OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in the European Union

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Foreword

Policies for the Future of Farming and Food in the European Union is part of a series of studies that apply the OECD Agro-Food Productivity-Sustainability-Resilience Policy Framework (PSR), an evidence-based approach to assess if the policy environment is conducive to achieving sustainable agricultural productivity growth and increased resilience. To date, the PSR Framework has been applied to reviews of Australia, Brazil, Canada, the People's Republic of China, Estonia, the European Union, Japan, Korea, Latvia, the Netherlands, Norway, Spain, Sweden, Türkiye, and the United States.

Reconciling agro-food productivity, sustainability and resilience is a challenge common to all countries, while also unique to a country's specific context and objectives. Following an evidence-based analysis and an international comparison of performance indicators, PSR reviews offer customised recommendations that aim to improve agriculture and food systems policies.

The European Union's diverse agro-food sector is at a critical juncture, confronting climate change and successive global crises while addressing the triple challenge facing food systems: ensuring food security and nutrition, providing livelihoods for actors in the food chain, and improving environmental sustainability. The EU Common Agricultural Policy (CAP) is also at a crossroads, increasingly expected to deliver on broad food systems objectives that go beyond the agricultural sector.

This review analyses how EU policy instruments and interventions in place until 2022 have enhanced the productivity, sustainability and resilience of the EU's food and agriculture sector. Further, it explores the potential of the CAP 2023-27 to meet the objectives of the European Green Deal. The proposed recommendations focus on bringing innovation into the centre of the agricultural policy strategy, redesigning payments and regulations, and strengthening data strategies, as well as adopting new approaches to deliver environmental services.

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Furthermore, valuable comments and insights were drawn from discussions with policy makers and experts from the European Commission, EU Member States, independent experts and stakeholders during several meetings between April 2022 and January 2023.

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Acronyms and abbreviations

AES	Agri-environmental scheme
AKIS	Agricultural Knowledge and Innovation System
AWU	Annual working unit
BERD	Business expenditure on research and development
CAP	European Union's Common Agricultural Policy
CfS	Candidate for substitution
CPVO	Community Plant Variety Office
CPVR	Community Plant Variety Rights
CSP	Common Agricultural Policy Strategic Plan
DG	Directorate-General
DG AGRI	Directorate-General for Agriculture and Rural Development
DIGITAL	Digital Europe Programme
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee Fund
EBA	Everything but Arms
EC	European Commission
EFA	Ecological focus area
EGD	European Green Deal
EIC	European Innovation Council
Eionet	European Environment Information and Observation Network
EIP-AGRI	European Innovation Partnership for Agricultural Productivity and Sustainability
EIT	European Institute of Innovation and Technology
EJP Cofund	European Joint Programme Cofund
EJP SOIL	European Joint Programme Cofund: Towards climate-smart sustainable management of agricultural soils
EPO	European Patent Office
ERA	European research area
ERA-NET	European Research Area Network
ERDF	European Regional Development Fund
ESF	European Social Fund
ESIF	European Structural and Investment Funds
ESR	Effort Sharing Regulation
ETS	Emissions Trading System
EU	European Union
F2F	Farm to Fork Strategy
FADN	Farm Accountancy Data Network
FAS	Farm advisory service
FI	Financial instrument
FLAN	Farm-Level Analysis Network
FSDN	Farm Sustainability Data Network
GAEC	Good Agricultural and Environmental Conditions
GBARD	Government budget allocation for research and development
GDP	Gross domestic product
GERD	Gross domestic expenditure on research and development
GHG	Greenhouse gas
GMO	Genetically modified organism
GSP	Generalised Scheme/System of Preferences
GSSE	General Services Support Estimate

ha	Hectare
IACS	Integrated Administration and Control System
ICT	Information and communications technology
IPM	Integrated pest management
IPR	Intellectual property right
ISCO	International Standard Classification of Occupations
JPI	Joint Programming Initiative
kg	Kilogramme
LDC	Least developed country
LFS	Labour Force Survey
LIFE	EU Programme for Environment and Climate Action
LULUCF	Land use, land-use change and forestry
MFF	Multiannual Financial Framework
MPS	Market price support
Mt	Million tonnes
Mt CO_2	Million tonnes carbon dioxide
Mt CO_2-eq	Million tonnes carbon dioxide equivalent
N	Nitrogen
NAP	Nutrient action plan
ND	Nitrates Directive
NRL	Nature Restoration Law
OG	Operational group
P	Phosphorous
%PSE	Producer Support Estimate transfers as a share of gross farm receipts
PAT	Precision agricultural technology
PBR	Plant breeder's rights
PES	Payments for environmental services
PoM	Programme of Measures
PSE	Producer Support Estimate
PSR	OECD Productivity, Sustainability and Resilience Framework
R&D&I	Research, development and innovation
R&I	Research and innovation
RBMP	River basin management plan
RDP	EU Rural Development Programme
SCAR	Standing Committee on Agricultural Research
SDG	Sustainable Development Goal
SMR	Statutory management requirement
SUD	Sustainable Use of Pesticides Directive
TFP	Total factor productivity
TRQ	Tariff rate quota
UAA	Utlised agricultural area
VET	Vocational education and training
Water JPI	Joint Programming Initiative: Water challenges for a changing world
WFD	EU Water Framework Directive
WTO	World Trade Organization
YEI	Youth Employment Initiative

Executive summary

Key messages

- The European Union's diverse agro-food sector is at a critical juncture, confronting climate change and successive crises such as the systemic shock of the COVID-19 pandemic and the war in Ukraine, while addressing the triple challenge facing food systems: ensuring food security and nutrition, providing livelihoods for actors in the food chain, and improving environmental sustainability.
- Through the OECD's Agro-Food Productivity-Sustainability-Resilience lens, this review, which draws lessons from the period 2014-22, shows that, in this ever-changing economic and policy environment, the EU agro-food system has demonstrated its resilience and has been able to keep productivity growing, in particular in post-2004 Member States, to reduce GHG emissions intensity, and to foster cross-country collaboration on innovation.
- However, in recent years, agricultural productivity has increased at a slower pace than in other OECD countries, while the environmental sustainability performance of the sector has not improved in line with expectations. This stalled progress is not due to insufficient ambition or lack of resources, but rather to policy design and implementation.
- The Common Agricultural Policy (CAP) 2023-27, which represents about one-third of the EU budget, includes promising new approaches and priorities. The CAP is considered strategic for the European Green Deal (EGD) agenda due to its potential for addressing environmental concerns, and is increasingly expected to deliver on broad food systems objectives that go beyond the agricultural sector.
- The transition of the EU food systems calls for an overall transformation, where innovation will play a critical role in delivering sustainable productivity growth. Meeting the ambitious EGD objectives will require further reform, by redesigning payments, regulations, innovation and data strategies, as well as adopting new approaches to deliver environmental services.
  - **Payments**. Further redesign CAP payments into separate measures targeted at income support and environmental sustainability and align the CAP expenditures with environmental and climate priorities. Introduce specific mechanisms to incentivise performance by Member States, reduce total spending on decoupled income payments and phase out coupled support.
  - **Regulations**. Address the implementation gap on sustainability objectives, enhance regulatory design and overcome potential barriers that hamper innovation.
  - **Innovation.** Bring innovation to the centre of EU agricultural policy strategy to ensure that it effectively helps the sector to become more productive, sustainable and resilient.
  - **Data**. Strengthen the EU agro-food data strategy and enhance digitalisation to monitor policies, create awareness, facilitate knowledge exchanges and find innovative solutions.
  - **Environmental services**. Advance in the adoption of result-based multi-annual payments and collective action for environmental services when possible, and introduce reporting on results.

The EU agro-food sector needs to adapt to an ever-changing economic and policy environment. Following enlargement, the European Union has grown in membership to 27 countries and strengthened its position as one of the world's largest agro-food players. Tackling the triple challenge food systems face is more difficult in the new policy context of growing environmental concerns and successive global crises. While recognising potential trade-offs with other objectives, the urgency of the climate and environmental situation means that the transition of the EU agriculture and food systems cannot be delayed. The systemic shock of the COVID-19 crisis, the war in Ukraine and its implications for food security, the need to halt and reverse the loss of ecosystem services and to adapt to climate change make improving resilience to unforeseen shocks and environmental sustainability even more urgent.

Productivity growth has been mild and not always associated with improved sustainability performance. Over the last 60 years, EU agriculture has expanded its production while transitioning from a growth model based on intensification to one driven by productivity growth, thanks to technology and efficiency gains. Nevertheless, long-term agricultural productivity growth in the European Union has been weaker than in other OECD countries. In many EU countries, biodiversity has declined, emissions continue to increase, and pressure on water has not eased. Despite increased efforts with new and more targeted measures, as well as increased funding, environmental performance has not met expectations.

The European Green Deal with the associated Farm-to-Fork and Biodiversity Strategies provide a new context for the Common Agricultural Policy (CAP). At about one-third of the EU budget, the CAP increasingly expected to contribute to objectives beyond the boundaries of the agricultural sector**.** While ensuring the food security of the European Union and contributing to global food security, the EU agro-food sector should also contribute to making Europe climate-neutral, protecting its diverse natural habitats and transforming the European economy in line with sustainability objectives.

The main challenge for the CAP is to overcome its path dependency and move towards a bolder and more forward-looking food systems policy. Recent CAP reforms have changed the way support is delivered, but have only resulted in incremental progress. Although the CAP 2023-27 is taking a performance-based approach with more flexible implementation at the Member State level much remains to be done to put the agricultural sector on a fully sustainable footing. An EU-wide, high-level discussion on the purpose of the CAP, the rights and responsibilities of farmers, and the financial weight given to income compared to environmental or other objectives is needed.

Going forward, the targeting of direct payments should be improved in light of the ambitious policy goals. Direct payments are the main tool to support EU agriculture, and efforts have been made to improve fairness and to better distribute payments. However, direct payments may have consequences in terms of keeping some farmers in uncompetitive activities, stifling innovation, slowing structural and generational change, and could weaken long-term resilience. In the short term, income support objectives should be met with targeted payments not only to be more effective, but also to allow more funding to be made available for voluntary payments for environmental services, and for investment in innovation and resilience. In the long term, the appropriate roles for agricultural and broader social policies should be reviewed.

There is currently a gap between policy ambitions on environmental sustainability and observable results. The stalled progress to date is due to policy design and implementation rather than insufficient ambition or lack of resources. A protracted policy reform process has often resulted in excessive flexibilities for Member States, and reduced incentives to implement policies with clear implications for environmental sustainability. Instead, such flexibilities allowed them to choose lower cost options with limited sustainability benefits. If the CAP is to be further reoriented towards environmental sustainability, this will require the re-instrumentalisation of support in the next programming period to improve the regulatory and economic incentives for farmers and policy makers in Member States to shift away from the *status quo*.

Research and innovation are key drivers in the transition towards more sustainable food systems but remained marginal in the 2014-20 CAP design. The resources devoted to agricultural knowledge

and innovation systems (AKIS) – through Horizon Europe and the CAP – are limited compared to the total support provided to the sector. Although the European Innovation Partnership for Agricultural Productivity and Sustainability is an important initiative and investment in AKIS and digital technologies has high potential to make enhanced productivity and environmental sustainability mutually compatible, investment in and adoption of innovation remains a challenge. Moreover, as noted above, the incentives created by the broader policy and regulatory environment for agriculture may slow the innovation needed to ensure long-term sustainability.

Recommendations for improved policy in the European Union

The stalled progress has not been due to insufficient ambition or lack of resources but rather to policy design and implementation. Meeting the ambitious EGD objectives will require redesigning payments, regulations, innovation and data strategies, as well as adopting new approaches to deliver environmental services.

- ***Payments*. Reform the structure of the CAP and policy design to better reflect stated priorities and align with EGD objectives.**
  - Strengthen the link between budget allocation and performance.
  - Strategically reorientate the CAP and the role of direct payments by separating and targeting measures aimed at income support and measures aimed at environmental sustainability, linking them to results and ensuring they do not undermine incentives for innovation and generational renewal.
  - Accelerate the transition to targeting income support to low-income farm households.
  - Increase the share of expenditures on innovation, information, training and advice.
  - Phase out market price support and payments with potential to harm the environment and to distort markets and trade.
- ***Regulations*. Address the implementation gap on sustainability objectives and innovation barriers via SMART (specific, measurable, achievable, relevant and targeted) regulations.** Reconsider the role and scope of cross-compliance mechanisms to increase their cost-effectiveness. Design outcome-based regulations that do not hamper innovation, specifying their objectives and monitoring outcomes to increase effectiveness in promoting sustainability.
- ***Innovation*. Foster agro-food innovation, advice and skills as cornerstones of a new sustainable food systems approach.** Enhance synergies between different policy signals to steer agricultural innovation efforts towards environmental sustainability. Promote innovation, skills and digital tools by encouraging EU Member States to improve their Agricultural Knowledge and Innovation System and establish their own agro-food innovation strategies. Develop a skills agenda and strengthen the capacity and impact of advisory services in guiding the transformation of agriculture towards innovative and sustainable pathways.
- ***Data*. Strengthen data-driven policy design, assessment and monitoring.** Expand the EU agro-food data strategy to respond to the triple challenge facing food systems. Dedicate CAP budget to investments in the data needs of farmers, food chain actors and policy makers. Embrace and promote digitalisation as an enabling technology to monitor policies, create awareness, facilitate knowledge exchange and find innovative solutions leading to sustainable productivity growth. Allocate part of the CAP measures to adopt innovative digital technologies to address the main challenges and needs farmers face and facilitate the offer and use of such technologies by advisory services.

- ***Environmental services*. Adopt result-based payments for environmental services and collective action when possible, and introduce reporting on results.** Transform voluntary schemes into result-based multi-annual payments for environmental services to increase policy performance and offer farmers additional sources of revenue. Use pilot experimentation to promote collective action and consider introducing collective incentives. Require reporting on results by the beneficiaries of the payments for environmental services.

Assessment and recommendations

Assessment of performance

The EU agro-food sector is at a crossroads

In January 2023, the European Commission and the European Union Member countries began implementing the new Common Agricultural Policy (CAP) 2023-27. The new CAP entails a new delivery model in which Member States play a critical role in determining and implementing their CAP strategic plans (CSPs). The CAP 2023-27 is also expected to deliver on broader food systems objectives, such as delivering on long-term food security and responding to climate change and ensuring the sustainability of natural resources. To this end, valuable lessons can be learnt from the previous CAP 2014-22 and from experimenting and innovating during the 2023-27 period. The following assessment refers to regulations, programmes and policies implemented up to 2022. While recognising that the CAP 2023-27 includes many changes that have the potential to address shortcomings observed in past CAP cycles, given the scale of the challenges, it is useful to both focus on what can be learnt from experience to date and what further actions need to be taken to ensure that the CAP is able to deliver a more innovative, productive and sustainable agricultural sector in the future.

New demands for environmental sustainability are emerging from a broader food systems approach…

The CAP represents about one-third of the EU budget and is expected to deliver on broad food systems objectives that go beyond the agricultural sector's boundaries. The EU agro-food sector ensures the food security of its population while also contributing to global food security. At the same time, the sector is strategic for the European Union's green transition agenda due to its environmental impacts and resource implications. The public expects EU food systems to respond to the triple challenge of providing healthy, safe and nutritious food while providing livelihoods for farmers and other actors in the food chain and improving environmental sustainability (i.e. preserving land, water and biodiversity resources, and reducing greenhouse gas [GHG] emissions).

The European Union has expanded to become a diverse group of countries with different levels of economic development, more varied types of land use and different approaches to agricultural production. The European Union has also strengthened its leading position in global agro-food trade, becoming the world's largest agro-food exporter and one of its largest importers, with agro-food products accounting for 9.3% of all exports and 6.8% of all imports.

The European Union's competitiveness in world food markets has been largely driven by agricultural productivity growth. For a long time, productivity gains were achieved through agricultural intensification, with significant negative environmental consequences, such as increasing GHG emissions, loss of

biodiversity on farmland, and damage to air and water quality. The Farm to Fork (F2F) and Biodiversity Strategies are part of the European Green Deal (EGD), which proposes a food systems approach to reduce agriculture's impact on the environment and foster the transition towards healthier, more sustainable and fairer food systems.

...while systemic uncertainties call for adaptability and resilience to different crises

When the EGD was launched in December 2019, nobody imagined that the COVID-19 pandemic, nor Russia's war of aggression against Ukraine in February 2022, would occur. Both these crises have elevated food security issues back to the top of the global and EU political agendas, while rising food and energy prices have challenged the vision of an ambitious green transition of the EU agro-food system. This, and the current high price for fossil energy and chemical fertilisers, are not only a challenge, but could also be an opportunity to transform the European agro-food system, benefiting as well from the opportunities created by the digital economy.

While the EU agro-food system has demonstrated its resilience during the COVID-19 pandemic and now Russia's war of aggression against Ukraine, the European Union has addressed current global food security concerns by temporarily relaxing or removing some environmental restrictions to increase production. Since the recent crisis is primarily characterised by a decrease of purchasing power rather than a reduction in food availability, this resilience may not be durable if the sector does not improve its environmental sustainability.

The green transition of EU food systems calls for a transformation where innovation plays a critical role in delivering sustainable productivity growth. Such a transformation must include a transition towards more balanced and diversified diets, but also broader involvement of the other agro-food actors, with new retailing and processing patterns, new business models, as well as new spatial configurations of supply chains where farmers will have to anticipate and possibly lead this process.

Productivity is growing, but slower than in other countries, and has recently decelerated in all but the new Member States

A sustainable path of productivity growth is key to achieving the F2F and Biodiversity Strategies objectives. Unlike intensification of the use of inputs that could harm the environment, sustainable productivity growth can reconcile the apparently conflicting demands of increasing food production and environment sustainability. Improving technology, practices and the efficiency of input use, or total factor productivity (TFP) growth, would make it possible to produce more food with fewer inputs.

Over the last 60 years, EU agriculture has transitioned from a growth model based on intensification (use of more inputs) to one driven by productivity growth, thanks to technological improvements and efficiency gains. This has allowed the volume of production to expand. However, long-term output growth has been weaker in the European Union than in other OECD countries and the global average, while TFP growth has been mild. Most of the gains in TFP in the European Union have been related to reductions in agricultural labour due to increased labour productivity, while capital investments played a lesser role in output growth compared to other countries, such as the United States. Overall, the European Union has not succeeded in decoupling output growth from the use of variable inputs, which is critical in view of the F2F targets to reduce the absolute level of input use.

Different types of structural change and contrasting policies have led to significant variations in productivity performance between those Member States that were EU Members prior to 2000 (EU14) and the newer EU Member States (EU13). Up to 2010, the productivity growth of the EU14 remained well above that achieved in the EU13, but this trend was reversed during the last decade, and new Member States have led EU gains in productivity. Decreases in the labour force have been steady over the last six decades in

the EU14, but the decline in the EU13 only started in the last two decades, when newer Member States experienced a significant and rapid increase in capital investments.

Productivity growth has not always been associated with improved sustainability

EU agricultural policies increasingly aim to improve the sustainable management of natural resources and contribute to climate action to ensure the long-term sustainability and potential of EU agro-food systems. However, productivity growth has not always been associated with improved sustainability performance, especially in terms of reversing biodiversity decline and reducing GHG emissions.

Several factors have contributed to a decrease in biodiversity. According to the available evidence, the quality and health of EU agricultural landscapes and farmland biodiversity are declining. Growing urban areas and other competing demands for land use have led to a reduction in agricultural land. Pastureland has decreased, and agricultural fields have become more homogenous and, on average, farmed more intensively.

Direct GHG emissions from agriculture have remained stable over the last decade. While over the first decade of the 21st century the reduction of livestock numbers and a more efficient use of fertilisers led to a consistent decrease in direct GHG emissions from EU agriculture, more recent data indicate a flat rather than a declining trend in GHG emissions. Nevertheless, GHG emissions have grown at a slower rate than the value of total output, indicating that the European Union has reduced emissions intensity and has successfully achieved a partial decoupling of GHG emissions from production.

Other environmental and resource challenges are growing in parts of the European Union, particularly in the case of water. Agriculture remains a major user of water and a source of pollution in many regions of the European Union, contributing to the unsatisfactory status of many water bodies in view of the objectives of the EU Water Framework Directive. At the same time, climate change is affecting agricultural productivity with new weather patterns that reduce the availability of water for agriculture in many countries. In addition, the negative effects of extreme weather events and animal and plant diseases have increased in most countries, and are expected to continue into the future.

At the EU level, several agri-environmental trends are still progressing. While nutrient surplus continues to be problematic in many regions, over the last 20 years, the European Union has reduced its nutrient balance per hectare while the total agricultural output has grown, leading to the absolute decoupling of nutrient balances from production.

The EU agricultural sector is undergoing structural change but must address generational renewal, gender bias and labour issues

The future capacity of the EU agro-food sector to combine productivity, sustainability and resilience performance will be influenced by recent and ongoing structural changes. The number of farms has been declining over time, while both the physical and economic size of farms have been increasing. This adjustment could be an important driver for productivity objectives but also for the adoption of technology and innovation aimed at increasing farm resilience and sustainability. In 2020, there were about 5.1 million fewer farms in the European Union than in 2005, a 36% decrease, while the agricultural area decreased only by 6.3% over the same period. The bulk of the reduction in farm numbers corresponds to holdings smaller than 5 hectares, while the number of farms larger than 100 hectares has increased. Agricultural labour and the share of the EU working population employed in agriculture has also dropped, while the average agricultural income per full-time employee has increased. Less than 10% of EU farms manage more than half of all agricultural land and therefore play a key role in the overall environmental performance of the sector.

Without generational renewal, the achievement of relevant social, economic and environmental objectives that are at the core of current EU agricultural policies are at risk. Young farmers are crucial for viable,

productive and innovative agriculture, but the proportion of young farmers has been decreasing over time. The problem of generational renewal goes well beyond the farming sector, and may potentially have negative long-term effects on, for example, land abandonment and rural viability. Access to land, and the corresponding payment rights, as well as to credit, are the main obstacles to setting up a business in the farming sector.

Women are underrepresented in the EU farming sector. Gender bias is a structural characteristic of agriculture in almost all EU Member countries. The CAP has few policy levers to change this and the efforts of some Members countries – e.g. Spanish Law on Shared Ownership – have not resulted in any significant change. Gender issues in agriculture deserve policy makers' attention, as diversity has been shown to improve resilience and adaptability.

Migrant workers are an increasingly important part of the EU farming sector. The outflow of local labour has been partially compensated by inflows of foreign labour, including undocumented workers whose numbers are difficult to quantify. These undocumented workers are often poorly treated, and many are confronted with detrimental working and living conditions. The consideration of socio-economic conditions and the assurance of social rights compliance, particularly for migrant workers, is therefore essential for the sustainability of the EU farming sector.

… the Common Agricultural Policy is also at a crossroads

The recent F2F and Biodiversity Strategies call for a co-ordinated effort in the European Union that reinforces farmers' competitiveness while contributing to a cross-sectoral set of ambitious environmental objectives with specific targets for the agricultural sector. The EU Common Agricultural Policy, representing one-third of the EU budget, is the most important EU policy to operationalise such a vision and objectives. Given the European Union's climate and environmental commitments to foster the green transition of EU agriculture, the European Union should break the path dependency that has shaped CAP reforms in the past and further transform the CAP into a policy that stimulates the capacity of the EU farming and food sector to encourage innovative responses to develop sustainable food systems. Moving towards greening and, as of 2023, the eco-schemes, are attempts to reorient support towards environmental sustainability incentives.

The CAP 2023-27 places a greater emphasis on performance, with more flexible implementation by Member States, and introduces a new way of working to modernise and simplify the policy. Important innovations, such as the eco-schemes and the programming approach that underpins the CSPs, have the potential to transform the CAP, but this will require significant efforts by Member States to improve policy design and the associated monitoring and enforcement procedures. The post-2027 programming period will be an important opportunity to accelerate this change and further transform the CAP into a tool to achieve the EGD objectives.

Thus, not only is European agriculture at a crossroads, but the CAP is as well. One of the CAP's most far-reaching reforms, known as the 1992 MacSharry Reform, demonstrated that multilateral processes, in that case the Uruguay Round multilateral agricultural negotiations, can catalyse significant changes. Current challenges call for another significant reform to respond to environmental and climate pressures, and to new demands from European society.

Current CAP funding allocation and expenditures are not contingent on performance

Nominal expenditure in the CAP has increased, but less than other policy areas. As a result, the share of resources allocated to the CAP in the total EU budget has declined from 65.5% in 1980 to 33.1% in 2021. The Total Support Estimate has also decreased, from 2.5% of gross domestic product in 1986-88 to 0.6% in 2019-21. The CAP is structured according to two distinct pillars: the first is centred on markets and farm incomes and is fully financed by the EU budget; the second focuses on rural development and is co-

financed by EU Member States (varying from 25% to 75% depending on the measures and the region). The CAP's overall budget (excluding EU Member State co-financing of Pillar 2) during the years 2014-20 was EUR 408 billion (USD 465 billion), of which 76% was initially allocated to Pillar 1 and the remaining 24% to Pillar 2.

Member States' main focus in the EU Multiannual Financial Framework (MFF) negotiation process is the net budgetary envelope. This process is characterised by the *juste retour* principle, where each Member State compares its financial contribution to the EU budget with the money that flows back into the country. However, this indicator does not provide a good indication of a Member State's comprehensive benefits from the EU budget and even less so of the overall benefits from EU membership. Once the MFF is concluded, it determines pre-allocations of CAP amounts among Member States. For direct payments, pre-allocations are largely based on historical allocations, rather than on more targeted criteria. Recent reforms have started convergence and resulted in greater uniformity in payment levels between Member States. The process of convergence is still ongoing and continues to be contentious in the European Union's MFF negotiations.

While keeping common policy tools, in particular EU budget, objectives, interventions, rules and indicators at EU level, major responsibility for the design and implementation of strategies for the CAP 2023-27 was transferred to Member States, which were required to present their proposed policy interventions in the form of CSPs. However, under the CAP rules, there is no mechanism in the budget allocation process to reward Member States for a higher level of ambition or a higher level of performance in their CSPs. The new delivery model of the CAP and the focus on performance would benefit from stronger budgetary responsibility from Member States, such as performance bonuses or other incentives.

Over time the CAP has undergone positive reforms…

The CAP's design is the result of wide-ranging consultations and multi-institution negotiations, which tends to favour incremental change rather than radical departures from one cycle to the next. Despite this institutional trend, far-reaching changes have been possible at certain points. An example is the 1992 MacSharry Reform, which introduced a system of coupled direct payments to compensate farmers for the anticipated loss in market income from the reduction in the level of market support prices. Similarly, the "mid-term review" reform package adopted in 2003, known as the Fischler Reform, introduced the single farm payment. By decoupling a large share of CAP support from production, the Fischler Reform is viewed by many experts as one of the most radical reforms of the CAP since its creation.

Looking at the many CAP reforms over the last 60 years, it is possible to identify three main axes of change: 1) greater market orientation; 2) greater integration of environmental and climate objectives; and 3) a broader focus on structural policy and rural development. The first two axes are reflected in the evolution of the European Union's Producer Support Estimate (PSE).

CAP reforms prior to the mid-2000s were successful in reducing producer support, notably market price support, while progressively "decoupling" support from production, as well as in increasing the scope of input constraints attached to payments. Since 2010, the European Union's PSE level and composition have remained almost unchanged, though increasingly with input constraints attached to payments, reflecting environmental and climate objectives. The increasing scope of this environmental cross-compliance has not changed the basis on which the payments are made; therefore, there are no significant changes in the composition of PSE categories. The PSE methodology also reflects cross-compliance in the increased share of payments with input constraints, but does not capture the scope of this conditionality.

Successive CAP reforms have led to a significant drop in the overall level of support measured as a proportion of gross farm receipts (%PSE), which decreased from 38% in 1986-88 to 19% in 2019-21. Progress towards market orientation is reflected in the share of the most production- and trade-distorting

forms of support, which decreased from 92% in 1986-88 to 23% in 2019-21. Given that such support (market price support, coupled direct payments and input support) potentially also contributes to negative environmental outcomes, further reductions should be a priority. This reduction would also contribute, among others, to achieve the goals and targets agreed in 2022 in the context of the Kunming-Montreal Global Biodiversity Framework.

… but direct payments still make up the bulk of CAP spending but are not targeted to, nor the most efficient tools for achieving, multiple key objectives

CAP direct payments represented 24% of agricultural income in the period 2015-20, but their distribution was uneven since they followed the skewed distribution of land use and farm size in the European Union. Despite many corrective measures, in some Member States a high share of direct payments goes to larger farms, where the need for income support is not always obvious. Furthermore, there is not enough information or analysis of the impact of these payments on improving income distribution among farm households, or its role in alleviating low levels of income among farmers. The data availability issue is further exacerbated by the absence of a reliable system to allow comparisons between agricultural incomes and those in other sectors of the economy, as well as by the lack of data on farmers' off-farm income.

