 **The 2024–2029 EU legislative period is crucial, as it offers the opportunity to build an enabling policy environment.** Relevant components are an ambitious climate policy for the land use sectors, a Common Agricultural Policy that focuses on the provision of public goods, a legislative framework for sustainable food systems, an action plan for the efficient use of biomass in the bioeconomy and a European Rural Deal that supports rural areas in realising future economic opportunities.

Content

For the purpose of this summary, references and most footnotes were removed from the text.

Introduction

Agriculture and forestry – the land use sectors – are crucial for attaining key sustainability objectives to which the EU and its member states have committed themselves. These objectives range from becoming climate neutral by 2050 to protecting biodiversity and advancing social and economic well-being. Agriculture not only produces food and other raw materials but also manages landscapes, shapes ecosystems, impacts animal welfare and has the potential to contribute to carbon sequestration. In addition to wood production, forests support an extensive range of ecosystem services, including carbon sequestration and storage, the provision of habitats, the protection of biodiversity, the retention of water as well as local cooling effects. Both sectors support livelihoods and provide economic value added. Our analysis takes these societal objectives as a starting point and shows the significant potential of the land use sectors, within the context of changes in demand for food, feed and other biomass, to contribute to their achievement.

While pathways to climate neutrality are outlined for many economic sectors, there is currently no integrated analysis of the potential of agriculture and forestry to deliver on the different sustainability dimensions within the EU. With this study, we intend to contribute to closing this gap. We present a scenario for the land use sectors as part of the food system and the bioeconomy in a climate neutral EU by mid-century. This scenario shows a strong contribution to climate neutrality, healthier and more sustainable food consumption, enhanced biodiversity and increased biomass production to replace fossil carbon across the economy. At the same time, animal welfare improves, and the EU becomes a net exporter of virtual agricultural land, thereby reducing the pressure on global land resources. Although this scenario is ambitious, it can be achieved if land is used efficiently, and if the demand for food, feed and other biomass is more sustainable compared to today.

This requires an enabling policy environment that creates economic opportunities for farmers, forest owners and rural entrepreneurs, as well as fair food environments for consumers. Among others, this includes addressing the challenge that providing public goods – such as biodiversity protection and climate change mitigation – often incurs substantial costs and is typically not remunerated by the market. This presents a challenge for farmers and forest owners facing international competition. Therefore, public payments are needed to adequately remunerate the provision of public goods.

Methodology

The scenario we present in our study offers an integrated vision that considers the interactions between the land use sectors, the food system and the bioeconomy within the context of a global market for agricultural and forestry products. We outline one plausible future among many possibilities. Although other futures are conceivable, achieving results for a range of sustainability objectives simultaneously, we demonstrate the central importance of certain measures.

We set 2045 as the target date for our scenario to align with Germany's legal commitment to become climate neutral by that year. While the EU's legal target for climate neutrality is 2050, we consider the results of the 2045 scenario are also applicable to 2050, allowing an additional five years for implementation.

The outcomes presented in this study are the result of our analytical steps:

1. We analyse the current state of the land use sectors and food system, as well as the relevant EU policy context, in relation to societally agreed sustainability objectives.
2. We identify the most important levers for achieving sustainability objectives for six thematic areas, namely biomass for the bioeconomy, food demand, livestock farming, arable farming, agricultural peatlands and forests.
3. We outline a scenario in which EU agriculture and forestry – in the context of changes in the demand for food, feed and other biomass – make a significant contribution to societally agreed sustainability objectives. This scenario is largely grounded in quantitative analyses. For agricultural production and food demand, we use the Common Agricultural Policy Regionalised Impact (CAPRI) Modelling System, a global partial equilibrium model of the agricultural sector. Since CAPRI does not cover forestry, the scenario's assumptions about forest management and results are derived from additional calculations.
4. For each thematic area, we outline a set of policy options that we expect will support our scenario. We also propose five cross-cutting policy priorities for the 2024–2029 EU legislative period.