Even if the CAP had a more targeted and even distribution of direct payments among regions and farmers, this would not overcome the main shortcoming of this type of support, which is that it fails to target farm household income and to address the ambitious environmental goals set for the sector. Given the objective of supporting low-income farmers, it is difficult to understand the rationale of redistributing payments to households based on the amount of land used for farming (or kept under good conditions) rather than on their overall household income. The environmental conditions attached to these payments are aimed at ensuring that a large number of EU farmers comply with basic rules for the environment, food safety, animal health and welfare, but the observed implementation shortcomings demonstrate that direct payments have not been the most effective tool to promote public goods nor to reduce the environmental externalities of the farming sector.

In addition to income and environmental objectives, direct payments are expected to improve farm resilience and employment. However, while direct payments ensure a stable source of revenue for the farm household, several studies have found that they are neither the most efficient nor the most equitable instruments to improve longer term resilience, in particular to improve the resilience capacities to adapt and transform. This is due to the leakages to unintended beneficiaries but also to potential slowdown of the structural adjustments of agriculture and subsequent improvement of farm productivity and incomes.

Direct payments are also not the most efficient tool to create jobs or to maintain employment in agriculture and rural areas. Policy instruments directly aimed at enabling investments that create new and sustainable employment would be better than direct payments that maintain non-viable jobs and activities. Moreover, in some cases, the benefits of CAP direct payments do not remain with the intended beneficiary but benefit other stakeholders or create barriers to entry. This happens when CAP payments are, to a large extent, capitalised into the value of land and, especially, land rents. Higher land prices and rents make entry for younger farmers more difficult, slow the rate of generational renewal, and impede the development of new projects and practices. The most important impact may be delaying the exit of older farmers who risk losing their direct payments and deterring generational renewal. The impact of the direct payments system in slowing down generational renewal and innovation deserves particular attention with respect to their effect on broader socio-economic objectives.

Other CAP tools aimed at promoting resilience lack ambition and a holistic perspective on preparedness, adaptation and transformation

The CAP includes a broad set of measures to promote the resilience of the farming sector, including support for investments, measures to support generational renewal, as well as risk management measures and crisis management tools. As currently designed, these have significant shortcomings and fail to follow an integrated and holistic approach.

Measures to support generational renewal are included in both CAP pillars in the form of direct support to young farmers and in mechanisms that give them priority access to Pillar 2 measures for investment, advisory services and business start-up aid. While these go in the right direction, they do not tackle the root of the problem. Indeed, the current CAP process fails to address many of the barriers to generational renewal in agriculture, such as access to land and capital, lack of business skills, inefficiency of succession plans, and lack of attractive professional perspectives in the agricultural sector. Furthermore, as noted above, given that the capitalisation of direct payment in land values creates a barrier to entry and an incentive for incumbents to stay, it is unlikely that these additional measures for young farmers are sufficient to offset or reverse these disincentives.

The CAP should take an integrated approach to risk management policies that addresses all incentives related to risk exposure, preparedness, adaptation and transformation. An increasing number of measures dedicated to risk management have been developed, focused on stabilising revenues *ex post*, after the extreme event has taken place. Yet farmers and national and regional governments struggle with multiple tools that are complicated to implement and which are not consistently available across Member States. Furthermore, a large share of public support continues to be delivered through direct payments that guarantee farmers a stable income, and several Member States provide *ad hoc* assistance through state aid after systemic weather shocks, or subsidise insurance with national funding. While this support is well intentioned, its impacts on the incentives to proactively prepare for and invest in upstream risk mitigation need to be considered.

Environmental and climate objectives are at the heart of the CAP, but a disconnect between ambition and implementation prevents progress

Growing environmental ambitions are not properly supported by incentives for implementation

Agriculture plays a central role in achieving policy objectives across a range of environmental sustainability areas. This role is reflected in EU Regulations, Directives and treaties on biodiversity, habitats and landscapes; air pollution (National Emission Ceilings Directive); GHG emissions (Effort Sharing Regulation and the LULUCF Regulation on land use, land-use change and forestry); water quality and quantity (Water Framework Directive and Nitrates Directive); and on the sustainable use of pesticides. Agriculture also plays a key role in achieving the Sustainable Development Goals (SDGs), particularly SDG 2 – Zero Hunger – and SDG 12 – Responsible Production and Consumption. Agriculture is also critical to the European Union's progress towards the targets of the Paris Agreement and of the Global Biodiversity Framework. The F2F strategy promotes a transition to sustainable food systems as part of the European Green Deal (EGD), and sustainable production and consumption of food are two of its six objectives.

Despite the establishment of an EU Biodiversity Strategy, the EU Nitrates Directive, and EU agri-environmental schemes (AES), the environmental performance of EU agriculture has not met expectations and agricultural production continues to adversely affect water, soil and air quality, and biodiversity. The trend towards increasingly specifying objectives and a more outcome-oriented approach to policy design and delivery is likely to increase the effectiveness of policy efforts directed at sustainability, but evidence of progress is still lacking.

The assessment of the main EU legislation and policy implemented until 2022 highlights the presence of a gap between the ambitions set out in policy and the results of their implementation. Flexible mechanisms helped find agreement in challenging negotiation processes and reflected the different situations of Member States, but often weakened efforts since farmers were allowed to choose approaches that were less costly and easier to implement, potentially preserving income but less effective in achieving environmental results. The New Delivery Model of the CAP 2023-27 has the potential to ensure greater transparency and reporting on progress that could counteract the negative aspects of flexible approaches. Nevertheless, further reforms should ensure a stronger connection between incentives and performance both for Member States and farmers.

The EU has ambitious overall climate mitigation objectives but relatively weak targets for agriculture

Incentives to address greenhouse gas (GHG) emissions from agriculture have previously been limited by the absence of sector-level emissions reduction targets at the EU level. This is a consequence of intersecting concerns regarding trade effects (carbon leakage) and food security (impacts of targets on production), but also of difficulties in measuring and reporting emissions. While agriculture is the third largest source of emissions in the Effort Sharing Regulation (ESR) sectors, to date, it has contributed a smaller share of GHG emissions reductions; this is not expected to change before 2030.

Under the current framework, Member States must ensure that the land use, land-use change and forestry (LULUCF) sector does not generate net emissions and contributes to enhancing the carbon sink ("no--debit rule"). Organic soils and peatlands, while only 1.2% of the total cropland area, represent one of the largest potential sources of emissions reductions via carbon storage. Rewetting of peatlands also could have important biodiversity co-benefits, but incentives have been insufficient to encourage Member States to significantly curtail agricultural production on this land.

Progress in reducing nutrient balances and achieving water quality objectives has stalled, but existing tools could still lead to progress

Progress on improving the status of surface and groundwater has accelerated after a slow start, but 2027 goals are still at risk of not being achieved. Investments in institutional improvements and better monitoring and reporting on the ecological status of water bodies will increasingly bear fruit, but non-point pollution from agriculture is still a concern that requires more resources and more effective regulation if all objectives are to be fully met. The CAP is increasingly used as a vehicle in this regard through cross-compliance and voluntary AES. Given the important role of agriculture in improving EU water quality, the increasing use of Pillar 2 funding for Water Framework Directive objectives can be an effective way to accelerate progress. There are also opportunities to use market-based measures more to provide incentives to producers to act; cost recovery and efficient water prices for agricultural users are not yet common in water policy among Member States.

The Nitrates Directive, in place for more than 30 years, addresses non-point-source emissions of nutrients from agriculture. Member States produce action plans to encourage farmers to implement best practices. These plans are evaluated and adjusted regularly, yet nutrient surpluses continue to pose risks to water quality and the pace of improvement has been slowing. Member States should adjust their plans when the evidence shows that problems persist. The water quality monitoring system of the Water Framework Directive is a valuable tool in this regard.

Cross-compliance is difficult to monitor and its cost-effectiveness is questionable

Cross-compliance in the CAP is designed to ensure that beneficiaries of direct payments maintain a good level of compliance with statutory management requirements (SMRs) and carry out practices that are

conducive to maintaining Good Agricultural and Environmental Conditions (GAEC). SMRs include several EU regulations and directives, such as those on animal welfare and the use of hormones, on the use of nitrates, on the conservation of wild birds, and on the conservation of natural habitats and of wild fauna and flora. GAEC are established at the Member State level within a framework given by the EU Regulation and include standards designed to prevent soil erosion, maintain soil organic matter and soil structure, protect biodiversity and ensure the retention of landscape features, and protect and manage water. That said, environmental benefits from SMR cross-compliance may be limited under the 2014-22 policy framework, as those requirements largely overlap with compulsory regulations, and farmers do not have to undertake any additional action beyond respecting the law. On the other hand, GAEC standards are additional operational practices which farmers must respect. However, the number of inspections is low and the penalties for non-compliance are both not proportional to the potential harm and too low to be dissuasive. The administrative burden of cross-compliance is high, and inspections can be cumbersome and costly. For these reasons, it is unsurprising that stakeholders have rated cross-compliance as being of low effectiveness, especially with regard to GAEC standards designed to improve water and soil management.

Implementation problems with greening have led to the introduction of enhanced conditionality and new eco-schemes

In the CAP 2014-22, greening requirements established ecological focus areas (EFAs), obligations for crop diversification and the preservation of permanent pasture. This was an ambitious attempt to strengthen the environmental requirements of Pillar 1 payments beyond cross-compliance. However, implementation flexibility led to few changes in farm practices and limited effectiveness of the greening requirements. The CAP 2023-27 has now replaced cross-compliance and greening requirements with enhanced conditionality and has added eco-schemes as a new vehicle for environmental and climate actions funded under Pillar 1. This is an agile response to address the shortcomings of the greening requirements and to increase the environmental ambitions of the CAP. That said, the extent to which enhanced conditionality will be effective deserves an evaluation, given the limited performance of this tool in the past. The capacity of eco-schemes to deliver will depend critically on the extent to which Member States are prepared to undertake and learn from the new performance-based approach.

Environmental measures can be improved with innovative policy approaches such as result-based payments and collective action, but need to limit administrative requirements

AES are a long-standing component of the CAP and the only measure in Pillar 2 that is mandatory for Member States to implement. AES have evolved from being applied in only a few countries with sensitive environmental issues to becoming a core mechanism for maintaining cultural landscapes and protecting farmland biodiversity. The CAP 2014-22 expanded their scope to include climate change action, and they represented 15% of Pillar 2 payments under the rural development funds, covering about 13% of EU agricultural area. AES are most commonly used for protecting biodiversity, ecosystems and landscapes, and supporting traditional practices, organic and sustainable farming. However, limited budgets, low uptake resulting from the voluntary nature of participation, poor design and implementation, high administrative burden, and poor targeting of practices rather than results frequently prevent AES from living up to their potential.

The CAP 2023-27 retains AES in Pillar 2 while introducing eco-schemes as part of Pillar 1 (not co-financed by Member States). Lessons learnt from AES can contribute to innovative policy design across countries. Results-based payments and higher compensation rates have been proposed to improve the performance of AES in certain Member States. Examples can be increasingly found in several countries, although they are not without challenges of their own such as high monitoring costs. Adjusting rules to encourage further experimentation and piloting could help make this policy option more dynamic and effective.

Another shortcoming of the current environmental measures of the CAP is that, by default, they are targeted to individual farmers rather than groups of farmers and other collectives. Collective approaches could be more effective and efficient for providing agri-environmental public goods, such as biodiversity and landscape, that are defined beyond the boundaries of individual farms. Collective action can also be a vehicle for peer learning, identifying environmental priorities and designing innovative practices. Spatially targeted AES could be a further mechanism to improve the effectiveness of voluntary measures (i.e. focusing interventions on areas with particular environmental problems). While such approaches are emerging in several countries, the Netherlands is the only country where the collective implementation of AES has been mainstreamed.

The CAP 2023-27 offers improvements, but the implementation gap remains, as does the need to balance income support and environmental sustainability objectives

The new CAP 2023-27 addresses some of the shortcomings observed in past CAP cycles. The New Delivery Model gives Member States more flexibility to design schemes that meet the needs of their farming sector. A clearer definition of Member States' needs and objectives will help to design more targeted and effective programmes and improve the policy design cycle. Achieving results efficiently should become a central feature of the CAP. Regularly reporting on progress would help address the perennial problem of flexibility mechanisms that lead to an "implementation gap" between policy ambition and implementation results. This would require measurable, relevant and timely objectives with the capacity to report on progress and adjust policies as appropriate as part of the policy development cycle. This would also require reliable and robust data to design result indicators.

The implementation gap has several causes that need to be systematically assessed to improve the effectiveness of CAP spending. First, within limits stipulated by EU legislation, Member States need to make choices that limit administrative overhead and more strongly focus on objectives and reporting combined with simpler administrative requirements would help with this. Second, member states tend to balance environmental objectives with the primary intention of CAP funds to support farmers' income; this results in environmental programmes that often do not challenge the status quo on the farm, as the requirements imposed are limited compared to the size of the payments.

An EU-wide, high-level discussion on the purpose of the CAP is needed on farmers' rights and responsibilities, the effectiveness of providing farm income support separate from the social security net and the financial weight given to income compared to environmental or other rural development objectives. The present architecture distinguishes between funds that are co-financed (Pillar 2) and those that are not (Pillar 1), but these funds no longer have distinct objectives. This can confuse farmers regarding the amount, form and purpose of the support they may expect to receive in the future.

Stricter environmental constraints could make European production less competitive and hinder incentives for implementation

Reconciling the tension between farm income and environmental sustainability will be critical for the CAP to contribute to achieving EGD objectives. More stringent environmental regulations for agriculture and food may increase production costs for specific products in the short term in the absence of technological or other innovation-based alternatives. This may negatively impact the international competitiveness of the targeted products and raise the possibility of increased environmental harm in third countries with lower regulatory standards (pollution leakage). The risk of losing competitiveness could be a factor contributing to the implementation gap.

In this context, a debate is underway in the European Union as to whether access for third countries to the EU market should be conditional on their exports meeting equivalent EU standards not only for product safety and quality but also in terms of other production standards such as environmental regulations. Such

an approach is rather complex to implement, taking into account the diversity of standards among international trading partners, and needs to be implemented in compliance with international trade rules. The European Union's free trade agreements cover some sustainability provisions with requirements that have evolved over time. The European Union also recognises the importance of multilateral initiatives to promote international standards in relevant international bodies and to encourage the production of agri-food products complying with high safety and sustainability standards. The European Union has also started to work directly with actors along the food chain via due diligence requirements.

Innovation may also improve resource efficiency and bring win-win solutions for farmers by reducing their costs of production while limiting environmental impacts. Other policy approaches could alleviate the potential negative impact on competitiveness of meeting the environmental challenges and reduce demands on public resources, for instance through a greater focus on results-based environmental payments, by phasing out environmentally harmful subsidies, and by implementing market-driven or demand-based approaches.

The European Union plays a major role as a research and innovation catalyst, but adoption of innovation remains a challenge

The long-term strategy for research and innovation seeks to achieve sustainable agriculture, but ambitions and resources remain limited both under the CAP and Horizon

The European Commission's first efforts to direct agricultural innovation towards sustainable development under Horizon date from 2016. That year, the Commission launched its long-term strategic approach to agricultural research and innovation and identified priority areas: sustainable resource management, plant and animal health and well-being, integrated ecological approaches, the development of rural areas, and enhancing human and social capital. To date, however, not all EU Member States have a national long-term strategy to guide agro-food innovation efforts in their countries. This strategic approach to agriculture research and innovation has been translated into the wider EU innovation policy strategy, Horizon Europe, through Cluster 6. This could be a very useful strategic planning instrument, but would benefit from being more strongly linked to the CAP and accompanied by a proactive strategic cycle of regular monitoring and assessment of performance, continuous co-ordination of the main policy tools, and a redefinition of priorities and plans for each new cycle.

Support provided to agricultural knowledge generation, agricultural education and extension services constitutes a small part of the total support provided to the agricultural sector, at only 6.1% of policy transfers in 2019-21. In 2014-20, knowledge, advice and innovation through co-operation measures were very limited under the CAP, with the initially planned budget accounting only for 1.5% of the rural development funding (including EU and national contributions). Reorienting resources currently used on most distorting payments could provide a means to increase innovation spending. Additionally, more evidence is needed to assess how these Pillar 2 expenditures translate into innovations or new skills that can effectively support the green transition of EU agriculture.

Despite some progress, agricultural innovation instruments could be better co-ordinated

The EGD requires good policy co-ordination to boost innovation to achieve the European Union's ambitious goals for food systems. While the CAP is not an innovation policy per se, the CAP measures, together with Horizon Europe, address the different stages of the innovation cycle from idea generation to dissemination. Horizontal and vertical co-ordination across policy areas and levels of governance within the European Union is still required. The Commission is already making efforts in this direction.

Agricultural research and innovation in the European Union comprise multiple streams and instruments. First, the Directorate-General for Agriculture and Rural Development leads agriculture policies, supporting

knowledge exchange and innovation via selected measures under the rural development funding and through dedicated platforms such as the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). Second, the Directorate-General of Research and Innovation and the Directorate-General for Agriculture and Rural Development implement policies that have an impact on the agro-food sector, in particular Horizon Europe. Third, other directorate-generals support relevant policies, such as the EU funding instrument for the environment and climate action (LIFE Programme) and the European Union's programme to support mobility activities in education and vocational training (Erasmus+), both of which may contribute to fostering sustainable agriculture by promoting knowledge, skills and innovation.

Individual EU Member States also support innovation efforts through their research and innovation programmes and specific agro-food research and education agencies. These programmes often serve different objectives and operate under different sets of rules without any overarching strategic planning. There is limited evidence that they have been implemented in a way that harnesses the full potential of synergies. The number and complexity of the innovation systems may also limit transparency and encourage beneficiaries to remain in their respective silos.

The European Commission provides a well-functioning framework for agricultural knowledge and innovation systems (AKIS) at the EU, national and regional levels. Nevertheless, AKIS are complex systems that would benefit from integration and better knowledge flows among all actors, in particular through advisory services. The interface of research and practice, promoting interactive innovation and digitalisation in agriculture requires particular attention. Integrating AKIS strategies into the CAP strategic plans as from 2023 is a promising step in this direction, but this integration has been more formal than substantive in several CSPs.

The overall regulation and policy environment may risk disincentivising innovation

EU regulations, such as those relating to biopesticides, genetically modified organisms and new breeding techniques, and the role of the precautionary principle, which seeks to avoid potential adverse impact on the environment or human health, may have unintended consequences on innovation. Innovation actors complain about the time it takes to get approvals, even where new techniques are allowed. This overall regulatory framework can create uncertainty for research and prevent innovation adoption, thus making innovation less attractive compared to other countries. Furthermore, the context of high government support for agriculture may undermine incentives to take risks to innovate and search for new opportunities.

Mechanisms for fostering co-creation, such as the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), are promising

The EIP-AGRI is the European Commission's main policy tool for promoting bottom-up multi-actor public-private agricultural innovation partnerships, as well as for giving methodological support and providing a networking platform to local operational groups (OGs). Both rural development funding of the CAP and Horizon Europe funding are channelled to join forces in these partnerships. The EIP-AGRI OGs are laying the foundation for demand-driven innovation, thanks to their interactive approach and the involvement of a wide range of stakeholders. They have significant potential to convert bottom-up grassroots ideas into innovative projects and ultimately into innovative outcomes. After a slow start, the number of OGs has been growing in recent years and tripled in 2023-27 CAP strategic plans compared to the 2014-20 period. They are an asset that deserves monitoring and evaluation of their performance and investigation of the drivers of success for the widespread implementation of the most successful practices.

Research and innovation programming has fostered co-operation between countries but needs to further integrate farmers

The European Union's Research and Innovation Framework Programme, led by the Directorate-General of Research and Innovation, strongly promotes cross-country collaboration through a single European Research Area, which has increased the share of agri-food publications and patented innovations with foreign co-authors. Research policy related to agriculture, forestry sectors and rural areas are co-managed with the Directorate-General for Agriculture and Rural Development. Research policies are also increasingly "mission-oriented", with an emphasis on project impact and results that are aligned with well-defined priorities. However, pre-defined topics may limit the possibility of developing grassroots ideas and the active role of small farms and other end users.

The current Horizon Europe programme aims to simplify the complex architecture of partnerships under the Horizon 2020 programming (2014-20). It also introduces four new European Partnerships with potentially high value for the agricultural sector: "Accelerating farming systems transition: Agroecology living labs and research infrastructures", "Agriculture of data", "Animal Health and Welfare" and "Food systems". Their functioning cannot be assessed at this stage, as they have not yet been implemented, but it is critical that they create opportunities for co-operation with farmers and, possibly, direct links to CAP measures, including eco-schemes and additional funding for innovation from Pillar 2.

Skills imbalances are a challenge for the future of the agricultural sector and the green transition

The effects of climate change, the increasing ambition of environmental regulations and the need to maintain competitiveness are new challenges for the sector. New digital technologies and analytical tools may transform these challenges into opportunities for the agricultural sector. Evolving requirements, however, demand new skills and capacities among agricultural workers, including digital, environmental management and entrepreneurial skills. While the demand for highly skilled workers in the agricultural sector is increasing, there is a high degree of skills shortages and mismatches compared to other sectors.

While the CAP provides some measures to address these skills imbalances, they are not ambitious enough to solve the problems. A clearer picture of the skills requirements for the next decade would help identify gaps and inform policy design. The Erasmus+ projects, such as FIELDS and I-Restart, aim to identify current and future skills needs for sustainability, digitalisation and the bioeconomy in agriculture and have the potential to help fill the gaps and support the prioritisation of educational and training needs in the European Union.

Despite the support offered to vocational education and training, farmers' participation in adult training programmes is low, indicating that unaddressed barriers exist. Connecting participation in training to accessing specific support (e.g. AES) could improve farmer participation. Similarly, connecting the support under the Young Farmer Payment and innovative investments with specific training could encourage young farm workers to gain additional skills and knowledge.

The CAP 2023-27 contains elements to boost knowledge networking activities and promote the role of farm advisory services in building transformative capacity, though progress on this needs to be monitored. The new EU-wide CAP network, which aims to improve the flow of information on EU agricultural and rural policy among national CAP networks, organisations, administrations, researchers, farmers and practitioners has the potential to foster greater synergies and increase inclusive knowledge exchange in the sector. Training advisors are now compulsory, and this may lead to a greater use of training and advisory measures and a more prominent role for advisors in national AKIS.

Farm advisory services are often not sufficiently attractive to farmers nor well geared to future needs

Farm advisory services are essential for helping farmers find solutions, leading to greater uptake of innovation and boosting sustainability in the sector. In most countries, advisory services have changed from mostly public services to a system that combines independent private advisors; private advisors from input providers companies; and new forms of public advisors, including private, public and mixed funding. Different advisory models have potential to reach similar goals.

However, despite the growing importance and diversity of the need for multidisciplinary farm advice, due to delivery mechanisms in the 2014-20 period, the funding for relevant policy instruments is marginal within the overall CAP budget (0.2% of Pillar 2 in 2014-20). Part of this support can be allocated to upskilling advisors, but the actual number of trained advisors is unclear. The demand for advice seems to be fragmented, as a large percentage of farmers remains hard to reach. Furthermore, the effectiveness of farm advisory services in the areas of innovation for environmental sustainability is difficult to assess due to methodological limitations and data issues.

A performance-based CAP requires additional investments in data, evaluation and reporting

The European Union has embraced several data-related initiatives that can improve the monitoring and evaluation of agricultural policy, but the shift towards a more performance-based CAP requires additional investments in data, evaluation and reporting. These data are needed to inform farmers and others about environmental pressures, identify priorities, design more efficient policy instruments (including result-based payments) and monitor performance.

Better data on agricultural household income is needed to design more effective income support

Income support is a long-standing objective of the CAP and the main focus of Pillar 1. Despite this, the available statistical tools do not measure the economic well-being of farm households. There is no reliable system to allow income comparisons among farmers, farm workers and those in other sectors of the economy. Nor is the system able to identify problems related to low-income farm households. Information on the disposable income of agricultural households from all sources, including on- and off-farm activities, is also lacking in databases such as the Farm Accountancy Data Network (FADN). Conclusions, therefore, cannot be drawn on the impact of CAP income support on the income distribution among farm households. Deficient information may lead to misleading policy conclusions, does not provide a solid basis to justify current income support to farmers and hampers the development of more targeted measures.

The increased emphasis on the social dimension of farming also requires new data

The CAP, especially Pillar 2, contains interventions aimed at attracting and sustaining young farmers; facilitating business development in rural areas; and promoting employment, growth, gender equality and social inclusion. The CAP 2023-27 has introduced for the first time the new social conditionality mechanism to link payments to compliance with certain European labour law provisions, including the working conditions of immigrants. The broad measures adopted to increase social sustainability have the potential to increase the attractiveness of rural areas, promote agricultural entrepreneurship, and improve labour standards and working conditions on farms. However, more granular data on the role of women and migrants are needed to design targeted and adapted policy responses to different social issues affecting the farming sector.

Measuring environmental performance is set to remain a major challenge

The new Performance Monitoring and Evaluation Framework is an important step to incorporate monitoring and evaluation in the policy implementation process. It covers all the CAP 2023-27 instruments and aims to measure performance in relation to the specific objectives of the policy using a set of common indicators. Nevertheless, some of the main shortcomings of the previous framework remain. In particular, there are no well-defined impact indicators to assess the environmental and social performance of farming. While the difficulty of measuring environmental and social outcomes at the farm level should not be underestimated, digital technologies have an enormous potential that remains largely untapped. Improved access to technology and more efficient use of spatial data – the Land Parcel Identification System (LPIS) – may offer viable solutions in the future.

Another positive development is the ongoing process of conversion of the Farm Accountancy Data Network (FADN) to the Farm Sustainability Data Network (FSDN). The FSDN will include additional variables that will fill some data gaps on environmental and social sustainability. Nevertheless, these and other data will only be available towards the end of the upcoming CAP period, therefore showing significant synchronisation problems between CAP developments and data needs. The heterogeneous and fragmented data landscape between Member States further exacerbates confidentiality constraints on data collection and harmonisation. Furthermore, incentives are needed for individual farmers to collect data about their performance on environmental results and use this information to design their investment strategies and practices on the farm.

Evaluation of bottom-up multi-actor agricultural innovation partnerships is needed for policy learning

The 2023-27 CAP facilitates the uptake of the EIP-AGRI OGs by addressing two main barriers: the administrative burden and a lack of upfront funding. However, to date, there is no systematic evaluation of the functioning of OGs and their outcomes for the period 2014-22. A comprehensive data set is needed to track the characteristics and achievements of these partnerships and to analyse the factors that contributed to the best performance. More evidence is needed to ensure an appropriate feedback loop, with information and analysis of the main drivers of innovation outcomes that could enhance policy learning and the application of the best set-ups and practices among OGs. While some data are available, the current participation of advisors and the level of engagement of farmers across different projects has not been sufficiently analysed.

Policy recommendations

The green transition of EU food systems calls for an overall transformation, where innovation will play a critical role in delivering sustainable productivity growth. While the CAP 2023-27 includes a number of promising new approaches and priorities, meeting the ambitious sustainability objectives and raising productivity growth will require further significant reforms going forward. The above assessment helped identify 15 recommendations that are categorised into five areas: 1) payments; 2) regulations; 3) innovation; 4) data strategies; and 5) environmental services. Each of these 15 recommendations includes specific actions that can be applied either during the current programming period (2023-27), and which are labelled as **[Current]**, or that could be applied only in the next programming period, and which are labelled as **[Next].**

Payments. Reform the structure of the CAP and policy design to better reflect stated priorities and alignment with European Green Deal objectives

1. Align CAP budget allocations with stated priorities and address disincentives

- ***Target a larger share of the budget to performance-oriented payments for environmental and climate objectives [Next].*** Increase the agricultural sector's contribution to the F2F and Biodiversity Strategies' objectives by ring-fencing a higher share of CAP expenditures to remunerate the provision of public goods, in particular for environmental stewardship and climate change mitigation.
- ***Increase the share of the budget devoted to innovation, information, training and advice targeted to sustainability and resilience objectives [Next]***, both through direct innovation measures and indirect integration of innovation and advice in other measures. Increase the coherence between the vision of the green transition of the sector and the needed innovation-related activities that have the potential to contribute to achieving related environmental targets. A combination of different actions and policy tools may help to achieve greater coherence: identifying and addressing barriers to the uptake of available knowledge and innovation-related measures, reorienting more public investment towards agricultural research and innovation, and promoting private investment. CAP rules should make it easier for Member States to fund specific components of their AKIS they have identified as key levers to improve sustainability and resilience. More investment in information, training and advice is also fundamental to respond to sustainability challenges and ensure increased sector resilience.
- ***Invest in the risk management toolkit to improve preparedness, adaptation and transformation [Next].*** The CAP toolkit should include broader risk management strategies, in particular, *ex ante* tools. Finance advisory services to undertake risk assessments at the farm level, including the impacts of climate change, and to give impartial advice to farmers on risk management practices, including investment in adaptation and diversification, and *ex ante* investments in prevention of hazards (e.g. prevention of floods or diseases). Rather than focusing on increasing revenue stability by compensating losses *ex post*, promote farmers' awareness of the impacts of risks and climate change on their farm and enhance their co-responsibility on adaptation and transformation.
- ***Phase out the most-distorting and potentially most environmentally harmful forms of support [Next].*** Policy reforms over the past three decades substantially reduced the level of support to the sector and shifted the composition to less production and trade-distorting measures. Despite substantial progress in reforming support for the sector, the most distorting and potentially most environmentally harmful forms of support, such as coupled direct payments, input support and market price support, still represent nearly a quarter of support to producers. Reducing tariff rates for agricultural products and phasing out other distorting measures, which also contribute to negative environmental outcomes, would improve CAP coherence with the F2F and Biodiversity Strategies.

2. Ensure that all CAP payments that focus on sustainability, resilience and innovation objectives are linked to monitorable performance

- ***Strengthen the monitoring and evaluation of the CAP strategic plans (CSPs) with greater transparency and reporting on progress [Current].*** Make a mid-term assessment of the CSPs and the monitoring mechanisms. Define objectives and propose indicators and mechanisms to measure and monitor Member States' progress and adjust their plans. The flexibility provisions on regulations and directives should not be a source of implementation gaps. Provide Member States

with incentives to take meaningful action and to use such flexibility to achieve more ambitious targets in different situations.

- ***Reform payments to target environmental sustainability outcomes as defined in agricultural-related regulations [Current].*** While the CAP is increasingly used as a vehicle to achieve sustainability targets, a more extensive use of CAP funding to reflect and achieve the objectives of the Water Framework Directive, the Nitrate Directive and the Climate Law could be an effective way to accelerate progress in achieving the European Green Deal's ambition. Provide guidance to member states regarding how to maximise CAP integration with river basin management plans, nutrient action plans and climate objectives. Clarify and simplify rules to encourage co-ordination between the administrative bodies in terms of programme and payment delivery.
- ***Introduce specific mechanisms to incentivise good policy design and performance by Member States [Next].*** Link Member States' CAP budgetary allocation to the achievement of environmental and climate objectives. To improve the effectiveness of CAP spending, different options could be explored to strengthen this link and give Member States greater budgetary responsibility, such as introducing a performance bonus or other incentives.

3. Transition to targeted income support and introduce a clearer separation of income support from measures targeted towards environmental sustainability

- ***Undertake an in-depth assessment of the impact of CAP direct payments on household income inequality [Current]*** among farm households and with other sectors, on the incidence of low income and poverty among farmers, and on the inclusiveness of women and minorities in agriculture. This would require investing in data to measure the well-being of farm households, including on-farm and off-farm activities. Explore policy options to better define the rationale of income support and target it to legitimate social objectives, including the possibility of incorporating them into social security nets. Systematically measure total farm household income on a regular basis.
- ***Accelerate a transition process to target income support to low-income farm households [Next].*** This transition should be informed by and consistent with the findings of the in-depth assessment of the impact of direct payments. The bulk of income support to farm households should target low-income or poverty issues, ensuring that synergies with broader social policies are realised. A certain level of decoupled payments could be maintained to keep land for agricultural use.
- ***Reduce decoupled payments through better targeting and make them conditional only to basic GAEC requirements [Next].*** Reduce sector specific income support and keep a limited share of the income support package in the form of decoupled payments, applied as flat rate payments fully decoupled of any production to ensure income transfer efficiency. Maintain basic GAEC requirements for this type of support to ensure a broad-scale approach to sustainability, but also to maintain a sufficient area suitable for agricultural production across Europe and ensure a rapid response to market signals when food markets become tight and to food crisis situations.
- ***Define two different sets of direct payments: income support and voluntary payments for environmental services [Next].*** Structuring direct payment support into two well-defined and distinguishable packages will clarify the relationship between CAP spending and the different CAP objectives. It will give more certainty to farmers and avoid blurring the line between income support and other goals. This will also ensure that sustainability spending is not viewed as coming at the expense of income. Allocate a dedicated budget to each of the two packages and eventually introduce different co-financing rates according to the priorities established by each Member State. The support for environmental sustainability should be performance-based (see Recommendation 14).

4. Ensure that CAP payments do not create barriers to entry

- ***Explore the possibility of withholding CAP income payment rights from farmers who have reached the statutory retirement age [Next].*** Several countries (i.e. Austria, France and Germany) have already introduced linkages between CAP payments and pension schemes, for example, by requiring the farm to be passed on to a successor to receive a pension. Whilst respecting national legislation regarding pension rights, create incentives for Member States to withhold CAP payments from farmers who have reached the statutory retirement age to encourage generation renewal, as well as to improve the connection between income support and actual income problems.
- ***Reduce policy barriers to generation renewal, new entrants and women [Next].*** Support to young farmers should be integrated with a broader range of measures to address all major obstacles to setting up a farm, such as access to land and access to credit. The reduction of decoupled income support entitlements will reduce the cost of land, although it could continue to act as an obstacle to entry. The eligibility criteria for entry support should not be limited to the applicant's age, with more targeted and long-term investment programmes on innovative business plans aimed at favouring the installation of labour from non-traditional populations outside the agricultural sector and with skills that are undersupplied. Design specific measures to reduce the barriers to entry for women, learning from the experience of other countries.

Regulations. Address the implementation gap on sustainability objectives and innovation barriers via SMART regulations

5. Enhance regulatory design

- ***Assess the impact of the agro-food regulatory environment on innovation with a view to promoting a more integrated approach to policy making [Current].*** This will enable a better evaluation of the trade-off between different risks before delivering new regulations (e.g. on genetically modified organisms, gene editing and pesticide use). It will also ensure that an integrated policy approach is developed, comprising all the policy measures necessary to overcome potential innovation barriers, as well as all the necessary incentives and investments in R&D that are often indispensable for making environmental regulations effective.
- ***The objectives and targets of all new regulatory initiatives and proposals should be SMART: specific, measurable, achievable, relevant and targeted [Next].*** While maintaining a high level of ambition, ensure that the objectives and targets of new regulatory initiatives and proposals are based on a sound scientific assessment of the actions required to achieve them. This will avoid responses to objectives perceived as unfeasible or focusing on loopholes and technical compliance that does not lead to real success. Follow an outcome-oriented approach as a guiding principle for the design and delivery of all new regulations, learning from the experiences of, for example, the Nature Restoration Regulation Law, which is a good example of increasing the *specificity* in objectives to foster a more effective outcome-oriented approach.

6. Refocus the role and scope of cross-compliance to increase its effectiveness

- ***Make regular training on agriculture-related regulations a part of CAP conditionality [Current].*** Compliance with compulsory regulations under the current statutory management requirements will be the core of this training. Advisory services will be proactively used to promote awareness and understanding and to provide continuous professional training.
- ***Reform cross-compliance by focusing enhanced enforcement on a reduced number of practices that are monitorable at a large scale [Next]*.** Reduce the scope of cross-compliance

by selecting GAEC that can be easily controlled at a large scale, including through satellite images or other digital tools (see the first action point in Recommendation 11). This will limit the administrative burden for Member States and farmers. In liaison with the improved remote sensing tools, on-farm controls should be substantially strengthened, and penalties should be proportional to the environmental damage caused to ensure compliance is incentivised. These GAEC will be a reference level for all voluntary AES and eco-schemes.

Innovation. Foster agro-food innovation, advice and skills as cornerstones of a new sustainable food systems approach

7. Put innovation at the centre of food systems to achieve greater synergies between different policies and meet green transition targets

- ***Undertake a systematic evaluation of the functioning of EIP-AGRI Operational Groups and their outcomes [Current]*.** In parallel, gather further evidence on the effectiveness of the use of these funds, as well as their contribution to the achievement of sustainability goals. Establish a mechanism to track the characteristics and performance of each partnership. Analyse this evidence and the main drivers of innovation outcomes. Identify the best set-ups and practices among OGs and use this information for innovation policy design and implementation. Take stock of lessons learnt from the existing projects and identify key enablers and possible barriers. This will continue to facilitate policy learning and allow future policy tools to be better designed to induce innovation efforts for agricultural sustainability.
- ***Transform long-term agricultural innovation strategy into a strong policy programming tool that effectively links different policy areas [Next]*** by achieving a stronger integration between the CAP tools and the research and innovation framework programmes. First, use it for multi-actor identification of innovation priorities. Then, ensure a cross-sector approach to foster agro-food innovation, in particular in areas under the jurisdiction of different directorate-generals. Pay increased attention to potential trade-offs and synergies between different policy goals, as well as to collaboration on cross-cutting challenges of the green transition. Proactive use of agricultural innovation strategy (at the EU and national levels) could steer and strengthen potential interlinkages. As part of this agro-food innovation strategy, include the skills agenda and a data strategy.
- ***Encourage EU Member States to establish their own agro-food innovation strategies that are fully integrated into the CSPs and consistent with the EU strategy [Next]*.** These strategies should include operational targets compatible with the vision set out in the EGD. Invest in improving governance and co-ordination of Member States' research and innovation agendas for the sector.

8. Use incentives and policy levers to steer agricultural innovation efforts towards environmental sustainability and meeting green transition targets

- ***Strengthen the participation of farmers in the AKIS, both in identifying the environmental challenges and in co-creating solutions [Current]*.** Given recent efforts to reduce administrative burdens and the lack of upfront funding, it will be necessary to reassess potential barriers to farmers' and advisors' active participation in innovation projects for environmental sustainability. On this basis, address barriers and create incentives to promote their active role in the co-production of knowledge and innovation. Foster further co-operation among different actors within the AKIS in the European Union. Use the AKIS strategy, in particular the advisory services and the skills agenda, to increase farmers' awareness of the role of innovation in tackling the productivity-sustainability trade-offs and of the tools and policy measures available.

- ***Strengthen the mission-oriented EU approach for the benefit of an environmentally sustainable agricultural sector [Next].*** At the level of objectives, strengthen the integration of a long-term agricultural innovation strategy into the overall EU mission approach. While doing so, take into account the needs arising at all stages of the innovation process and uptake, including building human capital in the sector. At the level of implementation, use CAP measures as policy levers to support mission objectives by integrating innovation aspects into agri-environmental measures. Use the best ideas from OGs' innovation projects to enrich the spectrum and improve the cost-effectiveness of eco-schemes.

9. Build a new and strong skills agenda for transforming the sector through a sustainability innovation pathway

- ***Improve the assessment and outlook of skills requirements for the agricultural sector [Current]***, in co-ordination with different actors of the AKIS and of the value chain. The objective is to identify skills gaps for the upcoming decade, taking into account the new environmental agenda and the need to keep businesses competitive, and to explore possible action tracks. Use this improved information on the sector's current and future skills needs to build a long-term skills agenda and education planning.
- ***Develop an ambitious skills agenda for the EU agro-food sector and promote the active engagement of Member States through the inclusion of specific measures in the CSPs [Current].*** In co-ordination with the European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience, establish a skills agenda for the EU agricultural sector to improve skills alignment with the needs of the green and digital transitions. Set ambitious objectives for the next five and ten years and a clear strategy for upskilling and retraining agricultural workers, with a particular emphasis on competencies in the areas of environmental management and digital technologies. Engage the relevant stakeholders, including regulators, education, research, advisory services and food chain actors in this process. To foster investment in skills, mobilise the financial means by leveraging existing instruments such as the European Social Fund Plus, Erasmus, Digital Europe or the CAP.
- ***Strengthen the system of advisory services, in particular in the areas of sustainable environmental practices [Current].*** Facilitate the training and upskilling of independent advisors so that they can provide up-to-date, evidence-based advice to farmers. In particular, strengthen their knowledge and awareness of environmental pressures, sustainability practices and new technologies. Promote innovative ways to encourage the use of qualified advisors, e.g. through a voucher scheme as recently introduced in the Netherlands or an online platform for agro-food advisors as announced by Spain.
- ***Upskill farmers via a lifelong learning approach as an integral part of payments for environmental services (PES) [Next].*** Promote various learning methods, including self-learning, expert teaching, and peer-to-peer learning through online and in-person (with hands-on activities) channels. Address identified barriers to farmers' participation in adult and vocational training. For instance, target selected upskilling actions to farmers of different ages and qualification-level groups or those in remote areas. Also, specific advisory services could be proposed as part of PES to enhance farmers' awareness and knowledge of the required practices.

Data. Strengthen data-driven policy design, assessment and monitoring

10. Strengthen the EU agro-food data strategy to respond to the triple challenge of food systems and the corresponding data needs from farmers, the food chain and policy makers

- ***Expand the agricultural data strategy as an integral part of the European Union's agro-food innovation strategy [Current].*** Identify the main data gaps and implement actions to tackle them. Address the problem of a heterogeneous and fragmented data landscape in different policy areas and across EU Member States. Expand this strategy to identify priorities, especially in two areas: 1) agri-environmental performance at farm, landscape, regional and country levels responding to the new EGD ambitions; 2) farm household income and the social dimensions of farming, such as migrants and gender.
- ***Use the CAP budget to support investment in data and the use of digital technologies [Next].*** CAP measures should provide incentives to gather more data for farmers and policy makers. In order to fully adopt a performance-based approach, the lack of synchronisation between the CAP's policy cycle and the implementation of data initiatives like the FSDN needs to be addressed and improved for future CAP reforms.

11. Enhance digitalisation to monitor policies, create awareness, facilitate knowledge exchanges and find innovative solutions

- ***Make more extensive use of digital platforms to better monitor the implementation of agricultural and agri-environmental policies [Current].*** For instance, include platforms based on earth observation data as part of the formal policy monitoring process. In particular, greater use of highly differentiated spatial data (e.g. by parcel) on agricultural practices and landscape characteristics (e.g. slope, proximity to receiving waters, soil type) could allow for the implementation of more spatially targeted, monitorable and dynamically flexible policies.
- ***Address challenges farmers face in adopting digital technologies [Current]***, including lack of relevant skills, lack of trust, non-compatibility with farmers' needs, investment and maintenance costs, institutional constraints, transparency, oversight, and responsibility. Avoid new digital divides through accompanying measures to ensure equal access to technologies. Build farmers' digital technology awareness and strengthen the competencies needed to take advantage of digital technologies by directing part of the CAP measures dedicated to knowledge exchange and advice to these issues. Furthermore, allocate part of the CAP measure dedicated to investment to support the adoption of innovative digital technologies that are commercially available but not yet widely adopted within a given farm type. Provide space for experimentation on digital technologies for sustainability in the agricultural sector by enhancing co-operation between regional European digital innovation hubs and EIP-AGRI operational groups.
- ***Leverage digital technologies to strengthen advisory services [Current].*** Promote the use of digital tools to facilitate the offer and use of advisory services and encourage the provision of impartial advice on digital technologies. Encourage the creation and use of online advisory services, access to digital tools that provide advice on a wide range of topics, and encourage the provision of advisory services to groups of farmers with similar needs. Exploit the potential of digitalisation in knowledge exchange and diffusion for the professionalisation of advisors by training advisors with new technologies that monitor farm practices and processes.

12. Facilitate policy learning by addressing data gaps and improving evidence on the effectiveness of innovation partnerships

- ***Build evidence to better inform policy design [Current].*** Leverage the momentum generated by the transition from the FADN to the FSDN to ensure that the range of variables covered by the FSDN is comprehensive and sufficient to inform policy in key areas.
- ***Continue to improve the quality and availability of existing indicators on R&D and innovation policy efforts and impacts [Current].*** Enhance efforts to collect data on investment in agricultural R&D by thematic area to better monitor the contribution of agricultural innovation systems to the widely acknowledged goals of productivity, sustainability and resilience. To benefit multiple analytical projects and help better inform policy, encourage individual EU Member States to share existing data that have not yet been made public.
- ***Gather further data for the monitoring and evaluation of multi-actor innovation partnerships and projects [Current].*** Monitor and analyse their impacts on the sustainability of the sector and the uptake of innovation and experience from co-creation projects by both participating and non-participating farmers. Map themes explored in different projects and develop an analytical framework (including modelling) to assess whether obtained results depend on local conditions or whether the solutions could be implemented in different contexts.

Environmental services. Adopt result-based payments and collective action, and introduce reporting on results

13. Promote collective action for the delivery of environmental public goods and services

- ***Pilot collective agri-environmental measures (AES and eco-schemes) [Current].*** Use pilot experimentation to move from single field or farm to landscape space-based environmental action. Allow CAP payments to local authorities, local collectives or groups of farmers to ensure more effective achievement of environmental and climate outcomes, to increase capacity for landscape monitoring and to simplify requirements for beneficiaries.
- ***Use the CAP to promote collective action on environmental sustainability and innovation [Next].*** A broader strategy should be adopted to address the main barriers preventing the large-scale uptake and implementation of collective measures. Pillar 2 payments to resolve a local sustainability pressure or deliver local public goods should be made, by default, to the community of farmers facing the joint challenge, building on existing experiences in some Member States. Include in such measures a technical assessment of the environmental priorities and best responses and make the payment based on results. Promote synergies and direct links to other innovation measures and initiatives, such as the EIP-AGRI operational groups, to induce the co-creation of the best solutions to achieve results.
- ***Consider introducing collective penalties [Next].*** For instance, in river basins that violate Water Framework Directive objectives, based on an assessment, a share of the CAP direct payment could be retained from all farmers in the river basin until performance improves. This funding could be allocated to managers of resources (e.g. river basin authorities, municipalities or other local authorities) to improve monitoring, management, extension and advice.

14. Transform voluntary schemes into result-based payments for environmental services (PES)

- ***Encourage greater experimentation with AES and eco-schemes design towards result-based multi-annual payments for biodiversity and ecosystem services [Current].*** In the context of a transition towards PES, facilitate a learning process to rapidly move from practice requirements towards requirements based on results in the next CAP programming period. Related

efforts, both in terms of budget and dedicated policy tools, should be increased by investing in piloting projects, advisory and communication.

- ***Provide training to support the adoption of result-based approaches [Next].*** Help farmers understand the environmental challenges on their farms by providing training and assistance for environmental impact assessment, with specific reference to which changes they can implement to reach the goals set by result-based AES and eco-schemes. When farmers better understand the consequences of their choices, they may be more likely to adjust their practices.

15. Introduce reporting on results and ex ante assessment for payments for environmental services (PES)

- ***Require reporting on results by the beneficiaries of PES [Current]*.** Connect this reporting with SMART (specific, measurable, achievable, relevant and time-bound) objectives to enable an effective policy design cycle in a shorter timeframe. Consider introducing higher financing rates for farmers participating in schemes who have undertaken an environmental impact assessment of their farm operation through a recognised process.
- ***Make the eligibility to PES conditional to an ex ante assessment of the local environmental conditions [Next]*** to identify the main pressures and priority actions and create a baseline against which progress can be measured. Use this assessment as the basis to improve the coherence and targeting of the adopted policy measures, as well as their environmental performance. Take advantage of the opportunities offered by ongoing digitisation, including satellite data and machine learning. Promote the agri-environmental assessment in a collective manner for farmers envisaging a similar environmental situation and public good demands in the same location.

1 Policy objectives and outcome performance

The European Green Deal (EGD), with the associated Farm-to-Fork and Biodiversity Strategies, provide a new context for the EU Common Agricultural Policy (CAP). They embrace a broad food systems approach, responding to new demands for environmental sustainability. This chapter benchmarks outcome performance in the European Union against other OECD and non-OECD countries. Agricultural productivity is growing, but slower than in other countries and not always associated with an improved sustainability performance. A key challenge for the EU agro-food sector is ensuring that innovation can be successfully mobilised to improve resource efficiency and reduce farm-level production costs, to reconcile economic and environmental sustainability in the long term.

Key messages

- With the European Green Deal (EGD), the European Union aims to make Europe climate-neutral and protect its diverse natural habitats and transform the European economy. The Farm to Fork (F2F) and the Biodiversity Strategies include six agriculture and rural development targets to be achieved by 2030.
- The Common Agricultural Policy (CAP), representing about one-third of the EU budget, is playing an important role in operationalising the EGD vision and objectives in agriculture. The core of the CAP 2023-27 was approved before the EGD. It takes a performance-based approach around ten specific objectives, with more flexible implementation by Member States compared to previous CAP reforms. These objectives are consistent with the broader desired outcomes under the OECD Agro-Food Productivity-Sustainability-Resilience (PSR) Policy Framework.
- The European Union has maintained moderate agricultural total factor productivity (TFP) growth rates, ranging between 0.7% and 1.4% per year since the 1980s. This is on par with the international average, but in the 2011-19 period, TFP growth was below the world average. Most of the gains in TFP result from improved labour productivity.
- Since the 1960s, pre-2004 Member States (EU14) have maintained a high TFP growth driven by steady labour declines. In the last decade, their TFP growth has slowed down while it has strongly accelerated in the post-2004 Member States (EU13) thanks to a fast increase in output growth and a stable growth of input use.
- Overall, agriculture in the European Union has successfully achieved a partial decoupling of direct greenhouse gas (GHG) emissions from production levels, but absolute emissions have been stable rather than falling in recent years.
- During the last 20 years, agricultural areas have suffered severe biodiversity losses. Furthermore, despite a recent decline, EU27 nitrogen per hectare levels still exceed critical limits, leading to adverse effects on the environment. Annual pesticide sales remained relatively stable between 2011 and 2019, with increased levels of production and the purchase of less hazardous substances.
- The EGD ambition may have short-term negative impacts on the economic sustainability of the agriculture sector. These impacts may be counteracted in the long term if the new innovations can be successfully mobilised to improve resource efficiency and reduce farm-level production costs.

The European Commission presented its proposal for the new CAP 2021-2027 reform in June 2018, introducing a new way of working to modernise and simplify the European Union's policy on agriculture. The EGD was presented by the newly elected Commission a year and a half later, in December 2019. This chapter first outlines the scope of this review and provides an overview of the main EU agricultural and food policy objectives (Section 1.1). It then provides an assessment of EU trends in agricultural productivity (Section 1.2) and agri-environmental (Section 1.3) performance. Section 1.4 provides insights on future challenges of reconciling economic and environmental dimensions of sustainability in EU agriculture. Annex 1.A includes a more detailed analysis of the agri-environmental performance of EU Member States.

1.1. Frame and scope of this review

Agriculture plays a critical role as a sector that manages half of the European land surface and contributes to more than a tenth of GHG emissions. The European agro-food system must address the triple challenge facing food systems: ensuring food security and nutrition, providing livelihoods for actors in the food chain and improving environmental sustainability. Tackling this triple challenge is more difficult in the new policy context of growing environmental concerns and successive global crises. The systemic shock of the COVID-19 crisis, the war in Ukraine, and the need to halt and reverse the loss of ecosystem services and to adapt to climate change make improving resilience to unforeseen shocks and environmental sustainability even more urgent.

The EGD aims to accelerate progress to make Europe climate-neutral and protect its diverse natural habitat. The EGD was defined as a "new growth strategy that aims to transform the European Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" (EC, 2019[1]). As the policy environment evolves towards being progressively structured towards sustainability objectives, the CAP is increasingly important to operationalise the vision and objectives of the EGD for the farming and food sector because of the financial resources associated with it (Box 1.1).

The objective of this review is twofold. First, it examines to what extent past EU policy instruments and interventions (as in place until 2022), including national measures in some Member States, enhanced the productivity, sustainability and resilience of the European Union's food and agriculture sector. Second, since the EGD has created a new scenario for the future CAP, this review looks at the CAP 2023-27 architecture, objectives and interventions with respect to their readiness to include new roles and functions coherent with the EGD objectives to propose change in the following CAP programming period.

Box 1.1. Objectives of the European Union's Common Agricultural Policy

The Common Agricultural Policy (CAP) is the first common policy adopted by the European Union (EU) under the Treaty establishing the European Economic Community (the Treaty of Rome) in 1957 (Article 38). It is based on three principles: a common market, community preference and financial solidarity. Since its implementation in 1963, the CAP has evolved in response to domestic pressures, including changes in agricultural policy priorities, efficiency improvements and budget constraints, and to international pressures to reduce trade distortions. Nevertheless, the following CAP objectives set out in the Treaties have not changed since its creation:

a) to increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and the optimum utilisation of the factors of production, in particular labour

b) thus to ensure a fair standard of living for the agricultural community, in particular by increasing the individual earnings of persons engaged in agriculture

c) to stabilise markets

d) to ensure the availably of supplies

e) to ensure that supplies reach consumers at a reasonable price.

However, Article 5 of Regulation (EU) No. 2021/2115 states a significantly broader set of objectives for the CAP 2023-27. The new CAP shall aim to further improve the sustainable development of farming, food and rural areas and shall contribute to achieving the following general objectives in the economic, environmental and social spheres, which will contribute to the implementation of the 2030 Agenda for Sustainable Development:

a) to foster a smart, competitive, resilient and diversified agricultural sector ensuring long-term food security

b) to support and strengthen environmental protection, including biodiversity, and climate action and to contribute to achieving the environmental and climate-related objectives of the Union, including its commitments under the Paris Agreement

c) to strengthen the socio-economic fabric of rural areas.

Source: EU (2021[2]).

1.1.1. Assessing past EU agricultural policies through the OECD PSR Framework

The OECD Agro-Food Productivity-Sustainability-Resilience Policy Framework (OECD, 2020[3]) (the "PSR Framework") is used to frame the analysis and assess to what extent the European Union has achieved the objectives of its past agricultural policy. The PSR Framework captures the main objectives of the 2016 OECD Declaration of the Agricultural Ministers as it helps advise countries on the policy mix that can best contribute to enhancing the productivity, sustainability and resilience of their food and agriculture sector.

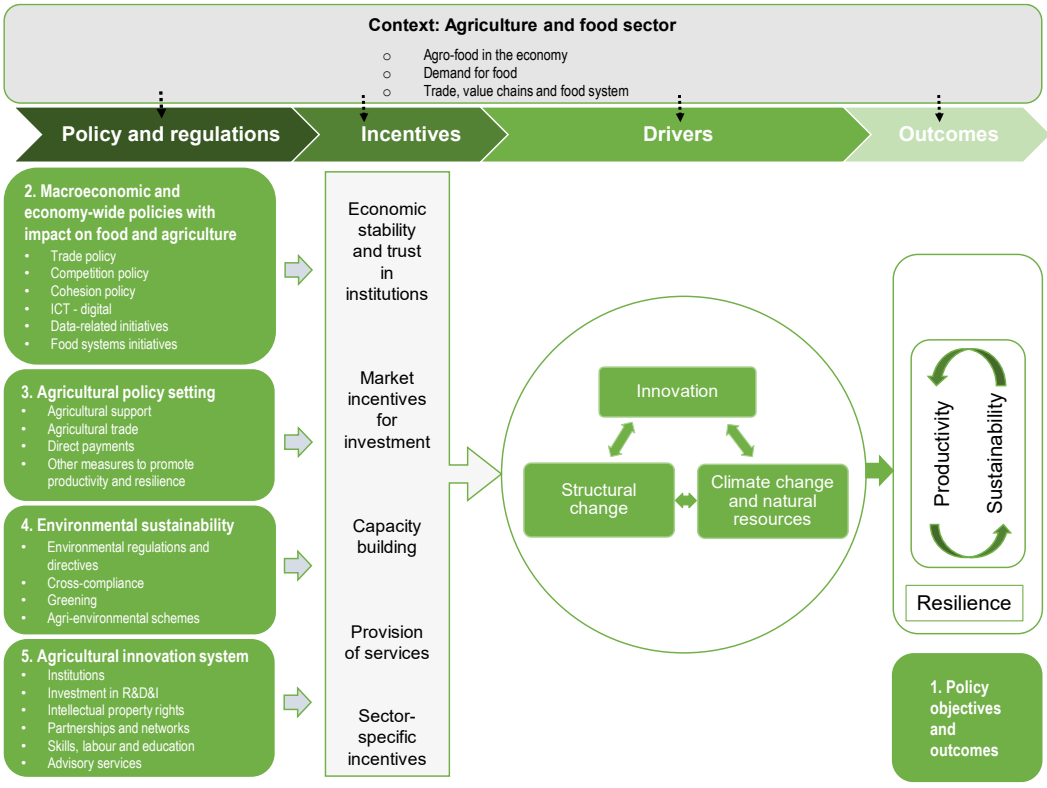
Since 2015, the OECD has applied different iterations of the PSR Framework in 13 in-depth country reviews, with 12 "Innovation, agriculture productivity and sustainability reviews", and the application of the most recent version of the PSR Framework to Norway (OECD, 2021[4]). These reviews identified how countries' policy settings addressed productivity, sustainability and resilience challenges and how they could be improved (OECD, 2019[5]). In the context of this review, the PSR Framework has been adapted to analyse the specific current policy challenges and opportunities for the European Union (Figure 1.1).

The PSR Framework implements an evidence-based approach built on indicators, including the OECD's Producer Support Estimate (PSE) and its composition by support categories (OECD, 2022[6]), as well as on the OECD agri-environmental indicators (OECD, 2019[7]). This review also relies on OECD work on Agricultural Total Factor Productivity (Bureau and Antón, 2022[8]) and uses the OECD Recommendation of the Council on Water (OECD, 2016[9]) as a reference.

The OECD PSR Framework and indicators not only help analyse the policy tools adopted to achieve objectives for the sector and to track progress, but also provide insights on the relationship between different objectives. That is, some policies may not only be inefficient at reaching their objective, they may also undermine progress on others. The PSR Framework can help identify appropriate policy packages to efficiently target multiple objectives.

The PSR Framework identifies innovation, structural change, natural resource use and climate change as the drivers of productive, sustainable and resilient agro-food systems, and considers how they are affected by policy incentives. The framework emphasises synergies and coherence between policy areas and avoids contradictory policy signals. Such coherence is fundamental to achieving a more productive and sustainable food and agriculture sector, which is also prepared for and resilient to future shocks.