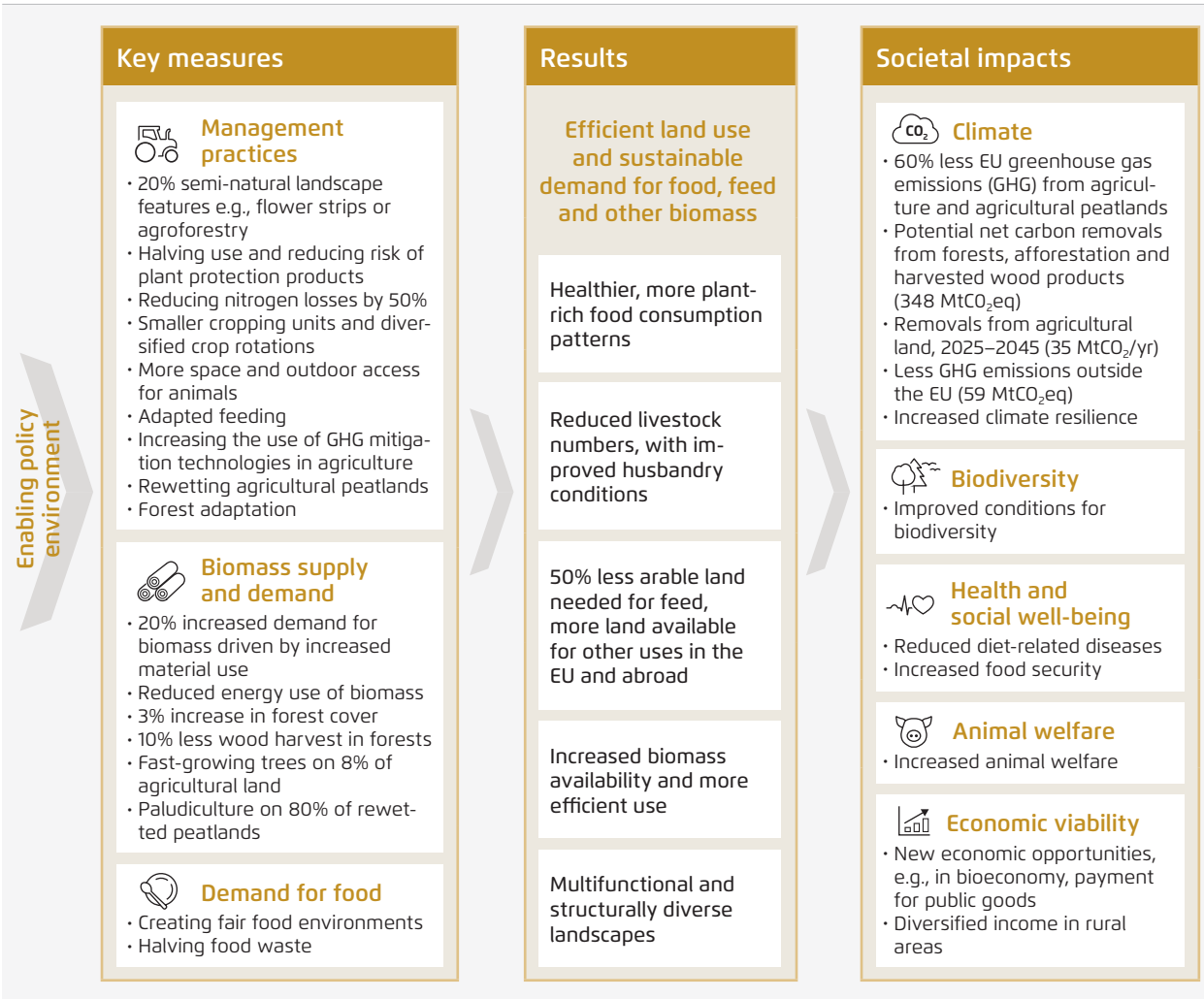
Scenario

Key elements and sustainability gains of the scenario

With our scenario, we show that agriculture and forestry, as part of the food system and the bioeconomy, can contribute substantially to climate neutrality, support healthier and more sustainable food consumption, enhance biodiversity in agricultural landscapes and forests, and produce biomass to help replace fossil carbon used throughout the economy. At the same time, animal welfare improves, and the EU becomes a net exporter of virtual agricultural land, thereby reducing the pressure on global land resources and indirectly contributing to food security. Realising such a scenario is ambitious although it is possible if land is used efficiently, and if the demand for food, feed and other biomass is more sustainable than today. This requires an enabling policy environment which provides economic opportunities for farmers, forest owners and rural entrepreneurs, as well as fair food environments for consumers.

Key measures and resulting societal impacts

→ Fig. 1



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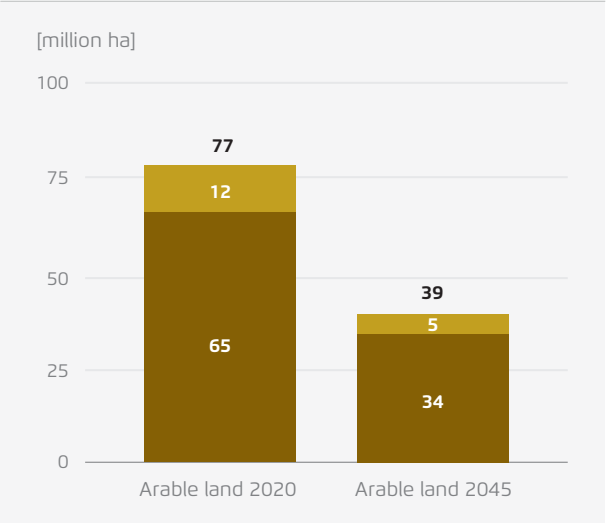
Efficient land use is one of the two main building blocks of our scenario. Land use fulfils diverse societal demands, ranging from the production of food, wood and other raw materials to the provision of habitats and other ecosystem services, such as carbon sequestration. However, land is limited in the EU, and trade-offs exist between different land use objectives. Efficient land use is important to optimise returns under any given demand scenario, to mitigate trade-offs and to deliver multiple benefits simultaneously.

A more sustainable demand for food, feed and biomass for material and energy use is the second building block of our scenario. Different consumption patterns of agricultural and forestry products are associated with different effects on climate, biodiversity and health. They also differ in their demand for land, which can either aggravate or help resolve trade-offs between land use objectives. Only the combination of efficient land use and sustainable demand enables the land use sectors to realise their full potential to contribute to societally agreed sustainability objectives. With our scenario we show one possible way of doing this.

A more sustainable demand for food and feed involves food consumption patterns that are rich in plant-based foods and lower than today in animal-based products. The reduction in the overall consumption of animal products by about 50% goes together with a decrease in livestock production in our scenario. This leads to a significant reduction in the demand for animal feed. Figure 2 shows a 48% reduction in the use of arable land for growing animal feed in the EU in 2045 compared to 2020, making land available for other uses. The demand for imported feed also declines and so too does the arable land area needed to produce that feed in other parts of the world. This reduces pressure on global land resources and can indirectly contribute to global food security, biodiversity and climate change mitigation. Such a shift in food consumption is a contribution to healthier diets while reducing negative environmental effects related to production. Food waste reduction is another component of sustainable demand. We assume a 50% reduction in food waste in our scenario, which alleviates pressure on land resources and helps reduce greenhouse gas emissions.

Global arable land used for EU feed in 2020 and 2045 → Fig. 2



Agora Agriculture based on CAPRI results and European Commission, see Annex Chapter 5

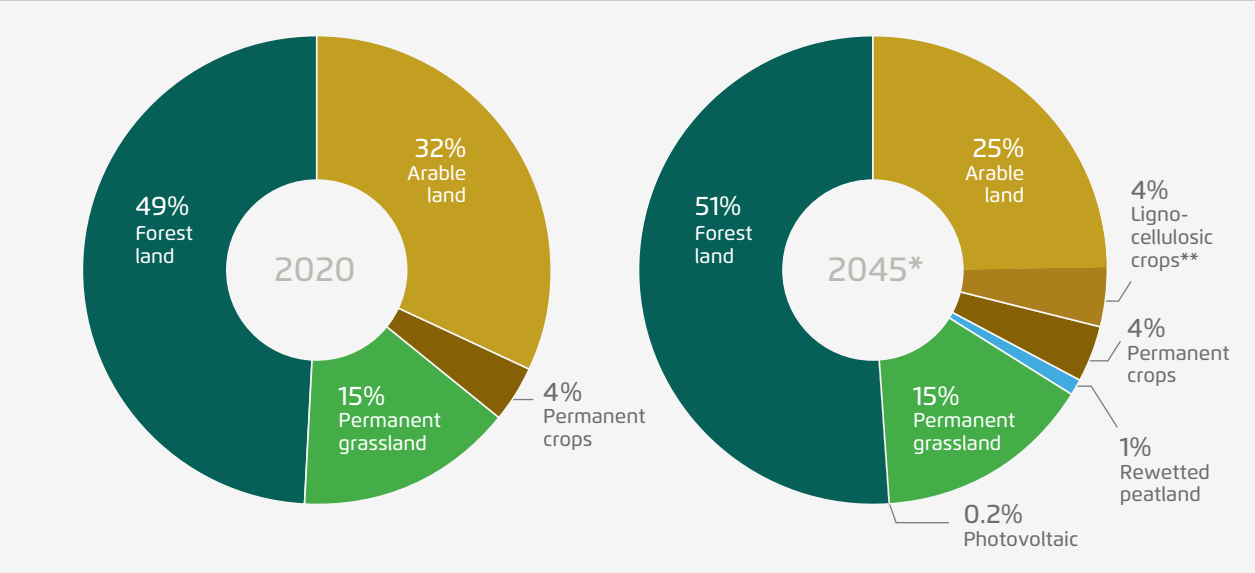
Sustainable demand is also important for biomass uses other than for food and feed. In our scenario, we project the overall demand for non-food, non-feed uses of biomass to increase by about 20% by 2045. There are two main drivers for this:

- An increase in the material use of biomass by about 70% to replace fossil feedstocks across the economy due to the economy-wide transition towards climate neutrality.
- A gradual shift away from using biomass for bioenergy production, which we assume will decrease by 15% between 2020 and 2045, as electrification becomes available for a wider range of uses.

Bioenergy requires 50 to 100 times more land per unit of energy produced than energy produced by solar and wind. In only a few cases it is an efficient

Land use in the EU agricultural and forestry sectors in 2020 and 2045

→ Fig. 3



Agora Agriculture based on CAPRI results. * due to rounding figures add up to more than 100%; ** e.g., short rotation coppices, agroforestry, miscanthus on arable land

basis for electrification, for example biogas made from agricultural residues. Likewise, we assume that first-generation liquid biofuels will be largely phased out due to more efficient alternatives, except in specific cases like heavy machinery for farming operations such as tillage and harvesting.

While the sustainable demand for food, feed and biomass is important for land use efficiency, land is still scarce, and efficiency gains are also required in crop production. We expect average crop yields to increase, driven by the uptake of improved agricultural technology, machinery, irrigation and progress in plant breeding, narrowing yield gaps across regions.

Figure 3 illustrates the distribution of land use in our scenario in 2045 compared to 2020. It shows that arable farming in the scenario changes, primarily driven by a reduced demand for feed and an increased demand for biomass. Reductions in fodder-grain production on arable land are accompanied by an increase of other crops such as lignocellulosic crops (e.g., fast-growing trees) and paludiculture[1] crops (e.g., reed or cattail) on rewetted peatlands for the bioeconomy. Though not shown in the figure, the production of vegetables on arable land increases substantially.

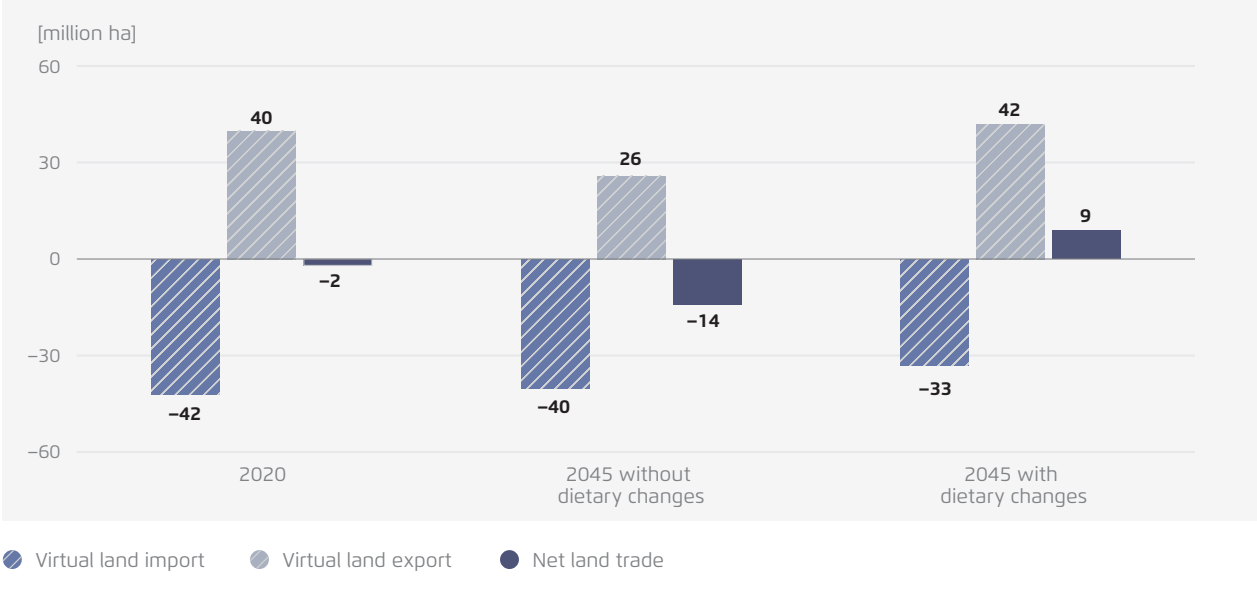
In the 2045 scenario, lignocellulosic crops are planted on around 8% of agricultural land, mostly on arable land (equivalent to 4% of the combined agricultural and forest land). They close the gap between the 30% increase in demand for woody biomass and the 10% decrease in forest harvest included in our scenario. This reduced harvest is due to adapted forest management. Additionally, the forest area expands by 5 million hectares by 2045. Both measures allow forest services to be maintained and enhanced for the future, including wood harvests, carbon sequestration and biodiversity functions.

The area under permanent grassland remains stable. The reduced livestock population allows for more grazing opportunities and grassland feeding. This is relevant from climate, biodiversity and animal

1 Paludiculture is a peat conserving form of agricultural production and forestry on rewetted peatland. In this study we focus on agricultural production.

EU net virtual land trade based on world average yields

→ Fig. 4



Agora Agriculture based on CAPRI results

welfare perspectives. Also, the area share of permanent crops remains almost constant in our scenario, although there are shifts within the land use category, such as an increase in the share of fruit trees.

Only around 2% of the agricultural area in the EU is rewetted by 2045 to reduce greenhouse gas emissions from drained agricultural peatlands (equivalent to 1% of the combined agricultural and forest area). In some regions, however, the rewetting of agricultural peatlands will have a substantial impact on land use patterns. Most of the rewetted peatlands will continue to be used productively. We assume 80% of the rewetted peatlands to be dedicated to paludiculture biomass production. The remaining 20% of these rewetted areas are used for energy production through solar photovoltaics (PV) and for biodiversity.

We project an installed capacity of 711 GW of ground-mounted solar PV on agricultural land which implies an additional installed capacity of 612 GW in our scenario compared to 2020. The resulting land demand is about 0.4% of total agricultural area (equivalent to 0.2% of the combined agricultural and forest area), therefore not impacting overall agricultural land use significantly.

The combination of efficient land use and sustainable consumption allows the land use sectors to contribute substantially to societal objectives within the EU (see below). It also allows the EU to increase net exports to other countries. As Figure 4 shows, the EU turns from a net importer of virtual land in 2020 to a substantial net exporter in 2045. We calculate that the EU imported a net of 2 million hectares of virtual land in 2020 and it exports a net of 9 million hectares in 2045. This development is especially driven by a reduction in feed imports and increasing net exports of dairy products while most other trade balances do not change strongly between 2020 and 2045. In addition, the EU is largely self-sufficient in biomass for material and energy use in 2045 due to the assumed increase in production of biomass with fast-growing trees. The aggregate positive EU trade balance is relatively robust against shifts to alternative product compositions. For example, if a higher share of wood products or biochemicals would be imported, a higher share of other commodities, such as grains, could be exported.