Figure 1.1. OECD Agro-Food Productivity-Sustainability-Resilience Policy Framework



Note: The five light green boxes correspond to the five chapters of the review. Chapter 2, besides economy-wide policies, also discusses the context of the European Union agro-food sector and the three drivers of change.
Source: Adapted from Figure 1 in OECD (2020[3]).

In the context of this review, the PSR Framework was mainly used to examine EU policy instruments, but in order to complement and integrate the policy analysis, additional data and information were gathered through two online surveys with EU Member States: one on the key design features of the agri-environmental schemes (results are presented in Chapter 4, Section 4.3.4) and one on key features of Member States' agricultural innovation systems (the main results are included in Chapter 5 and the objectives and contents of the two surveys are described in Annex 1.B). While the analysis covers the series of agricultural policy reforms implemented over the period 1986-2020 and focuses in particular on reforms since 1992, a more detailed analysis was carried out for measures adopted during the 2014-20 programming period.

1.1.2. Exploring the challenges for EU agricultural policies in the context of the European Green Deal

The European Green Deal (EGD) is the blueprint for making the European Union the first climate-neutral continent by 2050. To get there, the 27 EU Member States pledged to reduce emissions by at least 55% by 2030, compared to 1990 levels. The EGD consists of a set of proposals made by the European Commission for a wide range of policies, including a strong role for the Common Agricultural Policy (CAP) (EC, 2019[1]).

The Farm-to-Fork (F2F) and Biodiversity Strategies, both adopted in May 2020, are additional strategies within the EGD with implications for agriculture and food. The F2F Strategy (EC, 2020[10]) aims to address the challenges of sustainable food systems by recognising the links between healthy people, healthy

societies and a healthy planet. The strategy is also central to the European Commission's agenda to achieve the United Nations' Sustainable Development Goals (SDGs). The strategy highlights that "a sustainable food system will be essential to achieve the climate, biodiversity and other environmental objectives of the Green Deal, while improving the incomes of primary producers and reinforcing the EU's competitiveness". The Biodiversity Strategy (EC, 2020[11]) is another key component of the EGD with direct linkages to the agricultural sector. This strategy is a long-term plan to protect nature, reverse the degradation of ecosystems and build resilience to future threats (including the impacts of climate change, forest fires and disease outbreaks.

The F2F and the Biodiversity Strategies include six agriculture and rural development targets to be achieved by 2030:

- reduce by 50% the overall use and risk of chemical pesticides and by 50% more hazardous pesticides
- have at least 25% of the European Union's agricultural land under organic farming and a significant increase in organic aquaculture
- reduce by 50% sales of antimicrobials for farmed animals and in aquaculture
- reduce nutrient losses by at least 50% while ensuring no deterioration in soil fertility; this will reduce the use of fertilisers by at least 20%
- bring at least 10% of agricultural area under high-diversity landscape features
- achieve 100% access to broadband Internet in rural areas (by 2025).

In addition to the F2F and Biodiversity Strategies, the European Commission adopted a series of legislative proposals under the EGD to transform the European Union into a net zero emissions economy by 2050 (the Fit for 55 package). In particular, EU Regulation 2021/1119 (the so-called European Climate Law) sets into law the goal set out in the EGD for Europe's economy and society to become climate-neutral by 2050. It also sets the intermediate target of reducing net GHG emissions by at least 55% by 2030, compared to 1990 levels. The European Commission is also revising several pieces of EU climate legislation, including the EU Emissions Trading System, the Effort Sharing Regulation, transport and land-use legislation, and setting out how to reach EU climate targets under the EGD. Although agriculture was not specifically mentioned in the European Climate Law, in June 2021, the European Commission presented proposals on legislative tools to deliver on the targets agreed upon in the European Climate Law, paying ample attention to both the agriculture and the land use, land-use change and forestry (LULUCF) sectors. By 2035, the European Union aims to reach climate neutrality in the LULUCF sector, including also agricultural non-CO_2 emissions, such as those from fertiliser use and livestock. The European Commission's proposed revisions to the LULUCF Regulation aim at merging the LULUCF sector with non-CO_2 emissions from agriculture within the Regulation's accounting system by 2031, which would become the agriculture, forestry and other land-use (AFOLU) sector (Chapter 4, Section 4.2.1). While the provisional political agreement on changes to the LULUCF Regulation is not yet publicly available,[1] the Commission will submit an additional report in 2023 on whether non-CO_2 GHG emissions from agriculture should be included in the scope of the LULUCF Regulation.

Some of the F2F targets, such as reducing the overall use of pesticides, fertilisers and antimicrobials, are directly related to water quality. Overall, the strategy aims to align the goals and requirements of water legislation and other EU directives that have an impact on the quality of drinking water resources, in particular, the Water Framework Directive, the Nitrates Directive and the Sustainable Use of Pesticides Directive (Chapter 4, Section 4.2.4). At the same time, the F2F does not seem to address the sustainable management of water resources systemically. It also does not directly address the challenge of securing water supplies in a scenario characterised by increasingly recurrent drought and the excessive water abstraction for irrigation purposes that may cause local problems to the security of the drinking water supply.

The European Commission presented its proposal for the CAP 2023-27 reform in 2018, introducing a new way of working to modernise and simplify the European Union's policy on agriculture (EC, 2021[12]). The CAP 2023-27 is based on a more flexible implementation by Member States that considers local conditions and needs, with a performance-based approach seeking to increase the European Union's ambitions in terms of sustainability. It is built around ten specific objectives (Figure 1.2), which are also the basis upon which EU Member States have designed their CAP strategic plans (CSPs). Such objectives are linked to common EU goals for social, economic and environmental sustainability in agriculture and rural areas (Chapter 3 includes a more comprehensive analysis of CAP objectives and instruments).

In June 2021, the European Commission published a communication with its vision for stronger, connected, resilient and prosperous rural areas by 2040 (EC, 2021[13]). Although this is not a legislative proposal and there is no reference to it in the CAP 2023-27 regulations as it was adopted after negotiations were concluded, it introduces an innovative, collaborative process that may play a role in involving relevant stakeholders in the delivery of some of the EGD's objectives: the "rural pact" (EC, 2022[14]), which aims at mobilising public authorities and stakeholders to respond to the needs and aspirations of rural communities. The proposed vision also came with an EU rural action plan, to mainstream rural actions across a range of EU policies, including actions to create new employment opportunities and better access to infrastructure and services. As part of this action plan, a mechanism was put in place in 2022 and is being implemented to assess whether major EU legislative initiatives are "rural-proof", and a rural observatory (EU, 2022[15]) was launched to centralise, valorise and analyse data on rural areas.

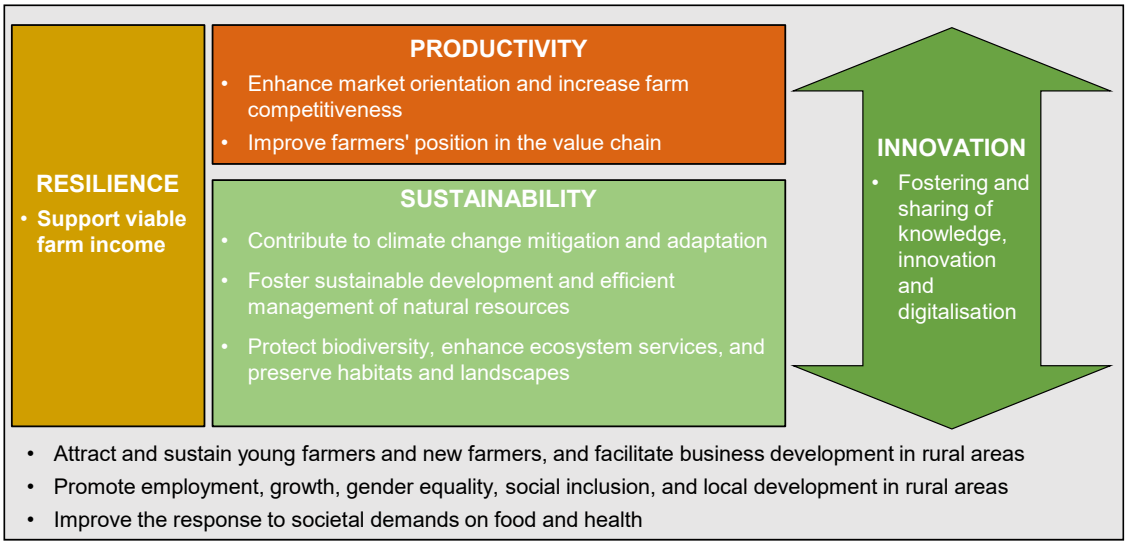
Many of the EGD's targets are not yet enshrined in legislation and there are no legal links between the CAP and the F2F and Biodiversity Strategies' targets. Moreover, so far, the EGD and related strategies have not been endorsed by the European Council and European Parliament and represent the views of the Commission only. Nevertheless, the CAP 2023-27 regulation on CSPs states that "When assessing the proposed CAP strategic plans, the Commission should assess the consistency and contribution of the proposed CAP strategic plans to the Union's environmental and climate legislation and commitments and, in particular, to the Union targets for 2030 set out in the F2F and Biodiversity Strategies" (see Chapter 3 for further details). It is evident that the EGD has created a new framework for the future of EU agricultural policies. It also calls for new roles and functions for the CAP, which need to be scrutinised and analysed in a new light.

Figure 1.2. The specific objectives of the Common Agricultural Policy 2023-27

Source: EC (2021[12]).

While not all of the ten objectives of the CAP reported in Figure 1.2 are included specifically in the PSR Framework and associated indicators (especially those referring to rural areas and societal demands on food and health), the fundamental goals of the CAP 2023-27 – including those established by the F2F Strategy, the Biodiversity Strategy and the Climate Law – are reflected in PSR outcomes (Figure 1.3).

Figure 1.3. The CAP 2023-27 objectives through the OECD Agro-Food PSR lens



Source: Authors' elaboration based on EC (2021[12]).

1.2. Benchmarking productivity performance in the European Union

Broadly, the key objectives of the CAP are consistent with the OECD PSR Framework and reflected in the related set of indicators that have been used to benchmark the productivity and sustainability of the EU farming sector. The core indicators used to measure outcomes in the PSR framework include: Total Factor Productivity (TFP) growth; and agri-environmental indicators such as nitrogen and phosphorus balances, agricultural GHG emissions, on-farm energy consumption, and the Farmland Bird Index.

TFP,[2] which measures the change in the ability of the sector to produce more with less, is an important indicator of performance to achieve these policy objectives. For example, TFP has played an important role in decreasing the emissions intensity of agricultural production (i.e. emissions per unit of output). TFP growth reflects the ability of the sector to use agricultural inputs more efficiently (higher output per kilogramme of fertiliser, per animal, per kg of animal feed, and per litre of fuel or kilowatt of electricity) and avoid harmful land-use changes (higher output per hectare of cropland or pasture) (OECD, 2022[6]). The PSR Framework (OECD, 2020[3]) includes an analysis of output growth and its components as a main tool to provide useful insights on productivity and sustainability performance in the long term. Combining TFP numbers with agri-environmental indicators such as on GHG emissions and nutrient balances provides additional insights into how productivity affects environmental performance.

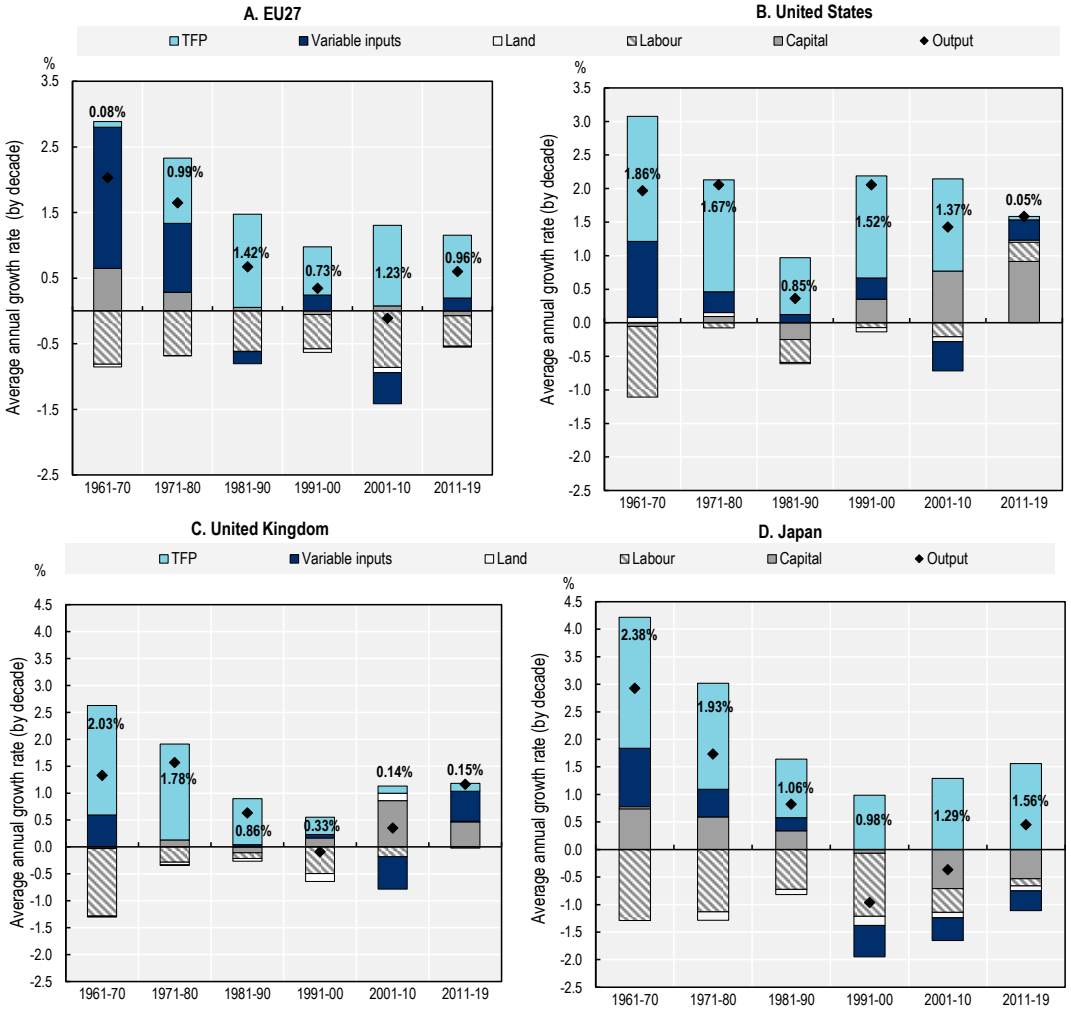
1.2.1. Agricultural output and productivity growth

Productivity growth is a useful performance indicator, not only for the sector's contribution to food security objectives but also for creating economic value for farms and for the competitiveness of the farming sector. OECD agri-environmental indicators can be used to assess the European Union's environmental sustainability objectives, including climate change mitigation and adaptation, the efficient management of natural resources, and the preservation of biodiversity.

Productivity growth is also desirable because more efficient use of resources responds to the desire to strengthen sector competitiveness by ensuring a viable income for farmers as well as creating new businesses and job opportunities. Equally, productivity improvements that reduce input use can help achieve the European Union's sustainability objectives. Furthermore, a deteriorating natural resource base may reduce the production system's resilience to climate variability and depress present and future productivity.

Agricultural output growth in the European Union[3] has weakened since the 1960s. The European Union has not maintained the strong growth rates achieved in the 1960s (2.0% per year on average; Figure 1.4) and 1961-2010 was characterised by a steadily declining pace of output growth, which became even slightly negative in the 2000s. Following a similar pattern as other countries like Japan, output growth has accelerated again recently (2011-19), while remaining weak compared to other countries (e.g. 0.6% compared to 1.6% per year in the United States). The performance of the United States in terms of output expansion has been mostly strong throughout the last six decades.[4]

Figure 1.4. Decomposition of output growth in the European Union, the United States, the United Kingdom, and Japan, 1961 to 2019

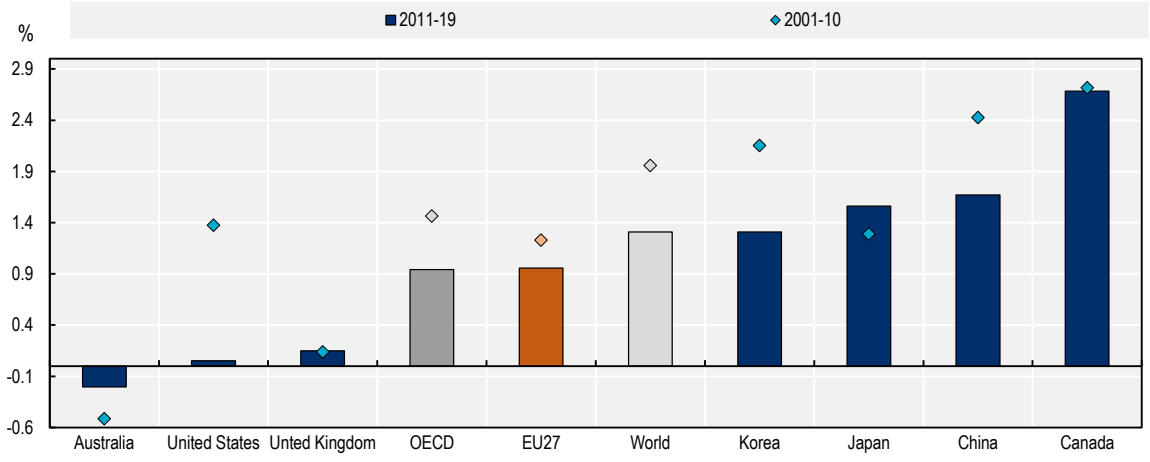


Notes: TFP: total factor productivity. Total annual agricultural output growth is calculated as an average for each of the six decades. Growth rates for TFP and inputs are expressed as contributions to the total annual growth rate so that the growth in outputs minus the growth in inputs equals TFP growth, i.e. TFP growth is the residual. Percentage values (in bold) refer to average annual TFP growth for the period. Variable inputs comprise feed and fertiliser. Capital refers to livestock and machinery.
Source: Authors' calculations based on USDA ERS (2021[16]).

TFP growth became the main driver of production growth in the European Union in the 1980s, two decades later than in several OECD countries, such as those included in Figure 1.4, but before the world average, which saw productivity becoming the key component of output expansion only in the 1990s. The transition from a growth model largely based on intensification (use of more inputs, and especially variable inputs) to one driven by productivity growth is crucial to reduce the environmental pressures associated with increasing agricultural production (OECD, 2022[6]). Since the 1980s, the European Union has had respectable TFP performance, with growth rates ranging between 0.73% and 1.42% per year (Figure 1.4).

The period between 2011 and 2019 saw a worldwide slowdown in productivity growth (Figure 1.5). This was less pronounced in the European Union, where TFP growth only declined by 0.27 percentage points and settled at an average rate of 0.96% per year (Figure 1.4). By contrast, productivity growth in the United States stalled at 0.05% per year after having been largely above 1% per year in all previous decades (with the exception of the 1980s). In the United Kingdom, productivity has experienced low rates of annual growth, below 0,4%, since the 1990s, while Japan has kept productivity growing at 1% or above. TFP growth in the European Union in the 2011-19 period was below the world average of 1.3% per year but close to the OECD average of 0.9% (Figure 1.5). Some OECD countries achieved large improvements in TFP growth in the last decade while others stagnated. Japan (1.5%) and Canada (2.5%) performed well, the United Kingdom and the United States slowed, and Australia saw a decline in TFP growth.[5]

Figure 1.5. Growth in agricultural total factor productivity (TFP) in the European Union and selected countries



Source: Authors' calculations based on USDA ERS (2021[16]).

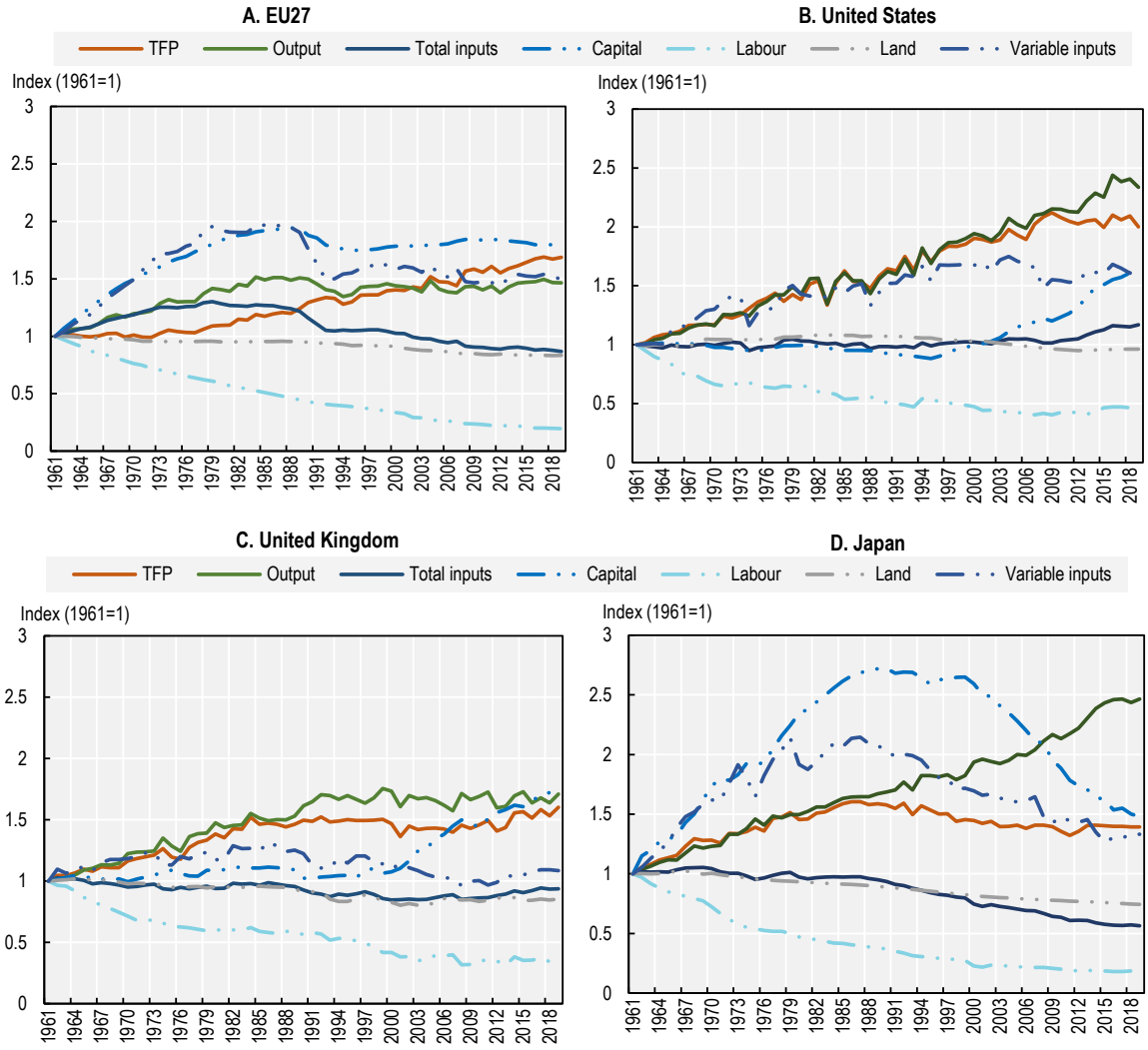
1.2.2. Evolution of inputs and output growth

Technology improvements and gains in efficiency have driven output growth overall in the past 60 years, compensating for large reductions in labour and smaller reductions in land use. Agricultural output grew by 50% in the European Union between 1960 and 2019 while total input use, including labour, declined by 13%, resulting in a 68% increase in TFP (the rates of output and input growth were 130% vs. 17% in the United States, 143% vs. -44% in Japan and 64% vs. -6% in the United Kingdom) (Figure 1.6). In the European Union, variable inputs and capital kept pace with output growth, while land use, and particularly labour, strongly decreased. The "miracle" of producing more with less is called total factor productivity (TFP), which increased by 68%.

Labour outflows are a common feature of agricultural development. The European Union experienced a consistent and rapid outflow of labour from the agricultural sector, with an accumulated 80% reduction of

agricultural labour over the last six decades (Figure 1.6), representing 4.3% of the total EU working population in 2019 (World Bank, 2023[17]; Eurostat, 2020[18]). Labour outflows occurred in parallel with structural change as the sector moved towards fewer, larger farms. As shown in Chapter 2, between 2005 and 2020, the number of EU agricultural holdings has fallen by 36%. While the number of holdings of less than 5 hectares fell by 45%, the number of farms of 100 hectares or more increased by 29%. Over this same period, the average utilised agricultural area (UAA) increased by 58%, although there is still a significant gap in average UAA per farm between EU13 and EU14 countries. Agricultural labour also declined in other OECD countries: 82% in Japan and 66% in the United Kingdom. In the United States, after a rapid reduction in the 1960s, agricultural labour fell at a slower rate in most decades, with an overall decline in the level of farm labour over the period of approximately 50% (Figure 1.6).

Figure 1.6. Evolution of output, inputs use and total factor productivity (TFP) in the European Union, the United States, the United Kingdom, and Japan, 1961 to 2019



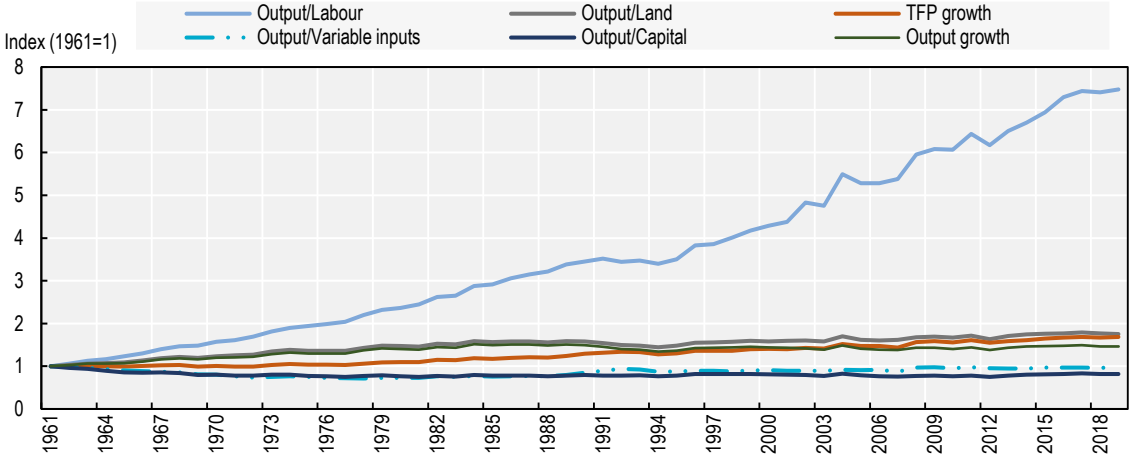
Source: Authors' calculations based on USDA ERS (2021[16]).

The fast outflow of labour in the European Union, comparable to that of Japan, has resulted in a steep increase in total output per worker (partial productivity of labour). In 2019, total output per worker was almost eight times higher than in 1961 (Figure 1.7). Most of the gains in TFP in the European Union were

concentrated in labour productivity. This is common among most OECD countries, but in some countries like the United States, the partial productivity of land, variable inputs and capital also increased.

After modest growth in the 1960s and 1970s, the use of capital (including machinery and livestock) of European agriculture has remained mostly stable. In Japan, capital investment has fallen over the last three decades. This lack of capitalisation contrasts with the United Kingdom and the United States, where agricultural capital was rapidly built up in the last two decades, partially explaining their recent stagnant productivity growth in the period 2011-19. While reducing measured TFP growth in the short term, capital investments may result in stronger productivity improvements over time as the benefits of new technologies embedded in this capital materialise. In that regard, the limited capital investments of EU farms in the last few decades may weaken opportunities for future productivity growth.

Figure 1.7. Evolution of agricultural production, partial and total factor productivity in the European Union, 1961 to 2019



Notes: TFP: total factor productivity. EU27.
Source: Authors' calculations based on USDA ERS (2021[16]).

Over the last 60 years, the European Union has been able to grow its agricultural output without significantly expanding the amount of land under production. Preventing further conversion of natural land to agriculture through continued productivity improvements can have important environmental benefits, especially in terms of avoided GHG emissions from land-use changes; nonetheless, the resulting intensification of production may raise other sustainability concerns, for instance in relation to soil and water pollution and biodiversity preservation (OECD, 2022[6]).