Changes in food consumption patterns are essential for realising the contribution of agriculture and forestry to societal objectives within the EU as well

as for lowering the pressure on global land resources. We conducted a sensitivity analysis which shows that applying our scenario with all the anticipated changes in agriculture, while maintaining 2020 consumption patterns and not reducing food waste, would result in the EU becoming a net virtual land importer of 14 million hectares in 2045, rather than a net exporter of approximately 9 million hectares in that same year. The larger EU imports and the smaller EU exports of agricultural products would lead to increasing agricultural production in non-EU countries and additional greenhouse gas emissions in these countries of 59 million tonnes of carbon dioxide equivalent ($MtCO_2eq$) compared to our main scenario.

In the following paragraphs we highlight how our scenario contributes to mitigating climate change, enhancing biodiversity, supporting health and social well-being, improving animal welfare and creating economic opportunities for the land use sectors and rural areas.

Climate change mitigation

Figure 5 shows that greenhouse gas emissions from agriculture and agricultural peatlands can be reduced by more than 60% by 2045 compared to 2020. This is substantial in light of the 8% reduction in emissions from agriculture and agricultural peatlands achieved during the 25 years between 1995 and 2020.

This sizeable change is achieved due to emissions reductions in three main areas:

1. Emissions from livestock, covering both enteric fermentation and manure management, go down by about 67%. Approximately 81% of this reduction is attributable to reducing livestock numbers. The other 19% result from the uptake of emissions mitigation technologies related to feed and manure management.
2. Emissions from agricultural peatlands decrease by 67% as a result of rewetting about 80% of today's agricultural peatlands and using the other 20% predominantly as shallow-drained grassland.
3. Emissions from agriculturally used mineral soils fall by an approximate 39% due to low emission fertilisation strategies (reduced nitrogen surpluses and increased nitrogen use efficiency).

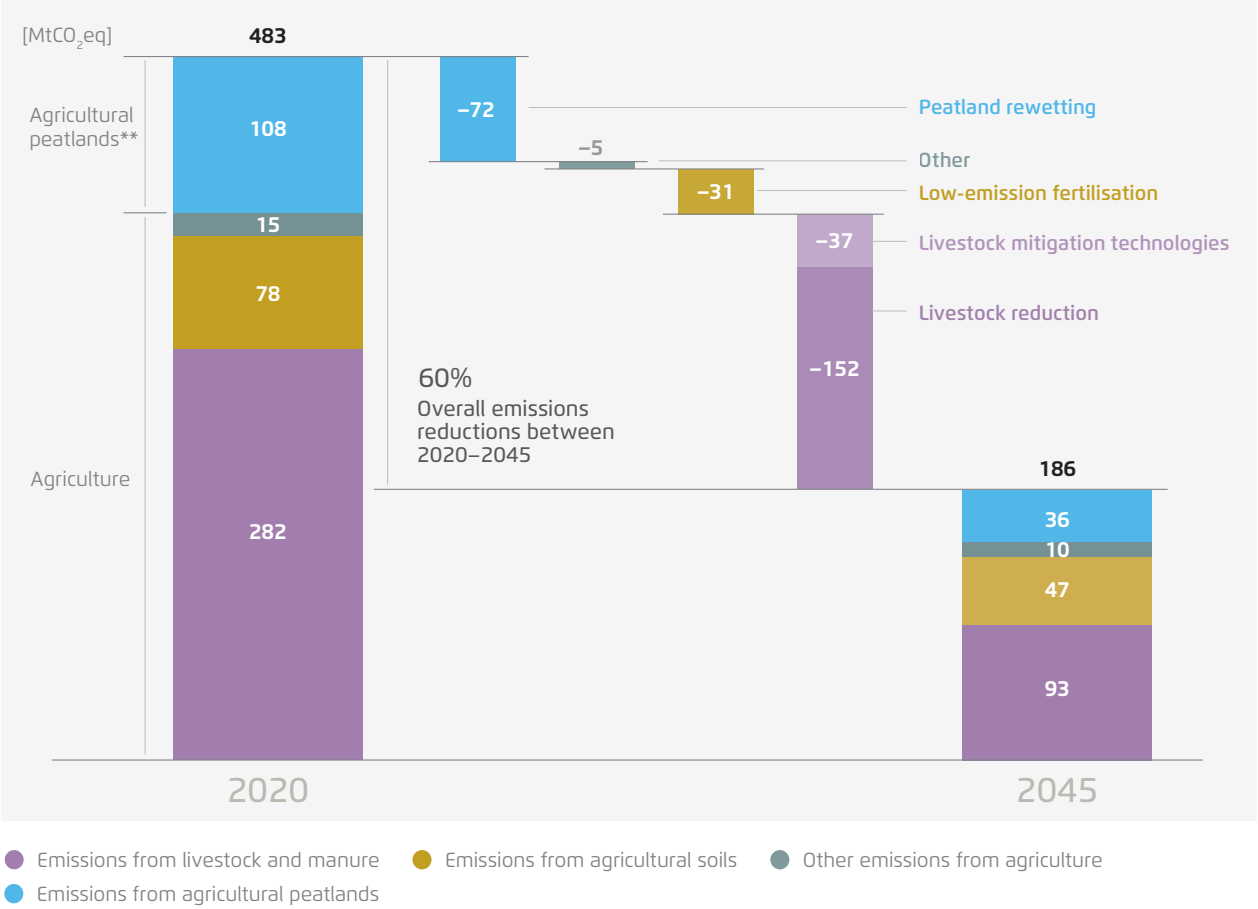
In addition to these emissions reductions, we foresee other climate benefits related to our scenario, including emissions reductions and carbon removals. The additional gains below are based on rough estimates.