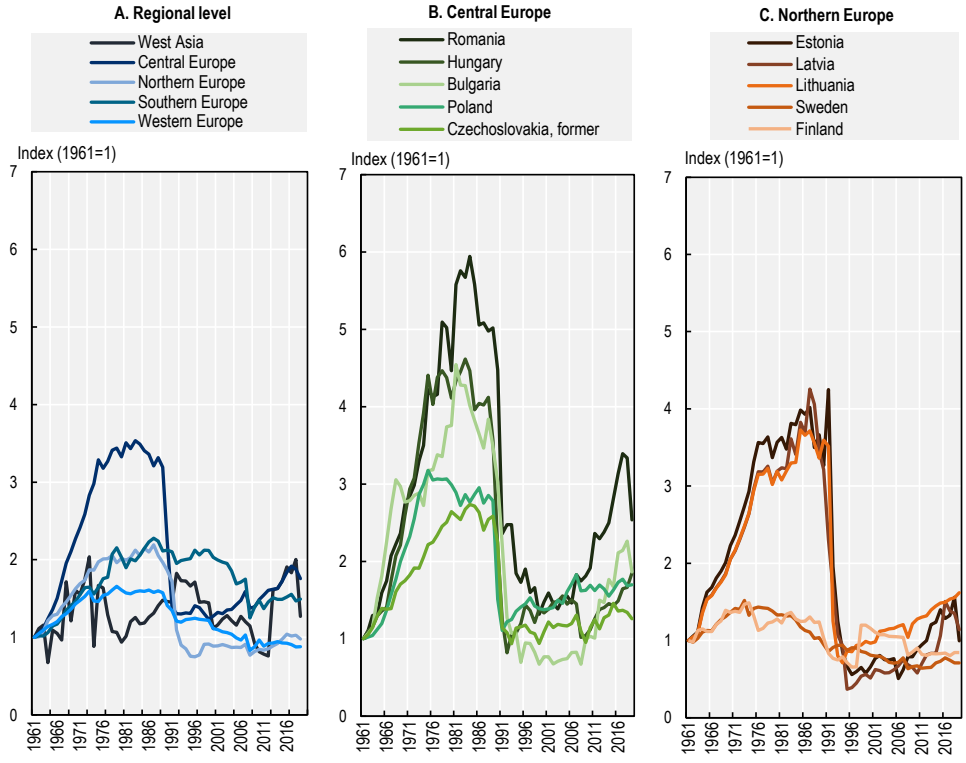
Before TFP growth became the main driver of EU output growth, increased agricultural production was driven by the growth of variable inputs (fertilisers and feed). The use of variable inputs in the EU agricultural sector nearly doubled over two decades, then stabilised in the 1980s (Figure 1.6). The slowdown in the growth of variable inputs use, together with the ongoing decline in farm labour, was reflected in accelerated TFP growth.

However, the most recent decade has exhibited a change in trend toward increasing use of variable inputs in the European Union, as well as in the United Kingdom and the United States. The European Union has not yet succeeded in decoupling output growth from the use of variable inputs, which is clearly significant in view of the F2F targets to reduce the absolute level of input use. The evolution of fertiliser use in Central and Northern Europe drove an abrupt, but short-lived, decline in variable inputs between the last years of the 1980s and the very early 1990s (Figure 1.8).[6] The sharp rise and fall in fertiliser use was particularly

severe in Romania, Hungary, Bulgaria, Estonia and Latvia and, where in the mid-1980s, the use of fertilisers was between four and six times higher than in 1961, before falling to, or sometimes even below, its initial level by the early 1990s.

The dramatic change in fertiliser use coincided in time with the transition process towards democracy of the former Eastern bloc and is common, to some extent, to all those countries.[7] The decline in input use, especially fertilisers, was among the most evident consequences for agriculture of the socio-economic and institutional reforms implemented in the post-Communist transition from centrally planned towards market-oriented economies (Macours and Swinnen, 2000[19]). In particular, price and trade liberalisations resulted in a stark increase in the price of agricultural inputs relative to that of outputs.

Figure 1.8. Evolution of fertiliser use across European regions, 1961 to 2019

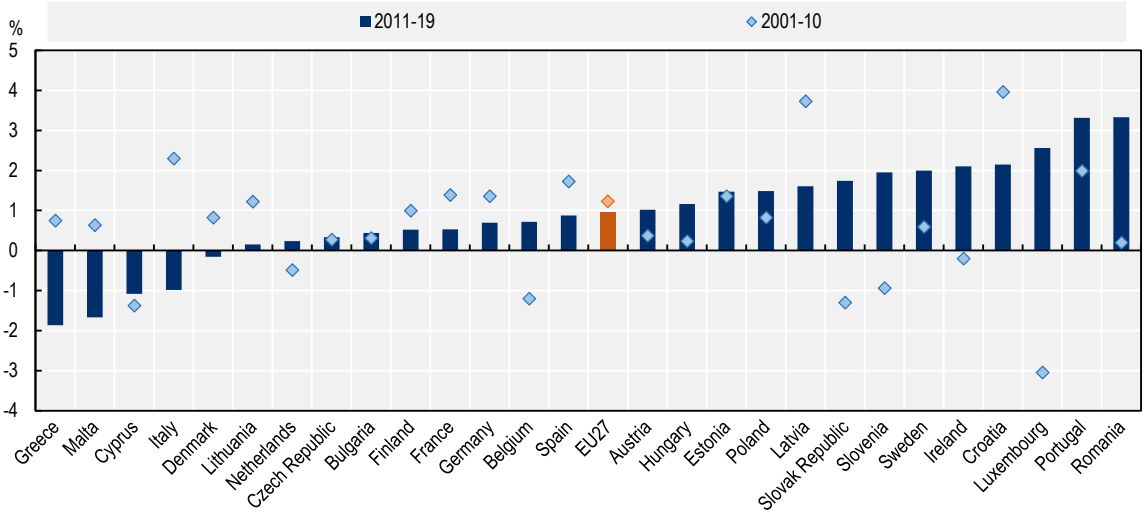


Notes: The regional categorisation of countries follows the one employed by the USDA ERS (2021[16]): West Asia, whose only EU Member State is Cyprus,[1] is excluded for the purpose of greater graphical clarity. Central Europe includes the following EU Member States: Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, the Slovak Republic and Slovenia. Northern Europe includes Estonia, Finland, Latvia, Lithuania and Sweden. Southern Europe includes Greece, Italy, Malta, Portugal and Spain. Western Europe includes Austria, Belgium, Denmark, France, Germany, Ireland, Luxembourg, and the Netherlands. None of the countries in Eastern Europe is currently a member of the European Union.
Source: Authors' calculations based on USDA ERS (2021[16]).

1.2.3. Differences in TFP performance across EU Member States

EU Member States experienced significantly different types of structural changes at the end of the 20th century, which is reflected in their recent productivity performance. Within the European Union, TFP growth in the period 2011-19 (Figure 1.9) ranged from an average annual decline of over 1.8% in Greece to an average improvement of over 3% per year in Portugal and Romania. The recent global slowdown in TFP growth is only partially reflected in the experience of EU Member States as several saw stronger productivity growth in the most recent decade. This was especially the case for countries that had experienced low or negative growth rates in TFP in the previous period (2001-10).[8]

Figure 1.9. Growth in agricultural total factor productivity in EU Member States



Source: Authors' calculations based on USDA ERS (2021[16]).

A large number of countries in Central and Northern Europe, together with two Mediterranean countries (Cyprus and Malta), joined the European Union in 2004, 2007 and 2013: these newer countries are collectively called the EU13,[9] while the pre-2000 Member States that joined before 2000 are called the EU14.[10]

It is worth comparing these two groups because of the structural changes that took place in the affected countries. The different timing of accession of these countries also implies that their exposure to European policies, in particular the CAP, was different in duration and modalities, leading to possibly diverging sectoral dynamics. Moreover, at the time of accession, agriculture was a more prominent sector (both in terms of percentage of GDP and share of employment) in the economy of the EU13 than the EU14 and significant productivity and institutional characteristics of the sector were already highlighted during the accession process (EC, 1998[20]).

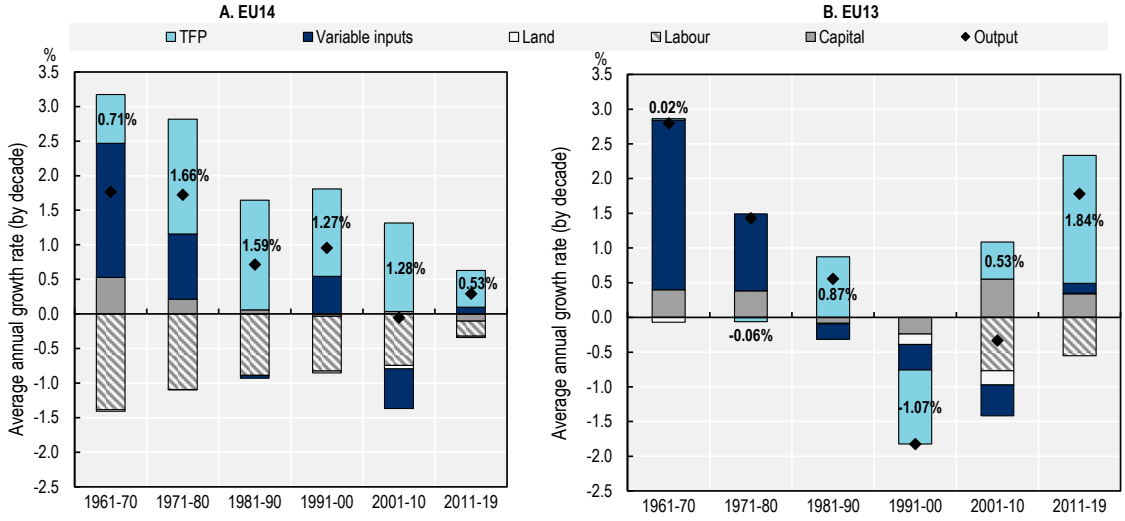
Decomposing output growth in EU14 and EU13 Member States shows important differences, both in terms of the pace of output and TFP growth and in terms of the evolution of inputs use in the two areas (Figure 1.10). After rapid output expansion in the 1960s, EU13 Member States subsequently saw a deterioration of their performance and eventually a complete collapse of both output and productivity growth in the 1990s. The rebound was, however, fairly fast and, in the most recent decade, EU13 Member States achieved strong output growth (at nearly 1.8% per year on average). It was a different story in the pre-2000 EU14 Member States; the declining pace of output growth was less pronounced, and they maintained a strong pace of output expansion until the 2000s.

The productivity growth of the EU14 remained well above that achieved in the EU13 until 2010, after which this trend was reversed. In 2011-19, pre-2000 Member countries saw a slowdown in their productivity growth, in line with the broader trends at the international level, whereas TFP growth strongly accelerated in the newer Member countries, thanks to a fast increase in output growth and a stable growth level of input use.

TFP growth in the EU13 countries was almost non-existent in the 1960s and 1970s (0.02% and -0.06%, respectively). During this period, output growth was driven by the use of variable inputs, which grew at much faster rates than in the pre-2000 countries and reached a cumulative increase of nearly 240% in three decades before rapidly declining in the post-Communist era. EU13 Member States also experienced a faster build-up of agricultural capital, especially in the last two decades, when capital investments were

stagnant or even declined in the EU14. Pre-2000 Member States have experienced steady losses of labour throughout the last six decades, whereas EU13 countries began to see significant declines only in the 2000s. Therefore, the fast decline of agricultural labour documented for the European Union was, until recently, entirely a feature of the pre-2000 Member States.

Figure 1.10. Decomposition of agricultural output growth in EU14 and EU13 Member States, 1961 to 2019



Notes: TFP: total factor productivity. Total annual agricultural output growth is calculated as an average for each of the six decades. Growth rates for TFP and inputs are expressed as contributions to the total annual growth rate so that the growth in outputs minus the growth in inputs equals TFP growth, i.e. TFP growth is the residual. Percentage values (in bold) refer to average annual TFP growth for the period. Variable inputs comprise feed and fertiliser. Capital refers to livestock and machinery.
EU14 refers to the 14 countries that joined the European Union before 2004. Due to data availability, Belgium and Luxembourg are included jointly. Therefore, the EU14 aggregate is built upon 13 data points, representing 14 Member States.
EU13 refers to the 13 countries that joined the European Union in 2004 or later. Due to data availability, the EU13 aggregate does not include Croatia or Slovenia; the Czech Republic and the Slovak Republic are included jointly. Therefore, the EU13 aggregate is built upon 10 data points, representing 11 Member States.
Source: Authors' calculations based on USDA ERS (2021[16]).

1.3. Agri-environmental performance

Agricultural activities are associated with diffuse air, soil and water pollution and can lead to the excessive exploitation of natural resources, ecosystem degradation and loss of biodiversity. The F2F and the Biodiversity Strategies aim to reduce the impacts of the farming and food sectors on the environment while protecting natural ecosystems. This section provides an overview of the environmental performance of the EU agricultural sector through trends of selected agri-environmental indicators and the links they may have to productivity.

The OECD PSR Framework (OECD, 2020[3]) stresses the importance of achieving sustainable productivity growth. This implies enhancing the efficiency of agricultural production while reducing its negative environmental externalities. Climate change represents an especially relevant challenge for agriculture, given that the agro-food sector is both highly vulnerable to its impacts and a major contributor to global GHG emissions while also presenting considerable potential for carbon sequestration (OECD, 2020[3]; 2022[6]).

1.3.1. Agricultural greenhouse gas emissions

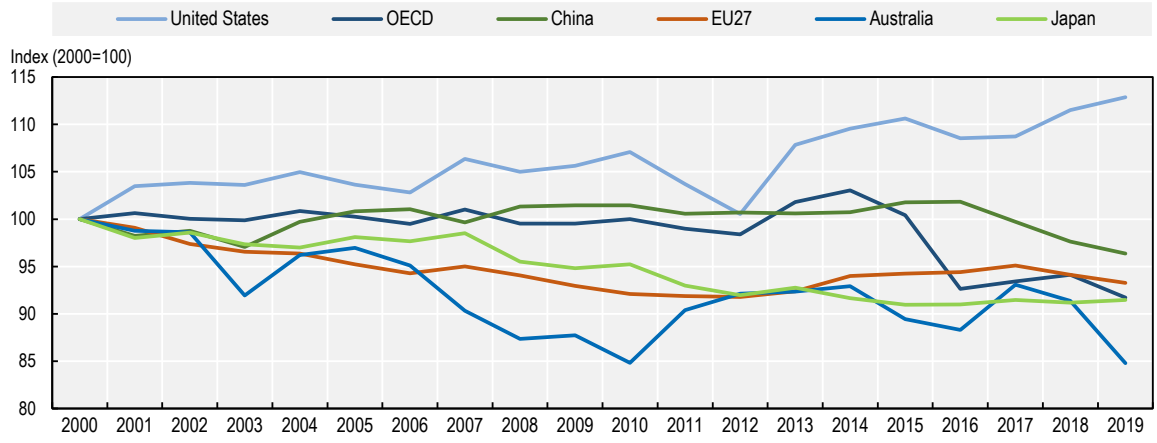
Direct GHG emissions from agriculture vary across countries due to differences in factors such as agricultural land area, the size of the agricultural sector, the mix of commodities produced and the structure of agricultural production. The EU27 as a whole is among the five largest emitters across the 54 countries covered in the *OECD Monitoring and Evaluation* report (OECD, 2022[6]), together with India, the People's Republic of China (hereafter "China"), the United States, and Brazil.

The EU agricultural sector directly generated 383 Mt CO_2-eq (million tonnes carbon dioxide equivalent) of GHG in 2020, representing 11% of total GHG emissions in the European Union. Among those, methane emissions from enteric fermentation (mainly from cattle) and manure management, as well as nitrous oxide (N_2O) releases from managed soils accounted for the largest part of the sector's emissions, at 47% and 31%, respectively[11] (EEA, 2022[21]).

GHG emissions from the EU agricultural sector fell by 7% in the period 2000-19, less than the OECD average of 8% (Figure 1.11). Japan and Australia reached even higher emissions reductions of 9% and 15%, while progress was lower for China (-4%). Canada and the United States experienced deteriorating trends with GHG increases of 4% and 13%, respectively. The trend development in many countries, however, was not steady. For the European Union (and Japan and Australia), most emissions reductions occurred before 2012. In the period 2013-17, agricultural GHG emissions increased by 4%. Recent trends show slow progress and indicate a stabilising rather than reducing emissions level. The main reason for lower GHG emissions in the European Union and other OECD countries at the beginning of the century were reductions due to falling livestock numbers from cattle, but also better use of fertilisers.

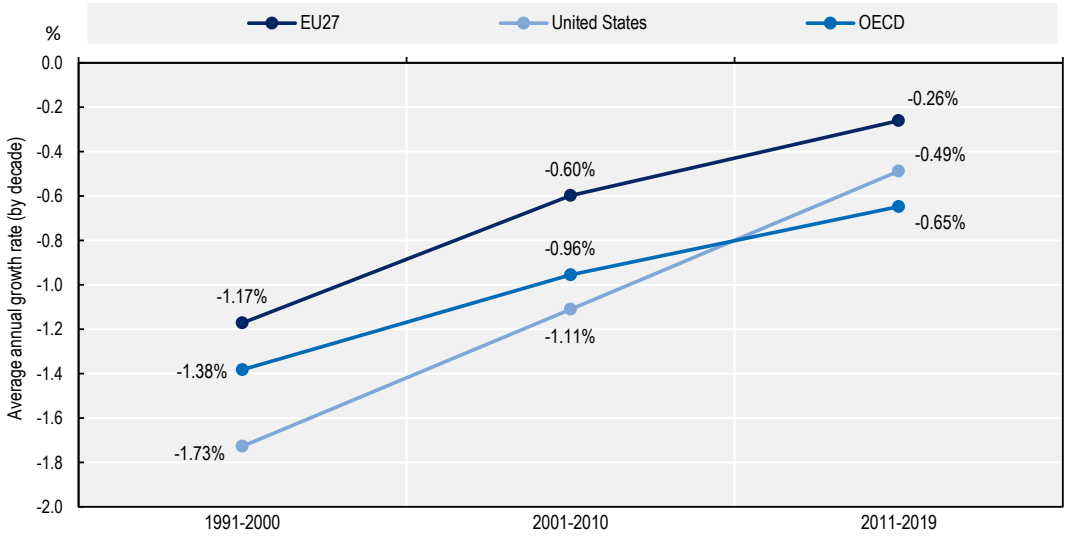
GHG emissions in the European Union have grown at a slower rate than the value of total output since the 1990s, therefore reducing the emissions intensity of its agricultural output (i.e. emissions per unit of output) (Figure 1.12).[12] That is, the European Union has successfully achieved a partial decoupling of GHG emissions from production.

Figure 1.11. Greenhouse gas emissions trends from the agricultural sector in the European Union and selected countries, 2000 to 2019



Source: OECD (2022[22]).

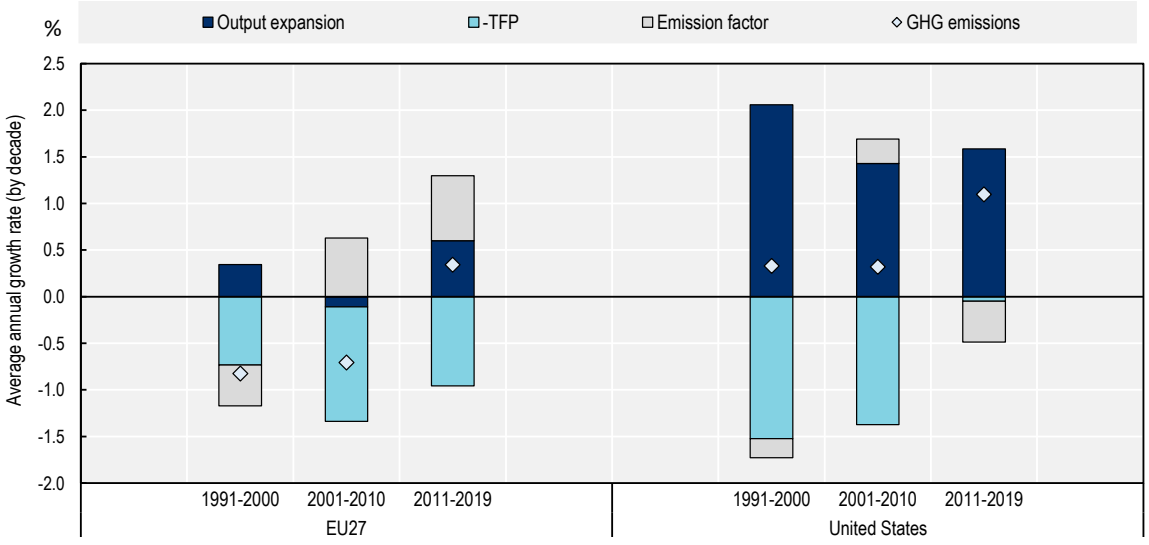
Figure 1.12. Evolution of changes in greenhouse gas emissions intensity in the European Union, the United States and the OECD, 1991 to 2019



Notes: Average annual growth rates "g" are related by the following formula: g(EI)=g(EF)-g(TFP), where EI is the greenhouse gas emissions intensity and EF is the emissions factor (emissions E per total inputs X, or E/X). Partial decoupling occurs when g(EI)<0.
Source: Authors' calculations based on USDA ERS (2021[16]); OECD (2022[22]).

Even though total GHG emissions from agriculture in the European Union declined between 1991 and 2010 and grew at a lower rate than in the United States in 2011-19, its emissions intensity declined at a slower pace (Figure 1.13). European agricultural production increased at a significantly slower pace than in the United States in all decades under consideration, even becoming negative in the period 2001-10, resulting in a slower decline in emissions per unit of output.

Figure 1.13. Decomposition of changes in greenhouse gas emissions in the European Union and the United States, 1991 to 2019



Notes: TFP: total factor productivity; GHG: greenhouse gas. Average annual growth rates "g" are related by the following formula: g(E)=g(Y)-g(TFP)+g(EF), where E is GHG emissions, Y is output and EF is the emissions factor (emissions E per total inputs X, or E/X).
Source: Authors' calculations based on USDA ERS (2021[16]); OECD (2022[22]).

While the emissions intensity of output has continued to decline throughout the last three decades, the pace of improvement has slowed. This trend is common to the European Union, the United States and the OECD, where the pace of reduction of emissions intensity in the most recent decade was 65-80% lower than in the period 1991-2000. This lowered ability to decouple GHG emissions from agricultural output potentially represents an obstacle to achieving European climate goals.

While improvements in agricultural TFP can play a crucial role in reducing emissions intensity through the more efficient use of variable inputs and the avoidance of emissions-expanding land-use changes, TFP growth itself is not the only answer to GHG emissions. This is because TFP measures the relative expansion of output and consumption with respect to the total use of inputs, which can reflect different possible input substitution paths (OECD, 2022[6]). That is, TFP growth may reflect an innovation path privileging technologies with lower overall input use, but this reduction of input may focus on non-emitting inputs such as labour, generating a relative increase in emissions-intensive inputs.

In the period 1991-2000, EU output increased at the same time as emissions decreased (absolute decoupling).[13] This decade was also the only one in which the European Union experienced a decline in its emissions factor (emissions per unit of input). Combined with a fast improvement in TFP and only a limited expansion of output, this allowed for a reduction in emissions. Despite remaining robust, TFP growth was outweighed in the most recent decade by the sum of the increase in both production and the aggregate emissions factor of inputs used, resulting in an increase in total emissions, thus not achieving absolute decoupling. However, TFP growth still exceeded growth in the aggregate emissions factor of input use and, therefore, output grew more rapidly than emissions, resulting in partial decoupling.

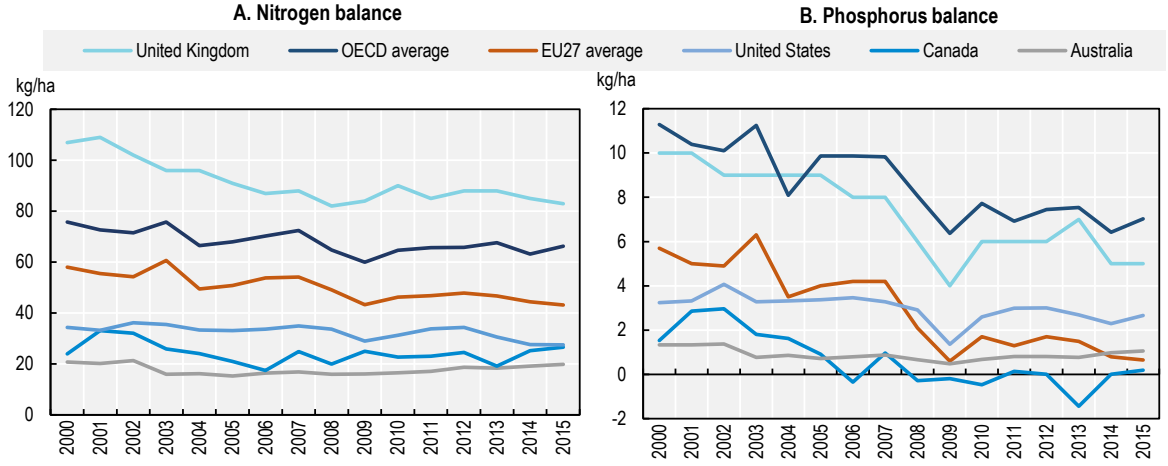
1.3.2. Nutrient balances

Nitrogen (N) and phosphorus (P) are essential inputs that foster soil fertility and support plant growth. Excessive nutrient inputs, however, can lead to surpluses that can contribute to air and water pollution (OECD, 2019[7]). Nutrient balances per hectare measure the difference between the amount of nutrient (N or P) applied versus that taken up in the harvested part of the plant. Nutrient surpluses can be used as a proxy to reveal the status of environmental pressures, such as declining soil fertility in the case of a nutrient deficit, or for a nutrient surplus the risk of polluting soil, water and air.

These nutrient balances show a declining trend in the EU27 in the past years. Between 2000 and 2015, nitrogen balances decreased by 26%, from an initial balance of 58 kg/ha to around 43 kg/ha (Figure 1.14). At the same time, the phosphorus balance fell significantly from 5.7 kg/ha in 2000 to 0.7 kg/ha in 2015, a reduction of more than 80%. Most progress in reduced nutrient balances occurred before 2009. Overall, despite reduced nitrogen balances per hectare, EU27 levels still exceed critical limits and pose risks of acidification and eutrophication in freshwaters, reduced richness in plant and animal species, and atmospheric emissions such as ammonia and GHGs (EEA, 2021[23]). This is particularly true in some western Europe countries (e.g. Belgium, Denmark and the Netherlands) and in some Mediterranean countries (e.g. Cyprus, Italy and Malta). Even in countries with low national averages, there can be regions with high nitrogen loadings because of agricultural intensity, such as livestock density.

Still, average nitrogen balances per hectare in the EU27 are lower than the OECD average (Figure 1.14). Nutrient balances decreased in OECD countries by 12% between 2000 and 2015. Country experiences vary significantly. The United Kingdom, for example, reports growing nitrogen balances while Australia, Canada and the United States have lower balances on the utilised agricultural area (between 36 kg/ha and 17 kg/ha) that are declining over time.

Figure 1.14. Nutrient surpluses per agricultural land area, 2000 to 2015



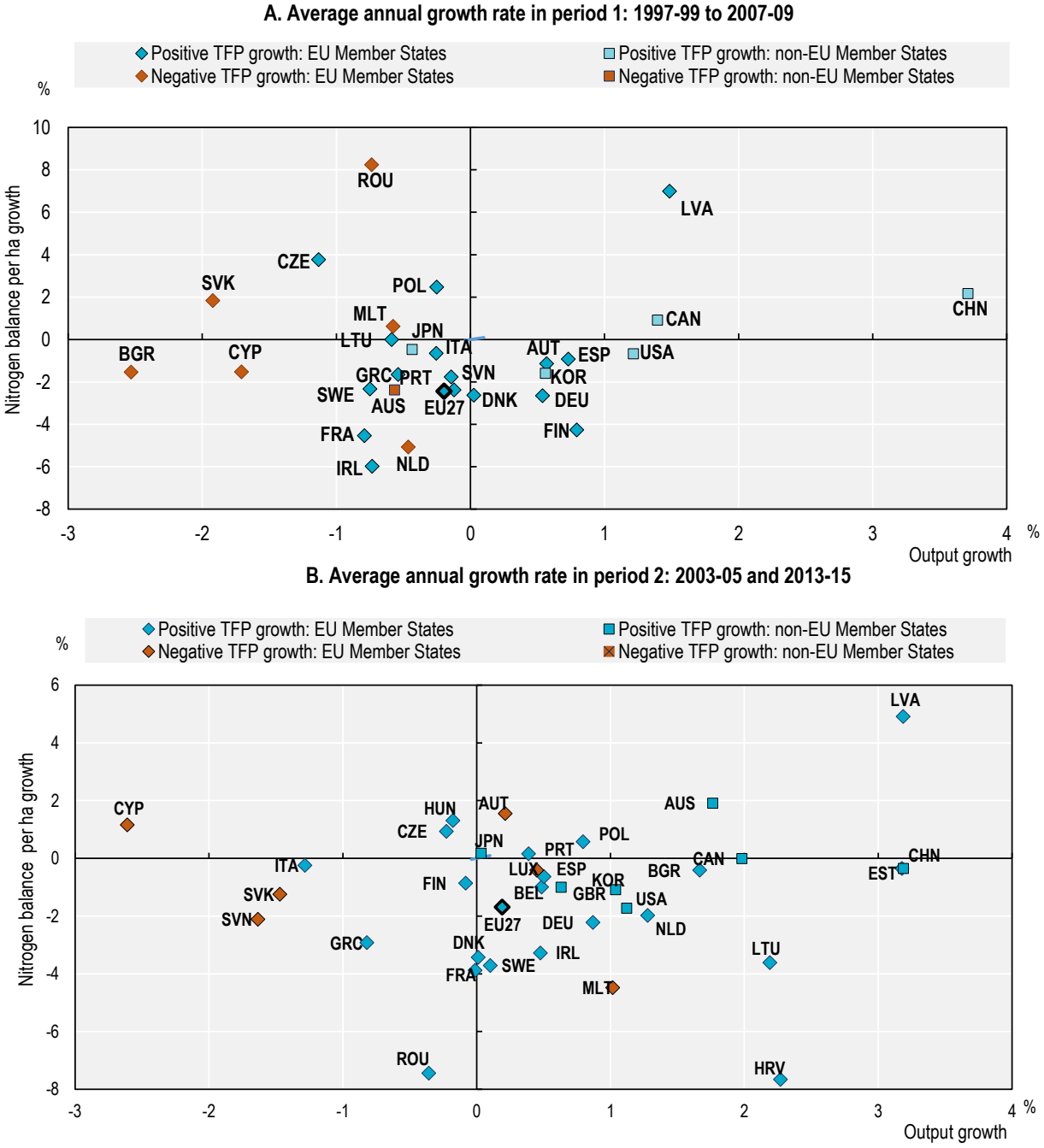
Note: Nutrient surpluses per agricultural land area (in hectare) are measured as the difference between the total quantity of nutrient inputs entering an agricultural system (mainly fertilisers, livestock manure) and the of nutrient outputs leaving the system (mainly uptake of nutrients by crops and grassland).
Source: OECD (2022[22]).