Additional estimated contributions to **emissions reductions**:

- By 2045, some 64 million tonnes of renewable carbon are supplied through woody biomass produced on agricultural land. This biomass is used to substitute fossil feedstock for energy and material use. Applying a rather conservative substitution factor of 0.55, at least 131 $MtCO_2$ emissions could be mitigated annually through using the wood from fast-growing trees when these are fully established in 2045.
- Emissions related to energy consumption in agriculture and forestry summed to nearly 74 $MtCO_2eq$ in 2020. These emissions can largely be avoided by electrifying stationary energy use and sourcing it from renewable energy. Vehicles operating for short intervals or within the farm gates can also be electrified. In contrast, off-road vehicles performing heavy-duty work are still likely to require energy-dense liquid fuels in the future. Some combustion engines may therefore still run on biofuels. We did not go into detail on these aspects in our scenario.
- Agricultural land is used to produce energy through wind and solar PV. We specifically focus on solar PV production due to its higher land demand compared to wind energy. We project an installed capacity of 711 GW of ground-mounted solar PV in our scenario, which implies an installed capacity of 612 GW in 2045 on top of the current capacity. To illustrate the potential of this change, we calculate the avoided emissions very roughly using the emission factors of today's EU energy mix. On this basis, the additional installed capacity of ground-mounted solar PV would save 127 $MtCO_2$ per year. Note, however, that this emission factor

Reduction of greenhouse gas emissions from EU agriculture and agricultural peatlands between 2020 and 2045*

→ Fig. 5



Agora Agriculture based on CAPRI results. * N_2O emissions from manure application under "livestock and manure", N_2O emissions from organic soils under "agricultural peatlands"; ** estimate for emissions from agricultural peatlands with CAPRI data on organic soils and emission factors from IPCC, see Annex Chapter 7

declines with an increasing share of renewable electricity. The installed capacity is divided between different types of ground-mounted PV:

- Conventional solar PV, focused on power generation (63% of the total, or 384 GW),
- Agri PV and biodiversity PV, enabling a combination of power generation, agricultural production and biodiversity enhancement (25% of the total, or 155 GW),
- Peatland PV, allowing power generation on rewetted peatlands (12% of the total, or 73 GW). Solar PV on rewetted peatlands contributes about 7% to the total estimated EU installed solar capacity in 2045. This is possible if solar PV modules are installed on 4% of rewetted peatlands.

Estimated contribution to **carbon removals**:

- Forest net carbon removals in 2045 are estimated at approximately 290 $MtCO_2eq$, similar to 2020 levels. However, the level of removals depends on the effects of climate change on forests, adaptation efforts and forest management strategies that support the forest sink. This projection includes an additional sink on 5 million hectares due to afforestation.
- The annual carbon removals by harvested wood products are projected to increase by 17 $MtCO_2$, increasing from 41 $MtCO_2$ in 2020 to approximately 58 $MtCO_2$ in 2045. This is attributed to the increase in material use of woody biomass.

- Carbon removals on arable land are achieved through permanent land-use changes. In our scenario, planting hedgerows on 0.6 million hectares in the period between 2025 and 2045 results in negative emissions of around 112 $MtCO_2$ for this period, or around 5 $MtCO_2$ on average per year.
- Moreover, around 13 million hectares of fast-growing trees are established on agricultural land, resulting in negative emissions of about 660 $MtCO_2$ in the period between 2025 and 2045, or around 30 $MtCO_2$ on average per year.

Biodiversity

While we quantify the contribution of our scenario to climate change mitigation, we do not quantify its effects on biodiversity. Quantifying changes in biodiversity is far beyond the scope of this study and the dynamics of biodiversity are complex. However, the measures implemented in our scenario for conserving and enhancing biodiversity, as well as our assumptions about their spatial and temporal scales, are grounded in meta-studies on the relationship between land use and biodiversity. The biodiversity measures we prioritise for EU agriculture and forestry are widely applicable, and their effectiveness is well documented.

The intensity of agricultural and forestry management in the EU impacts local biodiversity, as well as biodiversity in other countries through price-mediated indirect land use effects. Lower yields in the EU lead to higher imports or lower exports if demand in the EU remains the same. The major challenge is therefore to find a balance between high land productivity and providing species-rich habitats. Our scenario aims to enhance biodiversity within the EU, while also reducing the pressure on land resources globally. This can only succeed if measures to protect biodiversity in EU agriculture and forestry are accompanied by a change in the consumption of food, feed and other biomass.

Protecting biodiversity needs a landscape perspective. Concrete measures for biodiversity must be implemented by individual farmers and forest owners but require cross-farm and landscape-level coordination to be efficient. To support biodiversity on arable land, the scenario includes a combination of measures aimed at having a low impact on land availability for production and agricultural productivity. The package of measures includes the provision of semi-natural habitats, structurally diverse cropping systems, integrated plant protection and low-emission fertilisation.

Instead of fixed set-aside obligations for each farm, we propose 20% semi-natural landscape features[2] at landscape level. When calculating the regional land required for semi-natural habitats, we take into account existing landscape features both on and adjacent to agricultural land, including elements of the scenario such as semi-intensive grassland management and integration of fast-growing trees into the agricultural landscape. This means that additional semi-natural features on arable land are needed only in those landscapes where the share of 20% is not yet reached. According to our analysis, an average of around 5% of arable land in the EU needs to be dedicated to semi-natural features by 2045, though with large regional differences.

Beyond biodiversity, semi-natural features provide valuable co-benefits, such as for carbon sequestration, soil conservation, water protection and biocontrol. The multifunctionality of semi-natural landscape features is particularly evident in hedges, fast-growing trees and other agroforestry systems. These not only provide a strong ecological contrast in agricultural landscapes and sequester carbon, but also provide valuable biomass for the bioeconomy.

Other management practices also increase heterogeneity in agricultural landscapes with benefits for biodiversity. This includes diverse, site-adapted crop rotations and that the average field size at landscape level is smaller than 6 hectares. This is accompanied

2 The term "semi-natural landscape features" covers both non-crop habitats (e.g., hedges, flowering strips, fallow land, ditches and ponds) and crop habitats that are farmed within the boundaries of biodiversity conservation (e.g., perennial legume-grass mixtures, extensively grazed or mown permanent grassland and agroforestry systems).

by halving the use and reducing the risk of plant protection products and halving nitrogen balance surpluses by 2045 compared to 2020.

Another key to enhance biodiversity in agricultural landscapes is the maintenance of permanent grasslands. Extensive permanent meadows and pastures are hotspots of biodiversity. Land productivity and biodiversity conservation can also be balanced in permanent grassland. This includes controlled grazing, site-adapted fertilisation and regular maintenance. In our scenario this is supported by using permanent grasslands for feeding livestock but with reduced livestock numbers and adapted grazing strategies. Reduced livestock density also helps to decrease regional nitrogen balance surpluses. Nitrogen input from manure is cut by more than half, providing environmental benefits for biodiversity but as well for climate protection, air, water and soil quality.

Likewise, biodiversity in forests can increase through management choices related to a modest reduction of harvests in forest, the implementation of forest-adaptation strategies and through afforestation.

Health and social well-being

In our scenario, the share of plant-based foods in overall food consumption across the EU increases compared to 2020. We foresee a doubling in the intake of fruits and vegetables and an increase in the consumption of legumes. The average intake of animal products declines by about 3% per year, or by 51% in total between 2020 and 2045, with different shares of reduction for different animal products. Sugar intake also declines.

Food demand in our scenario represents an aggregate population-level intake of different food groups across member states. It is not a dietary recommendation for individuals. However, individual consumption patterns in line with this scenario can contribute to a reduction in diet-related diseases, positive climate impacts and an efficient allocation of land resources. The consumption scenario by 2045 is in line with recent developments in national dietary guidelines in European countries.

In current debates, food security is often referred to as being incompatible with making further steps towards sustainability in the land use sectors. In our scenario, however, we show that the combination of an efficient use of land and sustainable consumption contributes to food security both inside and outside the EU. Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. It is a multidimensional concept encompassing food availability, access to food, nutritional outcomes, supply chain resilience and environmental sustainability.

In our scenario, sufficient food is available in the EU to support nutritionally healthy diets. Self-sufficiency rates of most relevant food products remain stable or increase until mid-century. Additionally, the measures in the scenario contribute to a resilient food system and ecological stability. Moreover, fair food environments contribute to the availability, affordability and appeal of foods for healthy and sustainable diets, contributing to meeting dietary needs. Finally, social policy measures as part of the scenario enhance access to healthy diets for socio-economically vulnerable consumers. As highlighted above, the EU contributes not only to domestic, but also to global food security, at least indirectly by reducing pressure on global land resources by increasing virtual net exports of land.

Although we did not estimate changes in food costs for consumers due to the multiple factors influencing food prices in long-term projections, research indicates that in upper-middle-income to high-income countries, healthy and sustainable consumption patterns that are plant-rich result in lower costs compared to current diets. In our scenario, food prices are mainly tied to world market prices, as we do not foresee a major role for protective trade policies.

Animal welfare

Another element of the scenario is the improvement of animal welfare through various advances in husbandry and management practices for cattle, pigs and poultry. This includes the provision of more space, diverse environments adapted to each species, outdoor access and greater opportunities for animals to express their natural behaviours. Common practices include outdoor runs, free-range housing and enrichments such as straw. Non-curative procedures, such as tail docking in pigs and beak trimming in poultry, are mostly eliminated. The use of cages for poultry has been phased out. For cattle and other ruminants, a greater proportion of animals have access to pasture. To support the implementation and economic viability of these improvements in an environment of international competition, increasing animal welfare needs to be rewarded through public payments.

Economic opportunities for the land use sectors and rural areas

Our scenario implies a range of economic opportunities and challenges for agriculture and forestry. It involves substantial changes in consumption and production, with considerable implications for some of the current business models. For example, while a shift in consumption patterns towards more plant-based foods is critical for sustainability, the effects on livestock production, a central economic pillar of the agricultural sector, will be substantial. Also, the rewetting of agricultural peatlands will result in significant changes to production in some regions and a reduction in forest harvests will carry implications for forest owners.

At the same time, opportunities can arise from the overall increase in demand for products and services from agriculture and forestry. For example, the growing demand for biomass for materials can create opportunities for forestry and agriculture. There is significant scope for producing renewable energies, such as solar PV, wind and residue-based biogas. New food demands, such as for fruits and vegetables, which offer high added value per hectare, can create new market opportunities. Furthermore, the provision of public goods, such as biodiversity protection, carbon sequestration and animal welfare, can become real business models.

While these opportunities are real, they cannot be expected to always translate into concrete business models without a conducive policy environment. For example, it will be crucial to incentivise the establishment of new value chains in the bioeconomy. Likewise, barriers to the increased production of fruits and vegetables and alternative protein sources need to be overcome. Furthermore, given that the market typically rewards the provision of public goods only to a very limited extent, providing public goods may be a burden to the land use sectors, rather than a source of income. Therefore, in an open market we foresee an important role for public payments to provide incentives for the provision of public goods. Finally, supporting innovation is important, for example through a further development of the EU legal framework for plant breeding, sustainability labelling and the use of food waste in animal feed, as well as administrative simplification, such as through a European Common Agricultural Data Space.

The provision of public goods has a value for society, but usually involves costs for those who provide them. If the provision of public goods is rewarded through public or private funding, it can become a business model and thus part of the income of farmers and forest owners. The level of public payments for public goods will be based on societal negotiations, related among others to applicable minimum regulatory standards, the cost of providing the services and their value to society. This translates into income opportunities if the required measures are incentivised with public and private payments that equal or exceed the full cost of implementing them, including all costs for labour, land and capital.

Below, we estimate the cost of providing a selected number of public services. We also estimate the potential value of carbon removals related to some of these services. Both calculations are very basic and

rough. However, taken with caution, they provide an idea about the scope for potential business models related to the provision of public goods by farmers and forest owners:

- The provision of a higher animal welfare level across the EU may result in additional annual production costs of about 10–20 billion euro. Public payments to remunerate a higher animal welfare level can be particularly important for farmers that are adversely affected by the overall decreasing livestock production.
- The creation and management of biodiverse agricultural landscapes would result in investment costs, as well as annual costs incurred and income foregone for: 1) the establishment of semi-natural landscape features, 2) the diversification of crop rotations, 3) the management of smaller cropping units and 4) a less intensive use of grassland. We estimate these costs at about 90 billion euro investment cost for the period between 2025 and 2045, and at 9–20 billion euro annually.
- Rewetting drained agricultural peatlands reduces greenhouse gas emissions effectively but also comes with opportunity and investment costs for farmers. We estimate short-term opportunity costs of up to 1 billion euro annually and about 12 billion euro in total for the period between 2025 and 2045.
- We foresee approximately half the afforestation previewed in our scenario to be active afforestation linked to investments needs. We calculate some 2–3 billion euro of investment annually between 2025 and 2045. The cost of forest adaptation measures we estimate at 12 billion euro annually over the same period. Both measures support critical forest functions, including biodiversity protection and carbon removals. These measures are also important to maintain forest economic activities in the face of climate change. Payments in support of these efforts can strengthen forest owners' businesses.

Implementing certain measures, including those referred to above, can generate carbon removals. As the EU economy transitions to climate neutrality, these measures will generate societal value, which can be estimated based on future carbon prices. Estimates of future carbon prices are difficult to make, ranging from less than 100 to well over 200 euro by mid-century per tonne of CO_2. A more sophisticated calculation would discount the carbon price for land-based removal according to the risk of reversibility. We instead use a conservative carbon price estimate of 100 euro per tonne of CO_2 for a rough estimation of the value of the carbon removals listed above:

- The introduction of hedges and fast-growing trees on agricultural land is projected to generate negative emissions of 35 $MtCO_2$ annually on average for the period 2025 to 2045. Based on the conservative estimate of a future carbon price of 100 euro per tonne, this would translate to a potential societal value of over 3.5 billion euro annually.
- Harvest reduction and afforestation may lead to an average of 50 $MtCO_2$ of negative emissions annually for the period up to 2045. With the assumed carbon price of 100 euro per tonne, this translates into a societal value of around 5 billion euro annually. As harvest reduction as well as afforestation is costly for forest owners, it is plausible that economic incentives are established for generating this societal benefit.
- Finally, harvested wood products would generate 17 $MtCO_2$ of additional negative emissions, resulting in a societal value of about 1.7 billion euro annually with a carbon price of 100 euro per tonne.