The declining trend in nitrogen balances in the European Union is due to improved nitrogen management practices, e.g. different fertiliser application techniques, better manure management, increased nitrogen use efficiency and thus the nitrogen uptake of plants. The total use of mineral and organic fertilisers – including manure – decreased. This trend is linked with falling livestock numbers over the period, resulting in less manure (Eurostat, 2022[24]). OECD countries reduced nitrogen balances through reduced manure inputs despite increasing their average use of fertilisers. Nitrogen balance trends do, however, vary significantly across countries due to country-specific conditions of livestock densities, crop mixes and management practices (OECD, 2019[7]).

Average phosphorus surplus in OECD countries – with levels between 11.3 kg/ha in 2000 and 7.0 kg/ha in 2015 – is above that of the EU27 average. While country-specific conditions largely drive the differing levels between countries, the reductions of phosphorus balances over time in both EU27 and OECD countries were, to a large extent, driven by less use of compound fertilisers and increased phosphorus use efficiency (OECD, 2019[7]; Schoumans et al., 2015[25]). Most countries saw lower phosphorus inputs over time, in particular in 2008-09, following a jump in the price of fertilisers.

The European Union reduced its nutrient balance per hectare (of both nitrogen and phosphorous) in both the first decade of the century (1997-99 to 2007-09 for the analysis in this section) and the most recent decade (2003-05 to 2013-15).[14] In the latter period, total agricultural output grew, leading to absolute decoupling of nutrient balances from production. TFP growth was positive in the European Union during the two periods, potentially contributing to improved nutrient balances. However, there is no obvious relationship between positive TFP growth and performance on nutrient balances across Member States and other countries (Figure 1.15).

Figure 1.15. Nitrogen balances, output and total factor productivity in selected countries



Notes: TFP: total factor productivity; ha: hectare. The value for the EU27 time series corresponds to the median of all Member States.
Source: Authors' calculations based on USDA ERS (2021[16]); OECD (2022[22]).

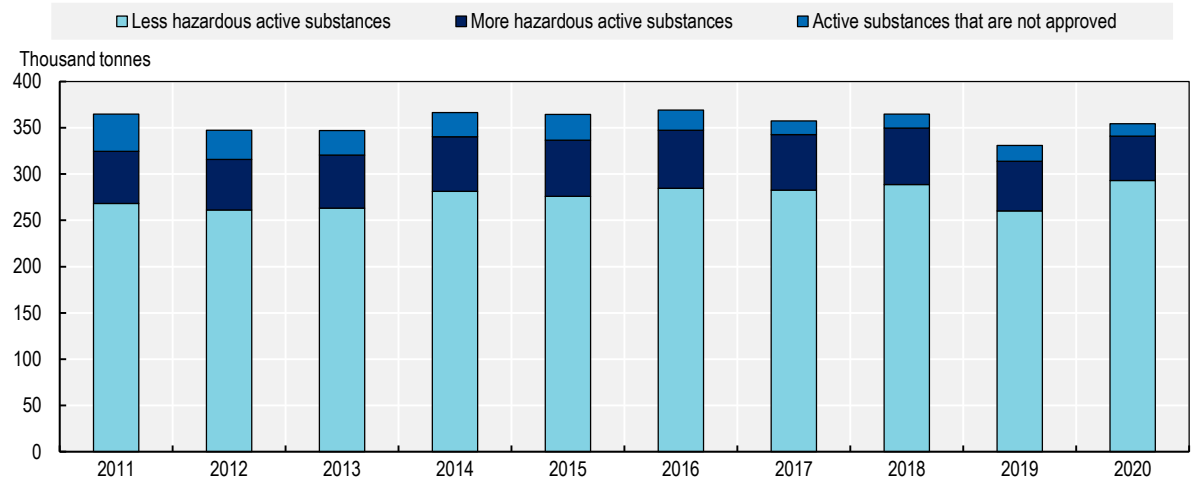
1.3.3. Pesticide sales

Annual pesticide sales volume in the EU27 remained stable at around 360 million kilogrammes between 2011 and 2020. Of the pesticides sold in 2019, fungicides and bactericides amounted to 40% of the total sales. Herbicides, haulm destructors and moss killers were the second-largest group (33%), while insecticides and acaricides represented 13% of sales (Eurostat, 2022[26]). In 2020, less hazardous products

took the largest share of sales volume (83%), while more hazardous substances and active substances that are not yet approved represented only 13% and 4% of the sales, respectively. In the period 2011-20, sales of the more hazardous products decreased by 4.6% (Figure 1.16).

Despite a reduction in the number of high-risk substance sales, the presence of pesticides in the environment remains a major problem in Europe (EEA, 2021[27]). Various factors influence the sales volume of pesticides, including, for example, climatic conditions, farm profitability and crop types. A transition towards a more sustainable use of pesticides is not only hindered by socio-technical conditions of farmers engaging in high pesticide farming systems but also by the slow pace of approval and lack of farm advisory support for biopesticides and other means of biocontrol.

Figure 1.16. Pesticide sales in the European Union by categorisation of active substances, 2011 to 2020



Note: Less hazardous substances include low-risk active substances (Group 1 of the Eurostat categorisation) and all the other approved substances other than the more hazardous active substances (Group 2 of the Eurostat categorisation). More hazardous substances are the active substances that meet cut-off criteria or are identified as candidates for substitution in accordance with set criteria (they correspond to Group 3 of the Eurostat categorisation). Non-approved high-risk active substances correspond to Group 4.
Source: Eurostat (2022[28]).

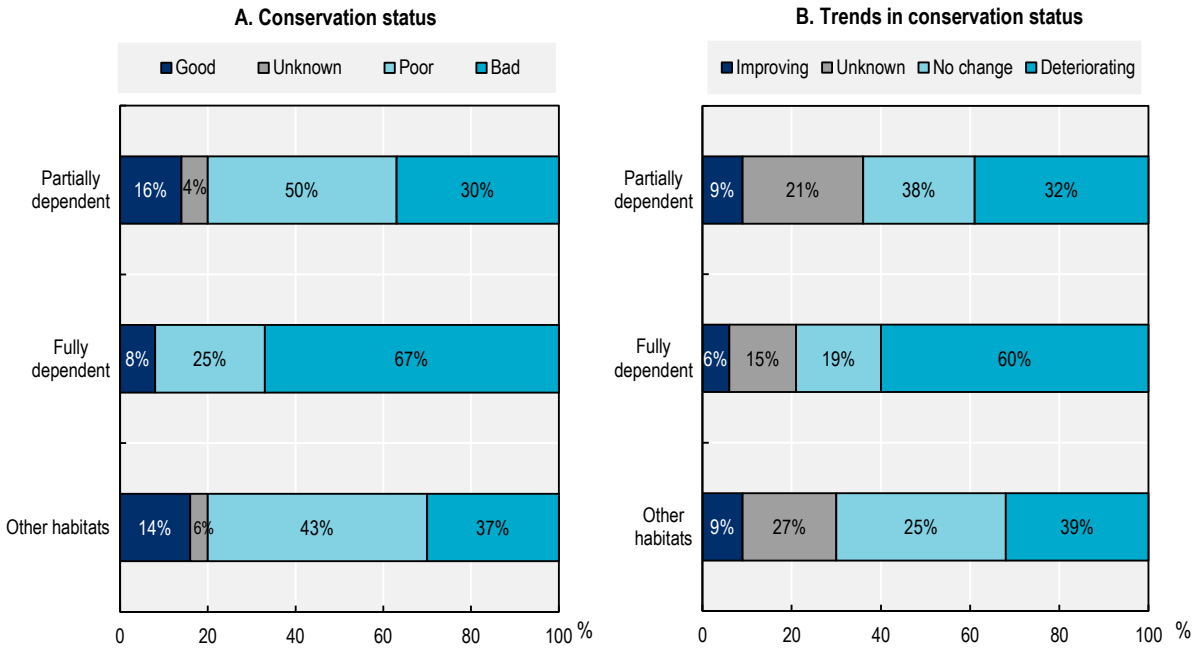
1.3.4. Biodiversity in agricultural habitats

Farmland is an integral part of the ecosystem of Europe and the single largest habitat in Europe, covering 39% of the total EU27 land area. Agriculture landscapes are a valued and appreciated part of Europe's cultural heritage. However, the quality and health of agricultural landscapes are changing, and agricultural biodiversity, in particular, has been in long-term decline.

Across the European Union, only 15% of habitats have a good status, according to the *State of Nature* report (Sundseth, 2021[29]). The vast majority (81%) are in a poor or bad status. Only 9% of habitats with a poor or bad status show an improving trend. For a third of habitats, the trend is stable (34%), but an equal number (36%) are continuing to decline (Figure 1.17). This decline is especially acute for bogs, mires and fens, dunes, and grassland habitats. In all cases, more than half of the habitats are deteriorating (Sundseth, 2021[29]).

Figure 1.17. Conservation status and trends of agricultural habitats

Percentage of area by status, trend and degree of dependence on agricultural practices



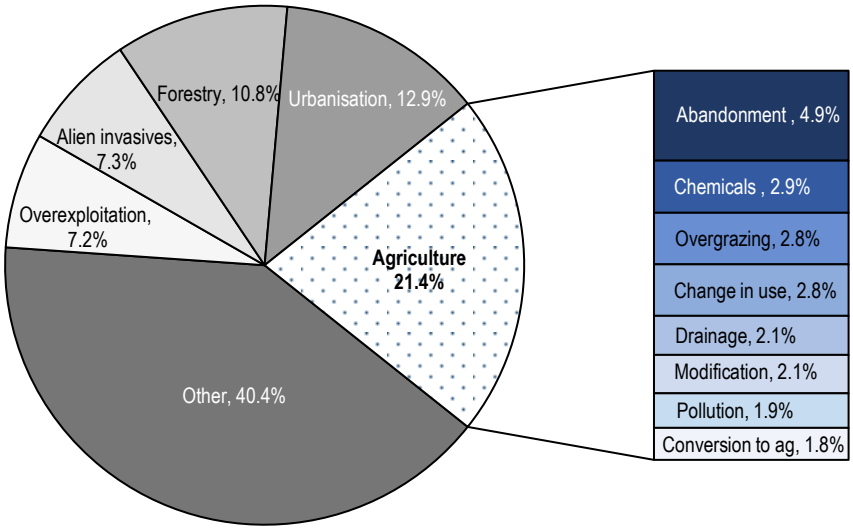
Source: Article 17 Member States' reports and EU assessments, as reported in Naumann et al. (2020[30]).

Agriculture has for a long time been the most common pressure and threat on species and habitats, being the primary factor in 21% of cases. Urbanisation and forestry are other major pressures (Figure 1.18). Biodiversity decline in agricultural areas is generally linked to deteriorating habitat quantity and quality on farmlands due to the intensification of agricultural activities. In fact, agriculture-related habitats with inadequate or unfavourable conservation status have increased in past decades, leaving less and less space for biodiversity to thrive (Mackenzie, 2018[31]). The drivers are various and include, for example, the loss of structural diversity through field size changes, the widespread use of pesticides, declining numbers of cultivated crop varieties, the intensive application of fertilisers, and the lack of protected and well-connected areas (Mupepele et al., 2021[32]).

The conservation status of farmland bird species, a proxy for overall biodiversity, has been raising warning flags for many years. The Farmland Bird Index, an indicator of populations of bird species dependent on agricultural habitats, fell by 60% between the years 1980 and 2019 (Figure 1.19). This downward trend has continued for farmland birds, even as the population of forest birds has been recovering.

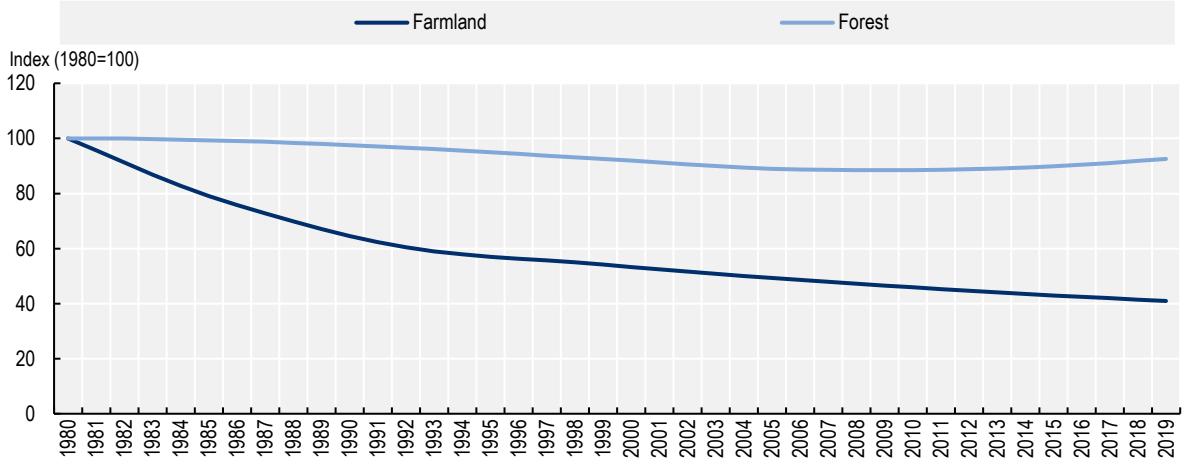
Figure 1.18. Pressures on biodiversity in the European Union

Reported frequency of high-ranking pressures



Note: Other includes natural processes, changes in water regimes, energy infrastructure, transport and climate change.
Source: Sundseth (2021[29]).

Figure 1.19. Trend in farmland and forest bird populations in the European Union, 1980 to 2019



Note: Farmland and forest birds according to European species habitat classification.
Source: EBCC/BirdLife/RSPB/CSO (2022[33]).

1.4. Reconciling economic and environmental dimensions of sustainability

The EGD ambition is intended to ensure the longer term environmental sustainability of EU agriculture but may have negative impacts on dimensions of economic sustainability, such as farm income and employment. In the short term, the trade-off between the environmental ambitions of the CAP and the net income of farmers that need to deliver new outcomes with a similar amount of payments could be particularly strong. Restrictions on input use, the requirement to set aside land for nature and higher animal

welfare standards are likely to raise costs for farming and increase competitive pressures. Reconciling this tension between farm income and environmental sustainability will be critical for the CAP to contribute to achieving the EGD objectives. Results-based environmental payments, and market-driven or demand-based instruments have been recognised as relevant approaches to improve agriculture's environmental performance while maintaining the benefits of global markets (Gruère et al., 2023[34]). In the medium and long term, new sustainable agriculture approaches (e.g. organic farming, agroecology, regenerative agriculture, etc.) and new innovations may be successfully mobilised to improve resource efficiency and reducing their costs (Box 1.2).

A series of modelling studies simulating the impact of implementing several EGD targets concur that production would fall, although they disagree on the farm income effects (Petsakos et al., 2022[35]; Beckman et al., 2020[36]; Henning and Witzke, 2021[37]). The potential impacts that selected targets could have on the EU agricultural sector have been studied. Barreiro-Hurle et al. (2021[38]) indicate that reaching these targets under the current CAP implementation achieves significant environmental benefits in the form of reductions in GHG and ammonia emissions as well as in gross nutrient surplus, although the extent in terms of positive environmental and economic benefits is not fully quantified. Results also show a decline in EU production and variations in prices and income for selected agricultural products, albeit to different degrees. However, none of the studies specifically includes targets for reducing agricultural emissions that will likely require reductions in livestock that go beyond those simulated in these studies or consider the competitiveness implications of the higher animal welfare standards that have been flagged by the European Commission.

Whether producers will end up paying for the higher costs of environmental protection and higher animal welfare standards or whether these costs can be passed on to consumers also depends on the degree of competition from international trade from third countries in the EU single market. If other producers are not subject to the same standards and can produce at a lower cost as a result, this could result in production shifting abroad. This outcome is highlighted particularly in the context of GHG mitigation since offshoring production could lead to higher global emissions, which is the opposite of the intended effect – a phenomenon known as "carbon leakage" (Arvanitopoulos, Garsous and Agnolucci, 2021[39]).

Improving resource efficiency and promoting the circular economy have the potential to be a win-win for farmers by reducing their input costs. Furthermore, the EGD aims to open new opportunities in the bioeconomy. This may be in the production of raw materials, such as hemp, for medicinal or industrial use, or by making use of food waste. It may be in the production of renewable energy. Although the production and use of biomass for energy are controversial and often criticised as unsustainable and competing with food production, it may have a role to play in meeting the net zero emissions target (Catuti et al., 2020[40]). Finally, as discussed in Chapter 4, there will be the possibility to use carbon markets to reward farmers for sequestering carbon, although many difficult questions around monitoring, verification, additionality, reversibility, transaction costs and ensuring accounting integrity remain to be resolved (Thamo and Pannell, 2016[41]).

Box 1.2. Approaches and practices to produce food in an environmentally friendly way

Several approaches have emerged since the early 20th century to promote environmentally friendly agricultural practices as part of production systems that are more environmentally sustainable. These have similar aims and share common features but differ in their scope, agreement around definitions, and extent to which they have been adopted by farmers and taken up in policy. Policies in the European Union and across the OECD have encouraged organic agriculture for a long time. At the same time, more recent concepts such as agroecology and regenerative agriculture are gaining policy attention.

Organic agriculture

The FAO-WHO Codex Alimentarius Commission describes organic agriculture as "a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity... This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system" (Joint FAO/WHO Codex Alimentarius Commission, 2001[42]; Joint FAO/WHO Codex Alimentarius Commission, 2001[42]). The main characteristics of organic production are the prohibition of most synthetic inputs and mandatory crop rotations (FAO Committee on agriculture, 1999[43]; FAO Committee on agriculture, 1999[43]; FAO Committee on agriculture, 1999[43]).

Organic production standards for processes and production methods have been developed by farmer and consumer associations, charities, certification bodies, and governments. They aim at differentiating products and segmenting markets, with claims regarding product characteristics transmitted to consumers through a food label (Rousset et al., 2015[44]). Organic production is not only about sustainability; the price premium obtained by organic products and its market segmentation reflects consumers' interest in the health, safety and quality characteristics they associate with organic food (Popa et al., 2019[45]).

As of 2021, 76 countries had implemented regulations on organic agriculture, while 20 had organic regulations that were not fully implemented (Willer et al., 2022[46]). Government regulations (such as the European Union Regulation (EU) 2018/848 on organic production and labelling) set minimum standards for products to be certified and sold as organic that can be supplemented by other food chain actors applying definitions and standards that are stricter or have a broader scope.[1] For example, the definition agreed upon in 2005 by the International Federation of Organic Agriculture Movements includes social issues, such as fair relationships and good quality of life. (IFOAM Organics International, 2005[47]).

Certification of organic production provides a uniform criterion for governments to support organic farming. According to a 2015 OECD survey, the main reasons for countries to support organic agriculture are to obtain the associated environmental benefits, respond to consumer demand and improve animal welfare (Rousset et al., 2015[44]). The European Union has supported conversion to and maintenance of organic farming since 1994 (and even earlier in some individual Member States). By 2018 the EU28 Member States provided support for 64% of the total certified organic land area in the European Union (or 5% of the total EU utilised agricultural area), for a total of EUR 1.8 billion (Lampkin and Sanders, 2022[48]).

Organic agricultural practices have environmental benefits, including lower pesticide residues, richer biodiversity and greater resilience to drought. However, the environmental performance of organic agriculture per unit of product is not necessarily superior and is highly context dependent (Seufert and Ramankutty, 2017[49]; Meemken and Qaim, 2018[50]). intensive management within organic farming regimes can also impoverish biodiversity and lead to an excessive application of animal manure.

Organic systems also frequently have lower yields and require more land to produce a given level of output, which can increase their greenhouse gas emissions footprint.

The global organic market expanded from EUR 15 billion to EUR 121 billion between 2000 and 2020. In the last two decades, the global organic area reached 75 million hectares (from 11 million in 1999), and the number of producers grew from 200 000 to 3.4 million (Willer et al., 2022[46]). The growing market, and adoption of organic standards by large market players, have led to criticism that organic farming is becoming "conventionalised", where the minimum is done to meet the standards while pushing the rules to their limit to allow larger scale farming and monocultures (Lampkin, Schwarz and Bellon, 2020[51]; Beste, 2019[52]). The costs and administrative burden associated with obtaining an organic certification can exclude small farmers and traditional practices from around the world, even if they produce food in ways that could be considered more sustainable than conventional agriculture.

Agroecology

Agroecology is "a holistic and integrated approach that simultaneously applies ecological and social concepts and principles to the design and management of sustainable agriculture and food systems, [seeking] to optimize the interactions between plants, animals, humans and the environment while also addressing the need for socially equitable food systems" (FAO, 2020[53]). While the concept emerged decades earlier, it gained prominence in the 1990s in the United States and Latin America and it is seen simultaneously as a science, a set of agricultural practices and a social movement (Wezel et al., 2009[54]).

There are no national or international agroecology standards beyond the ten elements established by the Food and Agriculture Organization (FAO, 2018[55]) and the principles established by the High-Level Panel of Experts of the Committee on World Food Security (HLPE, 2019[56]), but the concept is increasingly being incorporated and promoted in policy. In the European Union, the Farm to Fork Strategy refers to "agroecology (including organic farming)" as one of several sustainable practices to be funded by the new eco-schemes (described in Chapter 4, Section 4.3.5). At the Member State level, France has pioneered the inclusion of agroecology in its public policy, while others such as Germany have maintained a stronger focus on organic farming (Lampkin and Sanders, 2022[48]). Outside the European Union, Brazil incorporated agroecology in its 2007 National Policy for Technical Assistance and Rural Extension (FAO, 2018[57]).

A 2020 study found that in 15 case studies representing a wide range of production activities and of climatic and ecological contexts of Europe, agroecological farms tend to enhance biodiversity and water quality compared to non-agroecological farms (Landert et al., 2020[58]). However, no clear patterns were found regarding soil quality or economic performance. The results also suggested that agroecological practices could have higher greenhouse gas emissions and fuel consumption.

Regenerative agriculture

Regenerative agriculture encompasses a range of ideas and practices. A 2020 literature review (Newton et al., 2020[59]) found numerous definitions and descriptions based either on processes (such as using cover crops, integrating livestock, or reduced or no tillage), outcomes (such as improving soil health, carbon sequestration or increased biodiversity) or combinations of both. The same study found that the use of the term has surged since 2015, which suggests that it is gaining more attention from scholars and practitioners.

According to the European Academies' Science Advisory Council, regenerative agriculture stresses soil restoration and the interplay of crops and farm animals. The concept of regenerative agriculture is broader and less prescriptive than agroecology and organic agriculture, as it accepts a targeted use of

modern plant and animal breeding technology, tilling, and inorganic fertilisers or pesticides (EASAC, 2022[60]).

The United Nations Intergovernmental Panel on Climate Change's Special Report on Climate Change and Land lists regenerative agriculture as one of the sustainable land management practices (along with agroecology, ecosystem-based approaches and organic farming) that can be effective in building the resilience of agro-ecosystems. In the United States, some municipal governments have incorporated regenerative agriculture in their climate action plans (The Climate Reality Project, 2019[61]). While no standards have been developed by national governments or international organisations, private standards such as Regenerative Organic Certified (developed by the Regenerative Organic Alliance, a US-based group of farmers, business leaders and experts) are starting to emerge.

Circular agriculture

Circular agriculture focuses on using minimal amounts of external inputs, closing nutrient loops, regenerating soils and minimising the impact on the environment. It is built on the concept of circular economy, where the reuse and recycling of materials is not only a separate step to close cycles, but an integral part of the choices made in the production and use of products. In circular agriculture, this can be the use of manure as organic fertiliser and the use of wastewater in irrigation. Circular agriculture does not reflect a specific set of farm practices or standards, though it is often associated with mixed crop-livestock production, organic production and agroforestry. Circular agriculture is contrasted to the linear nature of conventional agriculture, where the intensive application of raw inputs such as fertiliser and chemicals leads to harmful outflows of waste and degraded soil quality in the farm system.

Since 2018, the Dutch Government has promoted a transition towards a circular agriculture, seen as "a collective search by farmers, interested citizens, businesses, scientists and researchers for the optimum combination of ecological principles with modern technology, with new partnerships, new economic models, and credible social services. It not only focuses on good yields and the sparing use of resources and energy, but also stresses the importance of putting as little pressure on the environment, nature and climate as possible" (WUR, 2018[62]).

Interactions of the concepts

The concepts presented, and the movements that originated them, are strongly intertwined, and the terms are sometimes used synonymously. In fact, a broad set of terms to describe environmentally sustainable agricultural techniques coexist in public discourse. Along with the concepts mentioned above terms and concepts have been introduced, such as "agroecological farming" "alternative agriculture," "biodynamic agriculture," "carbon farming," "integrated pest management", "nature inclusive farming," "conservation agriculture," "green agriculture," "organic regenerative agriculture," and "sustainable agriculture." (Newton et al., 2020[59]). The use of technologies (biotech, precision agriculture) can also focus on environmental outcomes (OECD, 2016[63]).

Organic agriculture stands alone as the most clearly regulated, certified and labelled of the mentioned approaches. This is due, in part, to its connection with specific product characteristics, such as the absence of pesticide residues and the resulting need for clear market segmentation. This is not the same as consumer preference for otherwise identical products that are produced in a more environmentally friendly manner. Agroecology or regenerative agriculture are regarded as processes rather than products and are not supported by regulations or standards.

1. The EU Regulation authorises the use of the terms "organic", "ecologic" and "biologic" in different European languages, and their diminutives (such as "bio" and "eco"), whether alone or in combination, for the labelling and advertising of organic products.

Annex 1.A. Agri-environmental performances and trends across EU Member States

The agri-environmental performance of EU Member States depends on various contextual and external factors. The country-specific structural features play a key role, including the dominating farming system, farming specialisations and practices, and the availability of agricultural land. Moreover, as discussed in this review, agricultural policies are essential drivers, and the effect of innovations and the potential of emerging technologies also play a key role (OECD, 2019[7]). The interaction and impacts of these different factors determine the performance of every country, leading to significant differences in environmental pressures and trends across the 27 Member States.

The following sections present the environmental pressures and trends of selected agri-environmental indicators in the EU Member States, using the most updated data from the OECD (2022[22]) and Eurostat (2022[64]) databases.

Environmental pressures on agricultural land

Environmental pressures on agricultural land also differ significantly among the 27 EU Member States, depicting a very heterogeneous picture across Europe that depends heavily on the structural features of the countries' agricultural sectors, including the size of land available for agricultural activities.

Nutrient balances, in general, largely depend on the chosen crop mix, adopted cultivars, the livestock composition and management practices (OECD, 2019[7]). In Europe, nitrogen pressures per hectare are particularly high in Central European countries as well as in Member States such as Cyprus and Malta. Many Eastern European countries report relatively lower numbers. Differences in nitrogen surpluses between the two groups amount to up to 168 kg/ha. One country, Romania, even exhibits a negative value, indicating a prevailing nitrogen deficit with potentially adverse effects on soil fertility. Yet, the high nitrogen balances per hectare in many Central European countries can be the result of the relatively large livestock sector, as well as of the widespread cereal production. Particularly in small European countries such as Belgium, Cyprus, Malta, and the Netherlands, high livestock densities determine surplus values. Livestock production (and partially also cereal production), in contrast, is generally lower in Eastern and Southern European countries, contributing to lower nitrogen balances per hectare (Eurostat, 2022[65]).

Similarly, data on phosphorus balances show that countries such as Spain, Portugal, Finland, Denmark, and Belgium reported surpluses (ranging between 4.5 kg/ha and 29.5 kg/ha), while many Eastern and Central European countries reported phosphorus deficits on agricultural areas of up to 7.1 kg/ha. Only a few of the 27 Member States indicated balanced values close to zero. The high phosphorus pressures in various Southern and certain Central/Northern European countries could be traced back to higher application rates of mineral fertilisers, as well as the intensive production of fruit and vegetables (OECD, 2019[7]; Eurostat, 2011[66]).

With regard to GHG emissions, many Central European countries reveal high levels of emissions per hectare of utilised agricultural area, while most Eastern European countries report lower levels. The Netherlands, Belgium, Malta, and Luxembourg were among the highest-emitting countries in the considered period, ranging between 5.2 tonnes of greenhouse gases per hectare (GHG t/ha) and 10.4 GHG t/ha. In fact, in those countries, emissions levels exceed the EU average more than twofold, indicating a much higher degree of agricultural intensification. The main reasons are the particularly high

emissions intensities from soils, enteric fermentation and manure management, together with less agricultural area available (Dace and Blumberga, 2016[67]). On the other hand, Bulgaria, Hungary, Estonia, and Romania were among the least emitting countries, with GHG releases of 1.3-1.5 GHG t/ha. Such low emissions intensities of agricultural activities may be attributed to the more extensive farming systems and the lower livestock production levels.

Similar emissions patterns were observed for agricultural ammonia, where countries like Malta, the Netherlands, Cyprus, and Belgium show the highest emissions per hectare (between 50 kg/ha and 99.5 kg/ha), while many Eastern European countries, especially Latvia, Bulgaria and Estonia, show the lowest (below 10kg/ha). These differences are the result of different livestock densities in agricultural areas (and to a minor extent emissions from fertilisers): emissions per utilised agricultural area are, on average, three to five times higher in Europe if high densities of livestock prevail (UNECE, 2021[68]).

Agri-environmental trends diverge among EU Member States

Looking at agri-environmental performance trends across countries and indicators,[15] the 27 EU Member States revealed clear differences in their relative performance over the decade 2008-18. Only very few countries significantly improved their overall performance across all indicators, but most show mixed results. While the majority of countries progressed well in reducing the human and environmental risk from pesticides and managed to use phosphorus more efficiently, achievements in increased nitrogen use efficiency vary across countries. Overall, the majority of EU Member States lack progress in reducing agricultural greenhouse gas (GHG) and ammonia emissions, and show a strong decline in farmland biodiversity.

Progress on nitrogen use efficiency varies widely across EU Member States. A total of 14 – predominantly Eastern – European countries exhibit improved nitrogen use efficiency over time. In contrast, the remaining countries, especially Lithuania, Latvia, Portugal, and Bulgaria, report negative trends, ranging between 2.8% and 1.8%. This can also be explained by the fact that initial levels vary across Member States. For example, in Latvia, although the use of mineral fertilisers has increased, nitrogen consumption per hectare of agricultural area remains one of the lowest among the EU countries (OECD, 2019[69]).

Other possible reasons for the different performances particularly between Eastern European countries compared to the remaining Member States could be the differing moments of EU accession and the resulting temporal differences in the impact of relevant policies. Accordingly, the relatively positive nitrogen use efficiency trends in Eastern European countries might rely on the effects of the Nitrate Directive in the considered period, e.g. through efficiency use increasing measures. Earlier accession countries might have benefited from such a positive impact at an earlier time.

The majority of EU countries show comparatively great progress in phosphorus use efficiency. Trends reveal significant increases over time in 19 of the 27 Member States, with an EU-wide increase of 25% from 2006 to 2014. Among those, predominantly Eastern but also various Southern European countries achieved the highest efficiency gains over time. Only a few countries show low improvement or declining rates, particularly Southern European countries such as Spain and Portugal, as well as Bulgaria, which report deteriorating trends of 2%, 3% and 4% during 2011-19.

An overall positive development across EU Member States in reduction of pesticide use was also observed. This is mainly based on efforts to encourage lower uses of pesticides and promote switches to lower-risk products that contain less active substances. The application of Directive 2009/128/EC on Sustainable Use of Pesticides (discussed in Chapter 4) could have been one decisive factor for this progress. There are varying reasons for the rising trends of pesticide risks in several EU countries: in the case of Finland, this is mainly due to increased sales volumes of urea, used as a repellent in forestry, while in Estonia the trends were affected by pesticides containing active substances belonging to the group

known as candidates for substitution remaining on the market in accordance with EU rules due to the lack of viable alternatives (Finnish Safety and Chemicals Agency, n.d.[70]; Eurostat, 2021[71]).

The 27 European countries performed by far the worst in farmland biodiversity, with significantly deteriorating trends of the Farm Birds Index over the period in almost all Member States. Only one country, Cyprus, reported an increase in 2019 compared to 2007.

However, the state of biodiversity in agricultural areas differs widely between Member States and this is largely dependent on the degree of agricultural intensification of the predominant farming systems. Yet, various further non-agricultural factors exist that may have adverse effects, e.g. the impact of invasive species, climate change or pollution (EC, 2022[72]). While it is the main priority for all countries to stop the continuing negative trend in farmland biodiversity, some countries (predominantly some of the post-2004 Member States such as Bulgaria and Romania) are richer in biodiversity and need to maintain the existing state while others (especially pre-2004 Member States) need to recreate natural habitats and promote species growth (Sutcliffe et al., 2015[73]).

Data on agricultural GHG emissions trends from the European Environmental Agency show that only three countries (Greece, Croatia, and Malta) succeeded in accelerating emissions reduction trends significantly over time, with decreases of more than 10% in 2019 compared to 2005. Seven countries reported distinctive increasing trends. Those were particularly high in Estonia, Bulgaria, Hungary, Latvia, and Luxembourg, with an increase of more than 10% between 2005 and 2019 (EEA, 2021[74]).

Considering GHG emission trends per hectare reveals even more negative trends in five Member States, indicating a significantly increasing degree of agricultural intensification in those countries. The drivers for emission trends vary between countries: while Malta achieved great reductions through reduced livestock emissions, increases in Estonia mainly stem from rising soil emissions. In addition, the country's accession to the European Union set a turning point and led to a reversal in formerly declining GHG trends (EEA, 2021[75]; Estonian Ministry of the Environment, 2021[76]).

Most EU countries also show relatively little progress in reducing agricultural ammonia emissions over the decade 2008-18. In fact, trends remained stable in 16 of the 27 Member States, while 4 countries reported increases: Austria and Ireland (both of which observed emission reductions during the previous decade), Latvia and Lithuania; and 7 countries reported decreases: Croatia, Cyprus, Denmark, Greece, Malta, the Netherlands[16] and Romania. Considering agricultural ammonia emissions on a hectare rather than an absolute basis even indicates slightly less progress across EU Member States, with significant negative trends in Hungary and Spain. A recent study (Murawska and Prus, 2021[77]) confirms the lack of progress in the sustainable management of agricultural ammonia emissions and even indicates the start of an overall rising trend in the period from 2010 to 2017, with significant increases in many Member States.

Given the low progress in agricultural ammonia emissions reductions, an increasing number of Member States anticipate they will fail to meet their emissions targets for 2030. In contrast, most Member States (21 out of 27), managed to stay beneath their ceilings in 2017 (EEA, 2021[78]). The reasons for the upward trend are manifold and differ across countries: in Germany, the increased use of inorganic nitrogen fertilisers is the main reason for agricultural ammonia increases, while higher numbers of cattle and swine as well as increased application of synthetic nitrogen fertilisers are the main trend drivers in Spain (EEA, 2021[79]).

Annex 1.B. Surveys for EU Member States

Two surveys – one on the key design features of the agri-environmental schemes and one on key agricultural features of Member States' innovation systems – were designed and sent to Member State representatives for completion to collect information on issues of special relevance to the review process. The surveys were administered through an online survey platform, which facilitated the involvement of several country experts in the data collection process.

The purpose of the Agri-environmental Schemes (AES) Survey was to collect information on key design features of the agri-environmental schemes applied by EU Member States to assess the resilience and environmental performance of their agricultural sector. In particular, the questions related to the process of setting AES, eligibility mechanisms, enrolment criteria, payment basis and enforcement mechanisms. The questionnaire was composed of 32 questions. The first section of the questionnaire included general questions related to the process of designing and implementing agri-environmental programmes. The second section invited respondents to identify the most important agri-environmental schemes (in terms of budget) in their respective countries and then asked questions specifically related to each agri-environmental programme.

The purpose of the Innovation Policies Survey was to gather information about key features of the agricultural innovation system and the most relevant policy environment essential to achieving sustainable agricultural productivity growth and increased resilience. Questions encompassed public and private actors and institutions involved in research, development and innovation (R&D&I); long-term strategies; investment in R&D&I; knowledge flows; international co-operation; digitalisation; and education and skills. The questionnaire was composed of 39 questions.

Both surveys included both multiple-choice and open-ended questions and provided respondents with the opportunity to include additional comments and information specific to the context of their respective countries. The surveys took place between mid-April and the end of June 2022.

Twenty responses were gathered for each of the two surveys, covering 19 EU Member States. Belgium is the only federal state that has submitted two separate CAP strategic plans for CAP 2023-27, one for Wallonia and the other for Flanders. Therefore, each region also completed and submitted a separate version of the surveys. The 20 respondents' units therefore were: Austria; Belgium, Flanders; Belgium, Wallonia; Croatia; the Czech Republic; Denmark; Estonia; Finland; France; Germany; Ireland; Italy; Latvia; Lithuania; the Netherlands; Poland; Portugal; the Slovak Republic; Slovenia; Spain; and Sweden.

For Germany, the information collected only covers the federal perspective. However, several of the themes covered by the survey are the responsibility of the German *Länder* with their own programmes.

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Notes

[1] As of 18 January 2023.

2 See Bureau and Antón (2022[8]) for an introduction to best practices on measuring TFP and the environment.

3 The EU aggregate is based on the 27 Member States as of 2022, after the withdrawal of the United Kingdom. Due to data availability, Belgium/Luxembourg and the Czech Republic/Slovak Republic are accounted for jointly. Data on Croatia and Slovenia are only available starting from the 1990s; for consistency, these two countries are excluded from longer time. Therefore, the EU time series is built on 23 data points, representing 25 Member States. For consistency, the EU numbers represent the aggregation of these 25 Member States along the 6 most recent decades.

4 The European Union is compared to the United States in several figures in this section. Other OECD countries, in particular Japan and the United Kingdom, are also included in several figures. There is not an output growth decomposition for the aggregate of OECD countries and such an aggregate would tend to have a profile that is very similar to that of the European Union (see, for instance, Figure 1.5), given the large number of EU countries in the OECD aggregate. For this reason, it is preferable to compare the European Union to a selection of single countries.

5 The fact that some countries experienced a decline in TFP does not mean that their productivity is lower than that of the European Union. The TFP decomposition methodology does not allow comparing productivity levels across countries, only the rates of growth over time.

6 Feed (the other component of variable inputs besides fertilisers in the USDA ERS *International Agricultural Productivity Database*) also experienced rapid growth in the 1960-70s, but not a comparable fall in the following decades.

7 Data on Croatia and Slovenia are only available starting from 1992 and therefore the existence of such a trend cannot be verified.

8 Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Hungary, Ireland, Luxembourg, the Netherlands, Romania, the Slovak Republic and Slovenia.

9 EU13 Member States comprise Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, the Slovak Republic, and Slovenia. Due to data availability, the aggregate for EU13 Member countries does not include Croatia or Slovenia. The Czech Republic and the Slovak Republic are included jointly. Therefore, the EU13 aggregate is built upon 10 data points, representing 11 Member States.

10 Prior to the withdrawal of the United Kingdom, this group was generally known as the EU15; it is sometimes also referred to as “old” or “older” Member States. It comprises Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and Sweden. Due to data availability, Belgium and Luxembourg are included jointly. Therefore, the EU14 aggregate is built upon 13 data points, representing 14 Member States.

11 This section focuses on direct GHG emissions from agriculture, which encompasses methane and N_2O only, not indirect emissions deriving from energy and land-use change.

[12] The value for the European Union corresponds to the median of its Member States.

[13] Absolute decoupling of output growth form environmental emissions occurs when output grows (g(Y)>0) and emissions fall (g(E)<0). For this to happen, TFP growth needs to be strong enough to outweigh growth in output and in the emissions factor of inputs: g(TFP)>g(Y)+g(EF). Partial decoupling is a less demanding condition and occurs when positive output growth is more than the corresponding growth in emissions g(Y)>g(E)>0. For this to happen, TFP growth needs to be just higher than the growth in the emissions factor: g(TFP)>g(EF).

[14] The full analysis of decomposing the evolution of the total level of the environmental outcome into output expansion, emissions factor and TFP undertaken for GHG emissions cannot be implemented for nutrient balances due to technical reasons: there are negative balances and data availability constraints. As an alternative, a graphical plotting exercise is undertaken for nutrient balance per hectare through two periods (1997-99 to 2007-09 and 2003-05 to 2013-15) that unfortunately are not the same as for GHG.

[15] See OECD (2019[7]) for a definition of all agri-environmental indicators in this section.

[16] Despite decreasing ammonia emissions in the Netherlands, ammonia levels are one of the country's main concerns as they are still at a high level and cause localised problems in nitrogen-intensive areas. See OECD (2023[80]) for a further elaboration on the ammonia problem in the Netherlands.

2 Context and drivers

The capacity of the EU agro-food sector to combine productivity, sustainability and resilience is driven by recent and ongoing structural changes, the management of natural resources, and the evolution of the EU innovation system. This chapter examines trends in agro-food production, consumption and trade, and discusses the EU economy-wide policies that impact the sector's performance. The European Union is the world's largest agro-food exporter and one of its largest importers. Agriculture occupies 39% of the land, but contributes only 1.7% to the European Union's gross domestic product (GDP). Recent food system initiatives, digitalisation and data-related strategies can contribute to relevant social, economic, and environmental objectives, improving agricultural practices, empowering farmers, and addressing challenges such as the generational renewal and improving the role of women in agriculture.

Key messages

- The European Union's agro-food sector ensures the food security of its population while also contributing to global food security.
- Agriculture production only contributes to 1.7% of the European Union's gross domestic product (GDP) but generates significant economic gains. The European Union is the world's largest agro-food exporter and one of its largest importers.
- While agriculture occupies 39% of the land, total agricultural land has declined over the last 20 years. This decline, driven mainly by urbanisation and afforestation, has especially impacted arable land and pastureland.
- European meat production and consumption have shifted from beef and veal towards poultry since the early 1990s.
- There has been an increasing concentration of agricultural production on fewer but larger farms during the last two decades.
- EU agricultural income continues to stay below the average income of the economy, although the gap between farm income and income in other economic sectors has been declining.
- The share of the EU working population employed in agriculture fell while the average agricultural income per full-time employee increased. The outflow of local labour has been partially compensated by inflows of foreign labour, including undocumented workers, whose number is difficult to quantify.
- Women are underrepresented in the EU farming sector as in many other OECD countries. Gender bias is currently a structural characteristic of agriculture in almost all Member countries.
- The European Structural and Investment Funds, the main investment policy tool to support job creation and sustainable economic growth, has had mixed results regarding regional convergence since 2000: regional disparities in GDP per capita declined significantly until the global financial crisis, but much more slowly afterwards. Moreover, regional inequalities within countries have not converged, and have, in some cases, increased.
- Digitalisation and data strategies are high on the EU agenda to contribute to achieving the objectives of the European Green Deal and the Common Agricultural Policy.

This chapter sets the review of EU agriculture and food-related policies in the broader economic and policy context. It presents an overview of the main features of the EU agriculture and food sector (Section 2.1), the essential drivers of the agro-food sector's performance as defined in the OECD Agro-Food Productivity-Sustainability-Resilience (PSR) Policy Framework (Section 2.2) and EU economy-wide policies that have an impact on the sector performance (Section 2.3). Several aspects of this overview are analysed in more depth in the three following chapters of the review: agricultural policy setting (Chapter 3), environmental sustainability (Chapter 4), and innovation for sustainability (Chapter 5).

2.1. Agriculture and food sector in context

2.1.1. The European Union is one of the world's largest agro-food players

An important contextual development of the European Union has been its successive enlargements from the six original Member States to a total of 28 in 2020 prior to the exit of the United Kingdom. These enlargements mean that EU Member States are now a much more heterogeneous group of countries than at the outset, both in terms of their overall levels of economic development, their agricultural orientations determined in part by the different agro-ecological and climate zones, and differences in agricultural structures and the use of technologies.

The EU agro-food sector ensures the food security of its population while also contributing to global food security. Agriculture only contributes to 1.7% of the EU GDP and 4.3% of employment, but agro-food exports and imports show larger shares (Table 2.1). Although the contribution of agriculture to both EU GDP and employment has been relatively stable since 2000, the share of agriculture in the European Union's exports has considerably increased during this period, also as a result of EU enlargement.

Crops – including cereals, oilseeds, fresh fruit and vegetables, and plants and flowers – predominate in agricultural output, accounting for 57% of total production, although this share differs significantly across Member States. Livestock products – including dairy, beef and veal, pig meat, sheep meat, and poultry and eggs – account for the remainder.

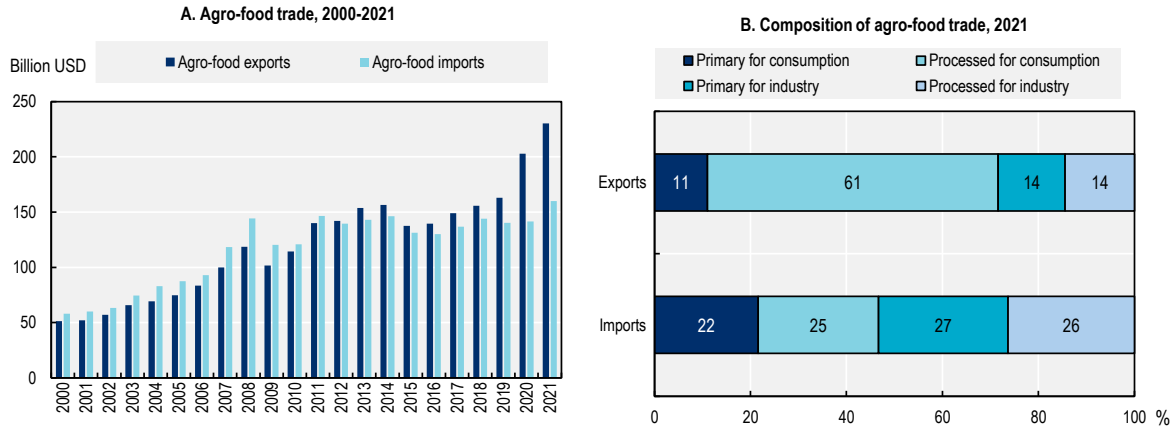
Table 2.1. European Union: Contextual indicators

	2000 (EU15)	2020 (EU27)
Economic context		
GDP (USD billion in PPPs)	9 932	18 631
Population (million)	378	447
Population density (inhabitants/km^2)	114	107
GDP per capita (USD in PPPs)	26 300	41 584
Trade as a % of GDP	11	12
Agriculture in the economy		
Agriculture in GDP (%)	1.8	1.7
Agriculture share in employment (%)	4.3	4.3
Agro-food exports (% of total exports)	6.0	9.3
Agro-food imports (% of total imports)	5.8	6.8
Characteristics of the agricultural sector		
Crop in total agricultural production (%)	54	57
Livestock in total agricultural production (%)	46	43

Note: EU: European Union; GDP: gross domestic product; USD: United States dollar; PPP: purchasing power parity.
Sources: OECD, UN Comtrade, and Eurostat and World Bank (WDI) databases, as reported in OECD (2022[1]).

Agricultural trade is essential to ensure food security, diversification of diets and better rural incomes in many EU regions. The European Union is a net food exporter, with agro-food products accounting for 9.3% of all exports and 6.8% of all imports. The European Union has been the world's largest agro-food exporter since 2013 and remains one of its largest importers as well. The region's agro-food exports are overwhelmingly composed of processed goods for final consumption (61%), while imports are more evenly distributed among other categories, with processed goods for final consumption accounting for the largest share of imports (28%) (Figure 2.1).

Figure 2.1. Evolution and composition of EU agro-food trade, 2000 to 2021



Notes: Numbers may not add up to 100 due to rounding. Extra-EU trade: EU15 for 2000-03; EU25 for 2004-06; EU27 for 2007-13, EU28 for 2014-19 and EU27 (excluding the United Kingdom) from 2020.
Source: Authors' calculations based on UN (2022[2]).

More specifically, the European Union is a net exporter in many categories of agriculture and food products (Table 2.2). In 2021, the main food groups characterising EU exports were beverages, spirits and vinegar; meat and edible meat; preparations of cereals, flour, starch or milk and pastrycooks' products; dairy produce, birds' eggs, natural honey and edible products of animal origin; and miscellaneous edible preparations. These categories represented about half of the total value of exports to non-EU countries (USD 106.1 billion). Net imported products, which included edible fruit and nuts; animal or vegetable fats; oil seeds and oleaginous fruits and miscellaneous grains, seeds and fruit; and coffee, tea, mate and spices, accounted for around 48% of the European Union's total agro-food import, corresponding to USD 71.1 billion.

Table 2.2. Agro-food trade in the European Union, 2021

HS code	Product description	Exports (USD million)	Share in agro-food exports	Imports (USD million)	Share in agro-food imports	Trade balance	Total trade (X+M)
22	Beverages, spirits and vinegar	39 453	18.7%	8 985	6.0%	30 467	48 438
08	Edible fruit and nuts; peel of citrus fruit or melons	6 530	3.1%	24 732	16.6%	-18 202	31 261
15	Animal or vegetable fats and oils	9 365	4%	18 662	13%	-9 297	28 028
02	Meat and edible meat offal	19 207	9.1%	4 034	2.7%	15 173	23 241
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit	5 138	2.4%	16 346	11.0%	-11 208	21 484
23	Residues and waste from the food industries; prepared animal fodder	8 804	4.2%	12 416	8.3%	-3 612	21 220

HS code	Product description	Exports (USD million)	Share in agro-food exports	Imports (USD million)	Share in agro-food imports	Trade balance	Total trade (X+M)
19	Preparations of cereals, flour, starch or milk; pastrycooks' products	17 023	8.1%	3 091	2.1%	13 931	20 114
21	Miscellaneous edible preparations	14 339	6.8%	5 710	3.8%	8 629	20 048
04	Dairy produce; birds' eggs; natural honey; edible products of animal origin	16 585	7.9%	2 053	1.4%	14 531	18 638
10	Cereals	11 525	5.5%	6 427	4.3%	5 097	17 952
20	Preparations of vegetables	10 222	4.8%	6 509	4.4%	3 714	16 731
18	Cocoa and cocoa preparations	8 903	4.2%	7 553	5.1%	1 350	16 456
09	Coffee, tea, mate and spices	3 283	1.6%	11 374	7.6%	-8 091	14 657
07	Edible vegetables and certain roots and tubers	6 607	3.1%	5 680	3.8%	927	12 287
24	Tobacco and manufactured tobacco substitutes	6 135	2.9%	2 697	1.8%	3 438	8 832
06	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage	5 344	2.5%	2 104	1.4%	3 240	7 448
17	Sugars and sugar confectionery	3 838	1.8%	2 063	1.4%	1 775	5 900
	Others	18 540	8.8%	8 414	5.7%	10 126	26 954
Total agri-food trade		**210 838**		**148 850**		**61 988**	**359 689**

Notes: Agro-food trade (including fish and fish products) codes in H0: 01-24, 3301, 3501-3505, 4101-4103, 4301, 5001-5003, 5101-5103, 5201-5203, 5301, 5302, 290543/44, 380910, 382360. It does not include intra-European Union trade.
Source: Authors' calculations based on UN (2022[2]).

2.1.2. The composition of the diet is stable, but the patterns of meat consumption are changing

The composition of the European diet has remained stable over the last two decades. The daily caloric availability has only increased by 2% (+52 kcal/person/day) to reach an average of 3 447 kcal/person/day in 2021. Overall, staples constitute the base of the European diet and provided 32% of the daily energy intake in 2019-21, followed by fats (16.6%), dairy products (12.5%), sweeteners (10.5%), meats (10.1%), fruits and vegetables (5.8%), and eggs and fish (both accounting for 1.4% of total calorie availability) (Figure 2.2).

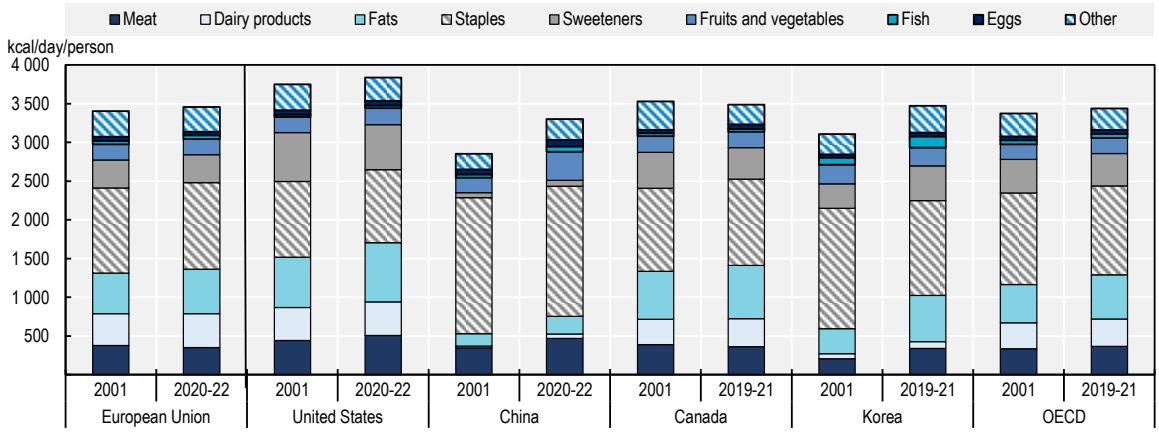
In the European Union, per capita meat consumption has decreased and has been shifting from red meat towards poultry, which is consistent with the trend in OECD countries (OECD/FAO, 2022[3]). This can mainly be explained by lifestyle changes towards lower meat protein consumption due to growing awareness of health, environmental and animal welfare issues and more sedentary lifestyles that limit additional protein intake (de Boer and Aiking, 2022[4]). Per capita red meat consumption has decreased by 14% in the last two decades, while per capita poultry consumption has increased by 30% over the same period. In comparison, per capita meat calorie availability has increased by 15% and 34% in the United States and China, respectively, during the last two decades (OECD/FAO, 2022[5]). In OECD countries, on average, trends reveal an increase of per capita availability of 8.7% from 2000 to 2019-20, with demand for red meat weakening and shifting to more white meat.

Per capita availability of dairy products, on the other hand, has increased since the 2000s in the European Union and other high-income countries. The daily calorie availability grew by 2.23% annually, reaching 439 kcal/person/day in 2019-21. This growth is mostly driven by an upward trend in the consumption of processed dairy products such as cheese and fresh dairy products. Per capita availability of cheese has increased annually by 1.30%, reaching 146 available kcal/cap/day in 2019-21, while consumption of other dairy products, such as butter and skim milk powder, have remained stable. In recent years, the composition of demand has been shifting towards dairy fat such as full-fat drinking milk and cream in the

European Union and the United States. Recent studies shed a more positive light on the health benefits of dairy fat consumption, contrary to the messaging of the 1990s and 2000s. This new evidence may have influenced consumers to modify their diets (OECD/FAO, 2022[5]).

During the last decade, EU countries introduced policies to encourage and promote a shift towards healthier diets. Front-of-pack labelling, dietary guidelines and sugar-sweetened beverage taxes have been used in several Member States, where diabetes and obesity trends have been worsening over time (WHO, 2019[6]). Other complementary measures, such as reformulation by the industry and reduction of children-targeted marketing, aim to reduce sugar, fat and salt consumption.

Figure 2.2. Per capita calorie availability of the main food groups in selected economies

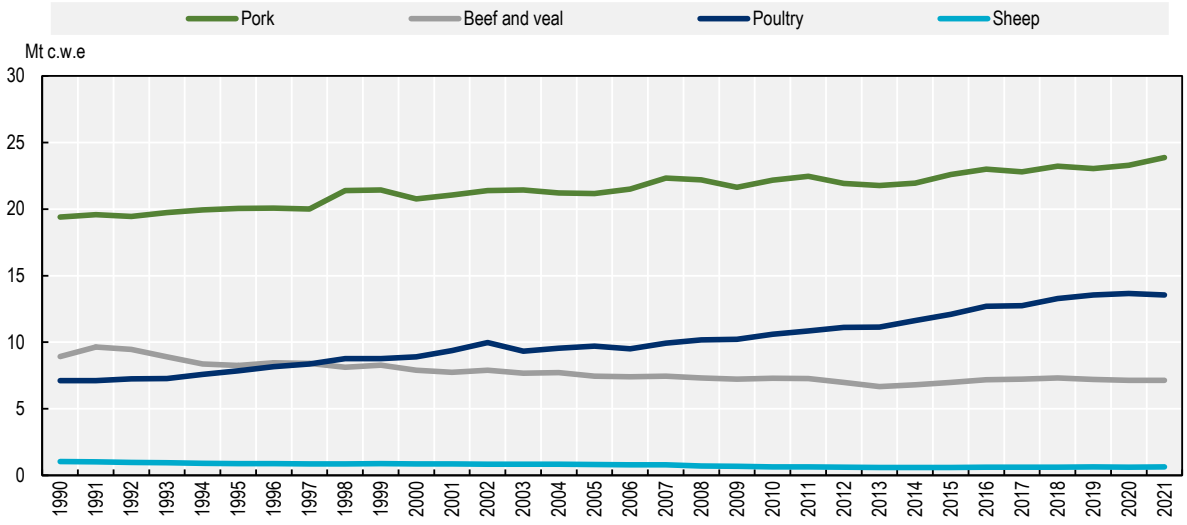


Notes: EU27. Estimates are based on historical time series from the *FAOSTAT Food Balance Sheets* database. Estimates of food availability, not equivalent to actual consumption. Quantities of food available for human consumption are higher than quantities consumed, as some of the food that is potentially available to consumers is lost or wasted along the supply chain. This share is particularly high for perishable products such as dairy products and fruits and vegetables. The FAO estimates that globally, about 14% of food produced is lost before reaching the retail level. An important share of food available to consumers is also wasted; this was estimated at 17% in 2019. Staples include cereals, roots, tubers and pulses. Fats include butter and vegetable oil. Sweeteners include sugar and high-fructose corn syrup. The category "Other" refers to other crops and animal products.
Source: FAO (2022[7]); OECD/FAO (2022[3]).