EU policy options

The 2024–2029 EU legislative period will be critical for strengthening the ability of farmers, forest owners, rural communities and consumers to actively contribute to societally agreed sustainability objectives. Policymakers must demonstrate long-term commitment and take decisive actions to create enabling policy environments. We emphasise three key considerations in designing an effective policy mix:

- **Use of market-based instruments**: Instead of relying primarily on command-and-control regulation, market-based instruments are important policy options. Such instruments can include an EU-wide emissions trading system for greenhouse gas emissions from agriculture and agricultural peatlands, as well as tradable certificates or taxes for plant protection products. By utilising price signals and economic incentives, such policy measures offer greater flexibility for economic actors to identify suitable management solutions, thereby safeguarding entrepreneurial options.
- **Payments for public goods**: Public payments to support the provision of public goods are a critical component in developing more sustainable business models in the land use sectors.
- **Fair food environments for consumers**: Consumers need enabling conditions. The wide range of sustainability benefits of our scenario largely relies on a shift to more plant-rich diets and on reduced food waste. Fair food environments are essential for making healthier and more sustainable food choices easier and more affordable for consumers.

The creation of an enabling policy environment requires a broad policy mix. We offer a detailed discussion of policy options for each of the six thematic areas in Chapter 4 of our study. In addition, we describe five cross-cutting policy priorities for the land use sectors, food system and bioeconomy for the 2024–2029 EU legislative period and beyond:

1. A climate policy for the land use sectors
2. A Common Agricultural Policy for public goods
3. An EU legislative framework to promote sustainable food systems
4. An action plan for the efficient use of biomass in the bioeconomy
5. A European Rural Deal

1. A climate policy for the land use sectors

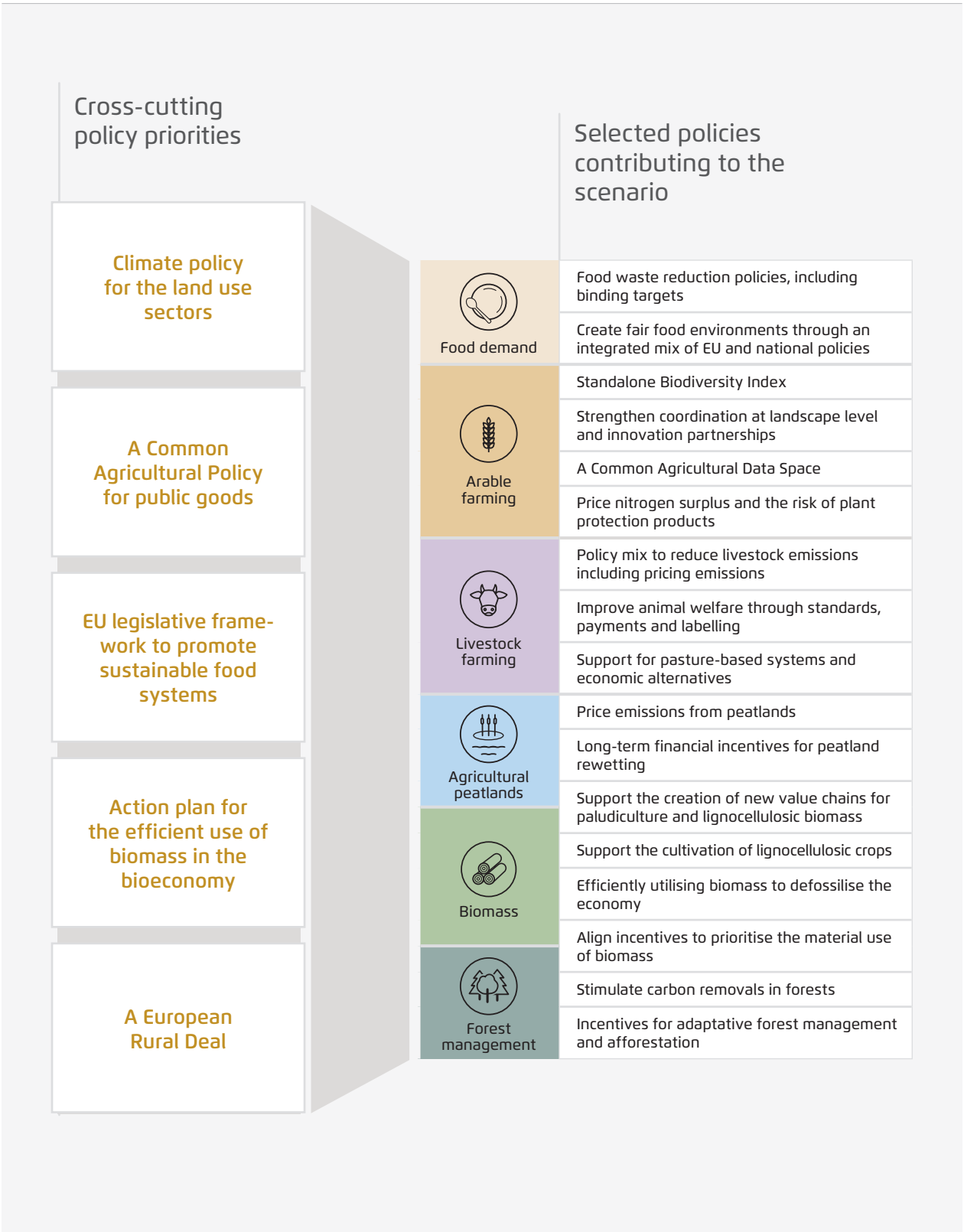
The design of a post-2030 climate framework will be one of the most consequential political processes of the 2024–2029 EU legislative period. Four aspects are particularly relevant for shaping a climate governance framework for agriculture and forestry:

A) **Defining an appropriate level of ambition for the contribution of the land use sectors to climate neutrality.** In our scenario, greenhouse gas emissions from agriculture and agricultural peatlands decline by about 60%, resulting in around 186 $MtCO_2eq$ of residual emissions by 2045. Considerable uncertainties surround potential land-based carbon removals. We estimate that net removals from forests could reach 290 $MtCO_2eq$ in 2045, which we view as an optimistic projection. Additionally, we assume 58 $MtCO_2$ removals from harvested wood products by the same year. Carbon removals from the planting of hedges and fast-growing trees on agricultural land are estimated to average 35 $MtCO_2$ annually between 2025 and 2045. These estimates offer a solid foundation for discussions on the level of ambition required for the land use sectors in climate change mitigation and for establishing climate targets.

B) **Translating climate ambition into climate targets.** Establishing a set of binding targets is a precondition for a long-term, predictable climate policy. We consider that:
   - Introducing an EU-wide reduction target for the combined greenhouse gas emissions from agriculture and agricultural peatlands would incentivise the sector to contribute more effectively to overall emissions reductions.

A policy mix for the land use sectors, food demand and biomass in the bioeconomy

→ Fig. 6



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- Establishing a separate target for carbon removals would complement an EU-wide net emissions reduction target. It is also important to consider setting separate sub-targets for land-based and technological removals. Additionally, a specific net removals target for forests would highlight the critical role forests play in carbon removals.

C) **Designing a framework to govern emissions from agriculture and agricultural peatlands.** The option of implementing an EU-wide Emissions Trading System (ETS) for agriculture-related greenhouse gas emissions is a subject of intense debate. Despite the complexities of establishing an ETS for the agri-food sector, such a system would reduce transaction costs and uncertainties compared to using multiple policy instruments for managing emissions. To be effective, an ETS should cover the major sources of emissions related to the agricultural sector. This includes methane emissions from livestock, nitrous oxide emissions from agricultural soils and emissions from agricultural peatlands. In some cases, allowances might be allocated for free (grandfathered), such as for emissions from peatlands.

D) **Introducing credible incentives for land-based carbon removals.** Carbon removals are indispensable for achieving climate neutrality by counterbalancing residual emissions. In the coming years, when removals are not yet needed for compensating hard-to-abate residual emissions, EU policies would need to focus on creating income opportunities through land-based removals. This should be done without compromising the ambition of emissions reduction efforts.

2. A Common Agricultural Policy for public goods

The Common Agricultural Policy (CAP) is the primary European funding mechanism for the agricultural sector, accounting for over 30% of the total EU budget.

In principle, the current CAP permits member states to use all available funds to reward the provision of public goods by agriculture. However, member states also have significant flexibility not to do so. As a result, the CAP budget is not sufficiently targeted at providing public goods. To improve the environmental and socio-economic impact of the CAP, the following steps can be taken.

A) **Gradually phase out basic and coupled income support.** This will allow farmers, markets and administrations time to adapt.

B) **Redirect CAP funds to enhance their environmental and socio-economic impact.**

C) **Simplify and increase the flexibility of the CAP:** Merge the budget of the two pillars into a single fund; introduce options for multi-year and single-year measures; replace conditionality with more flexible approaches that maintain baseline environmental protection without imposing excessive additional requirements on the sector without corresponding remuneration.

3. An EU legislative framework to promote sustainable food systems

Shifting food consumption patterns is essential for public health and for achieving broader sustainability objectives, such as reducing greenhouse gas emissions and protecting biodiversity. However, integrated food policies that offer coherent solutions across health, social, economic, environmental, climate and agricultural policy domains are yet to be developed at both the EU and national levels.

In 2020, the European Commission announced its intention to propose a legislative framework to facilitate the transition towards a more sustainable EU food system. This proposal has not yet been published. Putting forward a legislative framework to negotiate and establish a coherent policy approach for enhancing sustainability across the food chain needs to be a central task for the 2024–2029 EU legislative period.

We consider the following two elements to be important for such a framework:

A) **Establishing objectives and principles** to guide policy development and support predictability at both the EU and national levels.
B) **Introducing a mechanism to initiate the development of national food strategies and action plans.**

4. An action plan for the efficient use of biomass in the bioeconomy

The EU's current policy framework lacks coherent, long-term incentives to stimulate a bioeconomy that efficiently utilises biomass. Conflicting policy signals undermine the planning security needed to stimulate future-oriented investments in the bioeconomy. For example, the policy incentives for bioenergy often conflict with the most climate- and land-efficient uses of biomass.

The review of the Bioeconomy Strategy planned by the European Commission in 2025 presents an opportunity to address these issues. To support the development of a sustainable bioeconomy and create synergies between policy fields affecting biomass supply and use, this revision could include an action plan for the efficient use of biomass in the bioeconomy, including measures for carbon removal.

An action plan for biomass would establish strategic priorities for the coming months and years. It could address areas where current evidence shows a need for policy adjustments to reduce existing distortions and enhance system-wide benefits. Additionally, it can also include areas requiring further analysis regarding trade-offs, benefits and the technological and economic potential of different biomass uses. Key priorities for such an action plan may include:

A) **Adopt a policy road map to stimulate long-lasting and circular uses of biomass**.
B) **Incentivise the development of new value chains in the bioeconomy**, particularly for long-lasting products from paludiculture and forestry, for biogas production using sustainable feedstocks and for carbon removals.
C) **Promote a larger role for fast-growing trees in biomass production.** When well-integrated into the landscape, fast-growing trees offer significant benefits across multiple sustainability dimensions, including carbon sequestration, biodiversity, water protection and climate adaptation.
D) **Evaluate the international trade implications of EU biomass supply and demand** to determine necessary safeguards, such as carbon border adjustments, to prevent carbon leakage and address the offshoring of negative environmental and social impacts associated with EU biomass systems.
E) **Provide a comprehensive analysis of the current biomass production, extraction and usage as well as their future potential** to contribute to different societal objectives.

5. A European Rural Deal

Securing a reliable funding mix is critical for translating the potential opportunities from the transition towards climate neutrality into tangible outcomes for economic actors. The upcoming negotiations on the Multiannual Financial Framework (MFF) present a possibility to address this need, as they will determine the size and priorities of the EU budget for the 2028–2034 period. For this process, it is essential to engage in a well-informed debate about the costs associated with necessary changes in the land use sectors. This discussion should address the equitable distribution of these costs, the roles of various funding sources and the responsibilities at the EU, national and local levels.

While evaluating funding needs, it is important to recognise that the economic potential of the land use sectors is closely tied to the rural contexts in which they operate. Much of EU's economic development is anticipated to be driven by the ongoing "green and digital" transitions. While these can create opportunities, they also risk exacerbating disparities between some rural and urban areas.

Despite various EU rural development initiatives launched over the years, the challenges faced by rural areas may not have been addressed with the necessary scale and urgency. Introducing a "European Rural Deal" as a flagship political project for the 2024–2029 EU legislative period could contribute to a long-term economic transformation. It may include measures to improve social cohesion and ensure that rural communities can sufficiently contribute to and benefit from a climate neutral society. A European Rural Deal could:

A) **Create future-oriented economic opportunities in rural areas** to enable innovative business models that generate income and advance climate neutrality,
B) **Support the development of infrastructure for the benefit of rural communities**, including high-capacity digital networks, clean mobility systems and renewable energy,
C) **Maintain and enhance the attractiveness of rural living environments** by facilitating access to social services, including education, healthcare and cultural amenities.

The overarching objective of a European Rural Deal would be to ensure that the transition towards climate neutrality becomes an opportunity for rural areas across the EU.

Publication details

About Agora Agriculture
Agora Agriculture develops science-based and politically feasible approaches for a sustainable food, agriculture and forestry sector. As part of the Agora Think Tanks, the organisation works independently of economic and partisan interests and aims to contribute to achieving democratically negotiated sustainability goals such as climate neutrality and biodiversity protection.

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Title picture: Adam Smigielski | iStock

357/01-ES-2025/EN
Version 1.0, January 2025

This publication is available for download under this scan code.