2.1.3. The patterns of meat production have also changed

Along with the shift in European meat consumption over the last decades, the patterns of meat production have also changed (Figure 2.3). From the beginning of the 1990s, beef and veal production dropped by 27%, yet has remained relatively stable since 2010. Poultry production, on the other hand, experienced a significant increase of 90% in the same period. Accordingly, while beef and veal production was higher compared to poultry in 1991, this had reversed in 2021, with amounts of 6.9 million tonnes compared to 23.9 million tonnes of carcass weight. At the same time, the production of pork also increased by 22%, reaching a high peak of 23.9 million tonnes of carcass weight. Conversely, sheep production experienced the sharpest decline, 43%, with the lowest production quantities (0.6 million tonnes of carcass weight) in 2021. These structural changes in the EU livestock sector from ruminants to monogastric (e.g. from beef or poultry production) have led to reduced methane emissions and higher efficiency gains. While there is little awareness of the link between diets and climate change, a shift in European diets towards reduced meat consumption is crucial to achieving climate change targets (Wellesley, Happer and Froggatt, 2015[8]).

Figure 2.3. Production of meat in the European Union, 1990 to 2021



Notes: Mt c.w.e.: million tonnes of carcass weight equivalent. EU27.
Source: OECD/FAO (2022[3]).

2.2. Drivers of the agriculture and food sector's performance

2.2.1. Natural resources and climate change

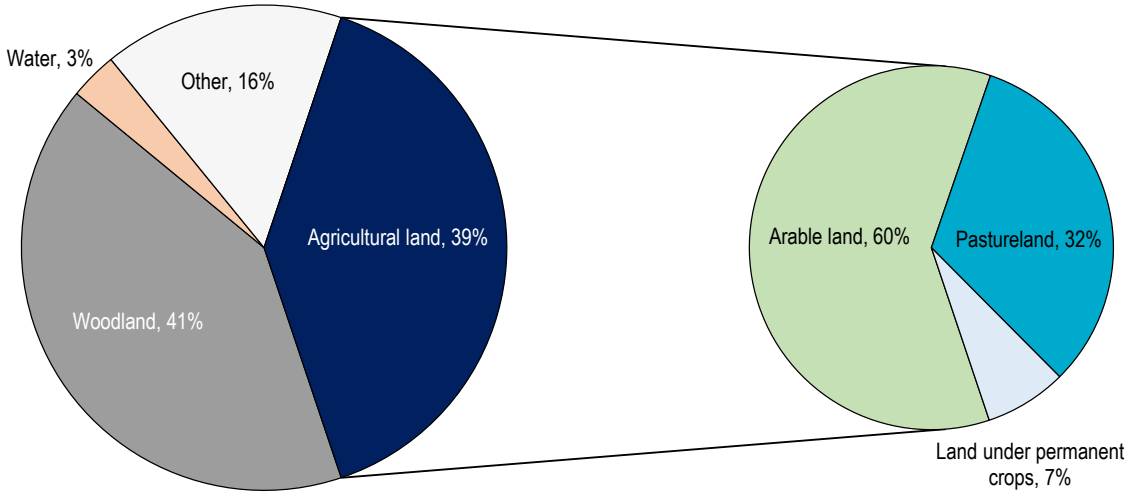
Urban expansion, afforestation and farming withdrawal led to a consistent reduction of agricultural land

In 2018, the largest proportion of the total area of the European Union was covered by woodland (41%), followed by agriculture, which occupies 39% of the European Union's landmass. The majority of utilised agricultural area (UAA) is arable land (60.3% in 2018), which is mainly used to produce crops for human and animal consumption. Permanent grassland accounts for a further third (32.5%) of the UAA and is mainly used to provide further fodder and forage for animals. The remaining area (7.2%) is used for permanent crops such as fruit, olives and grape production (Figure 2.4).

FAO data show that, during the last 20 years in Europe, there has been a consistent reduction – of about 10% – of agricultural land that has affected all types of land use. As shown in Figure 2.5, pastureland declined rapidly between 2008 and 2014 but has been mostly stable since. After a similar declining trend, land under permanent crops has increased since 2016. In 2020, it had returned to the 2007 level.

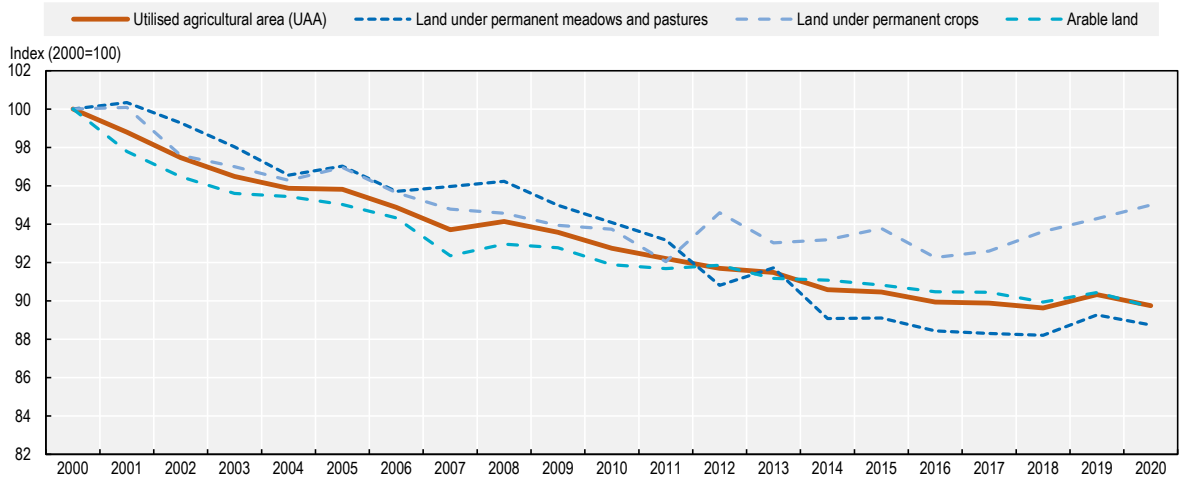
Agricultural land losses are mainly due to urban expansion – including transport infrastructure, afforestation and farming withdrawal. In the period 2000-18, 14 049 km² of agricultural land was urbanised, mostly at the expense of arable lands and permanent crops (around 50% of the total urbanisation), and of pastures and mosaic farmlands (almost 30%) (EEA, 2019[9]). Overall, the urbanisation process, combined with the homogenisation of agricultural fields and intensive land use, have negative effects on biodiversity. This is particularly evident for farmland and birds using this type of habitat (EEA, 2021[10]). As discussed in Chapter 1, the latest data on European common birds shows a continued decline of European farmland birds (PECBMS, 2022[11]).

Figure 2.4. Land use in the European Union, 2018



Note: EU27. Numbers may not add up to 100 due to rounding.
Source: Eurostat (2022[12]), accessed August 2022.

Figure 2.5. Developments in land use in the European Union, 2000 to 2020



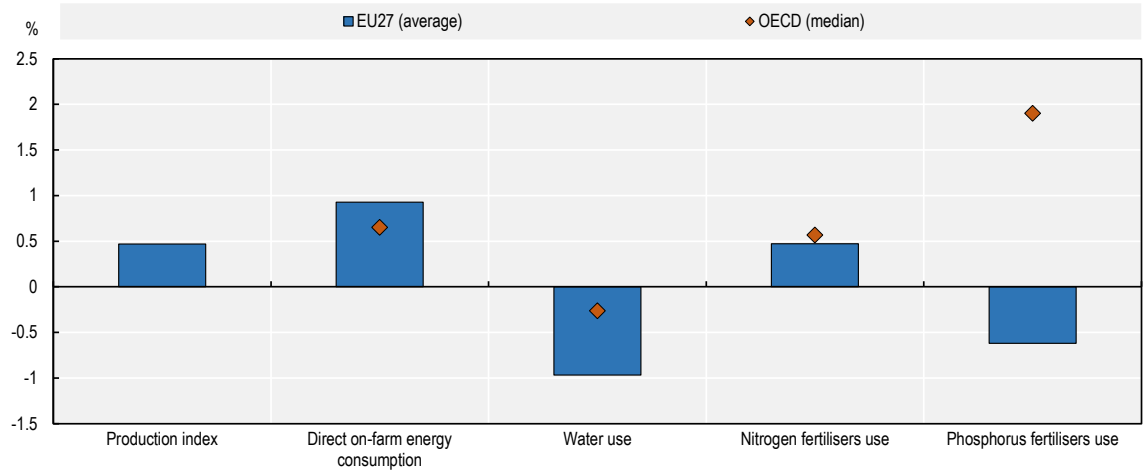
Source: FAO (2022[13]), accessed in September 2022.

There are signs of improvements in some agri-environmental indicators of inputs in the EU27 agriculture, but the sustainable use of water is still a major challenge

Increases in EU agricultural production observed over the last decade are combined with increases in the use of some inputs, such as direct on-farm energy consumption and nitrogen fertilisers. However, a reduction in water use was observed (-0.3% per annum) and, unlike the OECD average, a consistent reduction was also observed in the use of phosphorus fertilisers (-0.6% per annum) (Figure 2.6).

Figure 2.6. Production and input use in the European Union and the OECD

Average annual change, 2007-09 to 2017-19



Notes: All indicators are divided by agricultural land area. Data for nitrogen fertilisers and phosphorus fertilisers refer to the periods 2007-09 and 2012-14.
Source: OECD (2022[14]).

In 2019, energy consumption by agriculture made up 3.3% of final energy consumption in the European Union. Just over half (55%) of agriculture's total energy consumption was from oil and petroleum products (excluding biofuels), the main fuel type in most countries. The other key types of fuel were electricity (17%), natural gas (14%), and renewables and biofuels (9%) (Eurostat, 2022[15]).

While irrigation contributes significantly to agriculture's productivity, it exerts major pressure on freshwater resources in some regions, both by abstraction of the resource and by agricultural run-off (Gruère and Shigemitsu, 2021[16]). Trends in irrigated areas and water abstraction vary widely across Europe. Around 7-8% of the UAA in the EU27 was irrigated annually on average in the last ten years (Eurostat, 2020[17]). High shares of irrigated areas are found in southern European countries, especially Greece, Spain, Italy, and Malta, but also in France, Cyprus, Portugal, and the Netherlands (EEA, 2021[18]). Water is abstracted for use across economic sectors in the EU27. Abstraction for cooling in electricity generation remained the largest contributor to total annual water abstraction (32%) in 2019, followed by reported abstraction for agriculture (28%), public water supply (20%) and manufacturing (13%) (EEA, 2022[19]). There are considerable differences in the amounts of freshwater abstracted in each EU Member State, in part reflecting the size of each country and the resources available, but also abstraction practices, climate, and the industrial and agricultural structure of each country. However, specific regions may face problems associated with water scarcity; this is particularly the case in parts of southern Europe, where it is likely that agricultural water consumption (as well as other uses) will need to decline to prevent seasonal water shortages (Eurostat, 2022[20]). In any case, national water policies need to be adjusted to local contexts, especially in the context of a geographically and climatically diverse European Union (OECD, 2021[21]).

European agriculture is dependent on imports of fertilisers. EU farmers used 11.2 million tonnes of mineral fertilisers (nitrogen [N] and phosphorus [P]) in 2020 (Eurostat, 2022[22]), a third of which is imported. Over time, nitrogen-based fertilisers have been the most traded products with third countries. More than 3 million tonnes have been imported annually into the European Union since 2015 (EC, 2019[23]). The nitrogen-based fertiliser industry is heavily dependent on gas of Russian origin, and the Russian Federation (hereafter "Russia") and Belarus are key players in the world production of rock-based fertilisers (phosphates and particularly potassium). The military aggression in Ukraine and the application of

sanctions on Russia have led to higher fertiliser prices, which will likely impact the use of fertilisers in agriculture in the European Union and also on yields and quality (Chapter 3, Box 3.2) (Eurostat, 2022[24]) (Eurostat, 2022[24]). In November 2022, the European Commission released a communication outlining several best practices and ways forward to help farmers optimise their fertiliser use and reduce their dependencies while securing yield (EC, 2022[25]).

The effects of climate change on EU27 agriculture are expected to increase, but the impacts will depend on regional characteristics

Climate change represents one of the main environmental problems of the 21st century, which is already having several consequences on natural resources due to the increased climate variability and the increasing frequency, intensity, spatial extent, duration and timing of extreme climate events (IPCC, 2022[26]). Agriculture is one of the economic sectors facing the greatest impact, and even in Europe, climate change has already influenced crop yields and livestock productivity and will continue to increase pressure on production (OECD, 2014[27]; EEA, 2019[28]). Ortiz-Bobea et al. (2021[29]) estimated that climate change has reduced global agricultural total factor productivity (TFP) by about 21% since 1961. This slowdown is equivalent to losing the last seven years of productivity growth, even though relevant regional and cross-country disparities were observed: more severe impacts (from -26% to -34%) are observed in warmer regions such as Africa and Latin America compared to cooler regions such as North America (-12.5%) and Europe and Central Asia (-7.1%). Ray et al. (2019[30]) estimated that yields for all the dominant crops in western and southern Europe have already decreased between 6.3% and 21.2% due to climate change.

Weather and climate conditions also affect the availability of water needed for irrigation, livestock watering practices, the processing of agricultural products, and transport and storage conditions. As reported by the European Environment Agency, climate change impacts on agriculture are projected to produce up to 1% average GDP loss by 2050, but with large regional differences (EEA, 2019[28]). Recent projections (EC, 2020[31]) show that climate change could further restrict the water available for irrigation and result in yields that are lower than the potential achievable under full irrigation. Under an extreme assumption of no irrigation in the future, severe declines (over 20%) in maize yield have been projected for all countries, with crop losses of up to 80% for some countries in southern Europe (Bulgaria, Greece, Portugal, and Spain). This implies that without market adjustments, maize production may no longer be viable in areas with high risk for water scarcity and significant decreases in precipitation. In contrast to grain maize, wheat is mostly a non-irrigated, rain-fed crop in Europe. Increases in yields by around 5% on average are projected for northern Europe due to changes in precipitation regime combined with an anticipated growing cycle and enhanced growth from increasing atmospheric CO_2 concentrations. Yield reductions are projected for southern Europe by 12%, on average, corroborating empirical evidence of a limited CO_2 effect on wheat under limited water conditions. Limiting global warming to 1.5°C could reduce these losses by 5%.

While the increasingly extreme weather and climate events are expected to increase crop losses and reduce livestock productivity across all regions, climate change is projected to reduce crop productivity especially in southern Europe. In northern Europe, on the contrary, the lengthening of growing seasons and the higher temperatures will improve the suitability for growing crops. Finally, in various regions in Europe, increasing drought risk is expected to reduce livestock productivity through negative impacts on grassland productivity and animal health.

2.2.2. Structural change and socio-economic issues

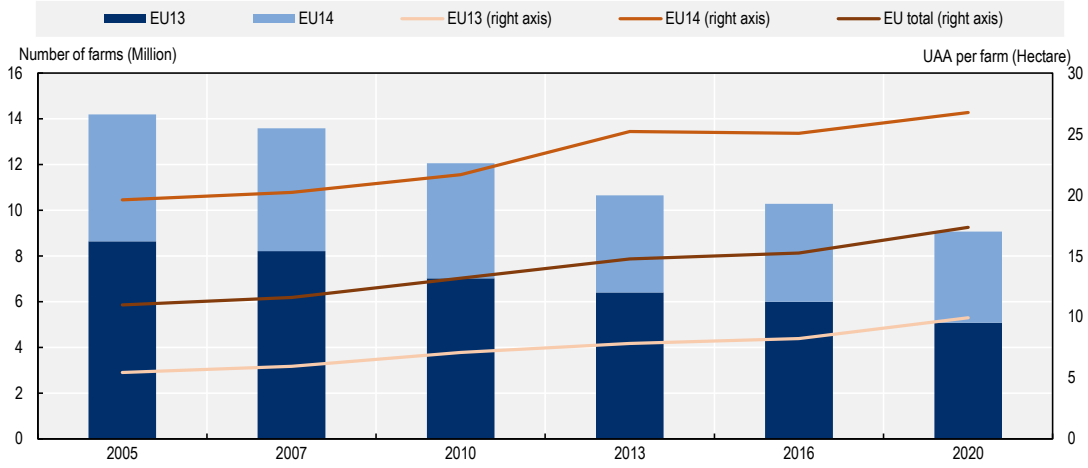
The EU farming sector has undergone significant structural changes over the last decades. The following subsection provides an overview of the most apparent and policy-relevant transformations in the sector: a reduction in the number of farms along with an increase in farm size and the declining share of young farmers in the agricultural working population.

Declining number of farms and increasing average farm size

A decline in farm population and an expansion of farm size are important characteristics of structural change in the agricultural sector of OECD countries, but growth in farm size shows substantial differences across single countries and periods depending on country-specific natural, geographical, historical, social and economic conditions, as well as the policy environment (Bokusheva and Kimura, 2016[32]). Data show that the EU27 agriculture has also experienced a constant trend towards fewer but larger farms. The number of farms has been declining for several decades, dropping from 14.2 million in 2005 to 9.1 million in 2020 (Figure 2.7). In the same period, the average farm size increased from 11 hectares to 17.4 hectares. This trend applies to both EU13 and EU14 countries. There are, however, significant differences between the average farm sizes of the two groups. While UAA per farm in the EU14 was 26.8 hectares in 2020, it was only 9.9 hectares in the EU13 countries. In the EU13, the number of farms decreased by 41.3% between 2005 and 2020, while there was only a 28.1% decrease in the case of the EU14 (Eurostat, 2022[33]).

Various factors can explain those structural trends. These include the low profitability of farming and better job opportunities outside of agriculture, increased productivity (e.g. through technological progress) and an increasing degree of rationalisation due to improved farm machinery, often requiring a larger scale to be efficient. Public policies and the institutional context play a role, especially market price support and coupled payments, which in the past had contributed to encouraging intensification and scale enlargement (EC, 2019[34]; Bijttebier et al., 2018[35]). On the other hand, decoupled direct payments have a more indirect impact on farm structure changes by encouraging farmers to stay in the sector (Chapter 3).

Figure 2.7. Evolution of the number of farm holdings and their average size in the European Union, 2005 to 2020



Notes: UAA: utilised agricultural area. EU14 refers to pre-2004 Member States. EU13 refers to post-2004 Member States.
Source: Eurostat (2022[36]), accessed January 2023.

Increasing value of production and respecialisation

The decrease in the total number of agricultural holdings between 2005 and 2020 is primarily due to the disappearance of farms smaller than five hectares, which make up nine out of ten disappearing farms. At the same time, farms with more than 50 hectares are the only ones that have increased (+9.7%). In the same period, the economic size of the EU farming sector also increased continuously. The total standard output generated by all farms in the European Union increased by 32%, from EUR 267.6 billion to EUR 353.7 billion (Table 2.3).

Table 2.3. Evolution in the number of holdings and standard output according to farm size in the European Union

	Number of holdings (in millions)			Standard output (in EUR billions)		
Total	2005	2020	% change	2005	2020	% change
Less than 10 ha	14.2	9.1	-36.1	267.6	353.7	32.1
From 10 to 49.9 ha	11.8	6.9	-41.4	75.8	71.7	-5.5
50 ha or more	1.8	1.5	-16.5	80.1	96.3	20.1
Total	0.6	0.7	9.7	111.7	185.7	66.3

Note: EU27.
Source: Eurostat (2022[36]), accessed January 2023.

While farms larger than 10 hectares increased their average standard outputs, smaller farms' standard output decreased. The 6.9 million smallest farms below 10 hectares, which represented 76% of the 9.1 million farms in 2020, only accounted for 20% of the European Union's total agricultural economic output (EUR 71.7 billion). With an average annual standard output of EUR 10 375 (in 2020), most of these farms count as (semi)-subsistence, as many consume more than half of their own production. A further 1.5 million farms with areas between 10 hectares and 49.9 hectares represented 27% of the total standard output (EUR 96.3 billion). By contrast, the largest 677 760 farms with an area of 50 hectares or more were responsible for 53% of the total economic output in the European Union, EUR 185.7 billion, while accounting for 7% of all farms. Those farms are characterised as large agricultural enterprises with an average output of EUR 273 987 per year (Eurostat, 2021[37]).

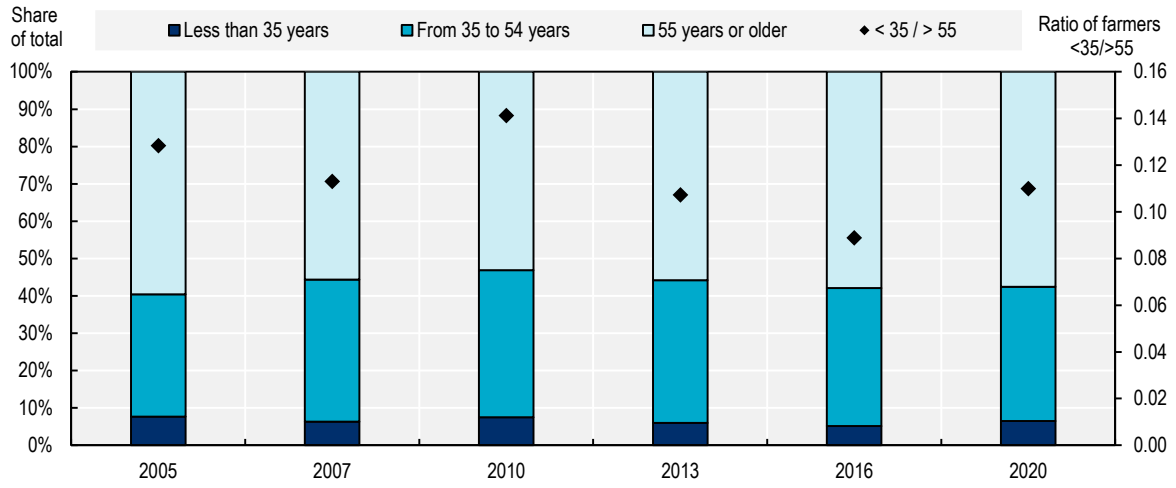
Along with the changes in farm number and average farm size, the pattern of farm specialisation also changed. Although EU farms continue to engage in diverse activities, they have increasingly moved toward specialisation. This is particularly the case for crop farms, whose share of total farms increased from 43% in 2005 to 58% in 2020. In contrast, the proportion of mixed cropping farms declined from 30% to 19%, while farms specialised in livestock experienced a relatively minor change, dropping from 24% to 22% in the same period (Eurostat, 2021[37]).

Declining number of farmers and generational renewal

Farmers and those working in the agricultural sector are also facing a structural change. The share of the EU working population employed in agriculture fell from 6.4% in 2005 to 4.2% in 2020. This is equivalent to a 36% decline in annual working units (AWU) (Eurostat, 2022[38]). This labour outflow is mainly driven by the shrinking number of farms and the strive for economies of scale through investments in machinery and technology and larger farms (Maucorps et al., 2019[39]). Nevertheless, agriculture remains an important sector for employment, with 8.2 million full-time equivalents in the sector in 2020. When including temporary or family work, the regular labour force reached 17 million people in 2020. Only 18.7% were in full-time employment on the farm; 81.3% undertook farm work as a secondary or part-time activity. Farming remains mainly a family activity, with 86.1% of those who worked regularly in agriculture being either farmers or family members; hired labour was only 13.9% (Eurostat, 2022[40]).

The proportion of young farmers is also small and diminishing (Figure 2.8), leading to the problem of generational renewal. In 2020, more than half of the farmers in the European Union were at least 55 years old, and between 2005 and 2020, the share of farm managers under the age of 35 decreased in proportion to the overall figure (from 7.3% to 6.5%). However, the latest 2020 figures show some signs of stabilisation or improvement: between 2016 and 2020, the share of farmers under 35 increased by 1.4% and the number of farmers over the age of 35 decreased (Eurostat, 2022[40]).

Figure 2.8. Evolution of the age distribution in farm labour force and the share of young farmers in the European Union, 2005 to 2020



Note: EU27.
Source: Eurostat (2022[41]), accessed December 2022.

The slow pace of generational renewal in agriculture is of particular concern since young farmers are key to embracing research, innovation and smart agriculture (EC, 2020[42]). They tend to be better educated than older farmers and are more likely to adapt to new production techniques. Younger and middle-aged farmers tend to reach higher economic outputs and cultivate larger areas, while old farmers manage significantly smaller farms in terms of economic output and agricultural land sector (EC, 2019[34]). Young farmers are additionally found to take up more sustainable practices (Brennan et al., 2016[43]) and are, therefore, essential for a sustainable and productive future farming.

Agricultural income

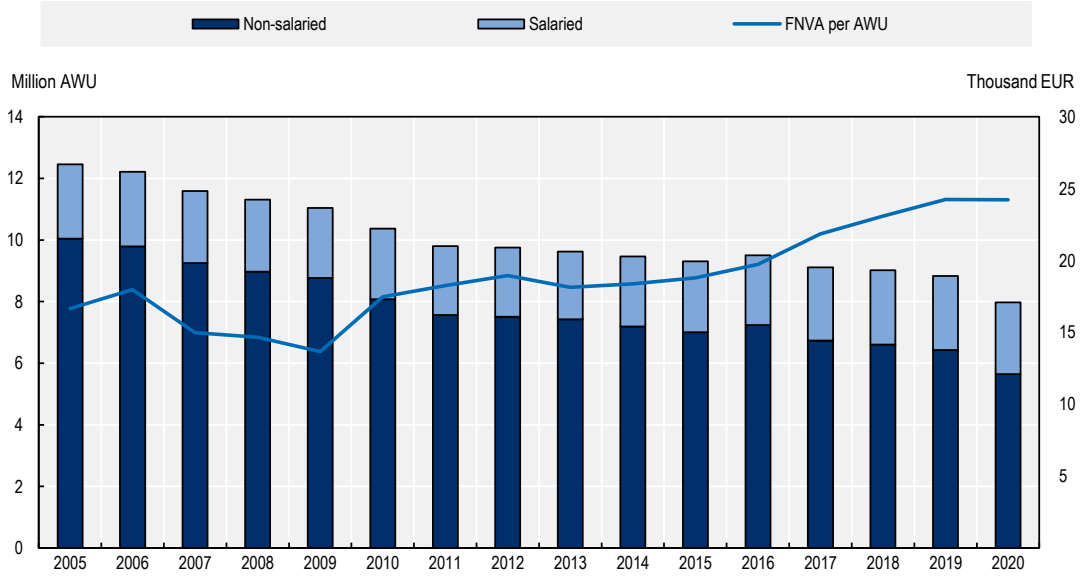
Ensuring a fair standard of living for farmers is one of the main objectives of the CAP (Chapters 1 and 3). Calculations based on Eurostat data show that EU agricultural income, as measured by entrepreneurial income per family work unit, continues to stay clearly below the average income of the economy, although the gap between farm incomes and incomes in other economic sectors is closing over time (EC, 2022[44]). Nevertheless, the average agricultural income per full-time employee – expressed as average farm net value added per AWU – has been increasing in recent years. Between 2007 and 2020, the income level rose by 48%, from an initial value of EUR 15 989 to EUR 23 649, yet with significant differences among Member States. Only around one-quarter of the total labour input draws a salary, yet the discrepancy between paid and unpaid workers has been declining to a small extent in the past years (Figure 2.9).

Many farmers conduct other gainful activities related to their holdings to increase their income. In fact, almost a quarter engaged in other gainful activities within the sector in 2016, 17% of those as a main activity (Eurostat, 2021[37]). This includes, for example, activities such as agri-tourism, energy production or direct marketing. Consequently, the picture of farmers' actual farm-related income also remains incomplete, such as the role supplementary income sources play in contributing to their overall income. Although the Farm Accountancy Data Network (FADN) started collecting such data in 2014, data are still incomplete and non-representative of the economic performance of farms (ECA, 2022[45]).

The data shown in Figure 2.9 on agricultural income in farming per AWU should be considered as an indication of the income performance of farms, but they should be interpreted with caution when analysing farmers' standard of living and making comparisons to other sectors of the economy. Many farmers or

household members receive earnings from activities beyond agriculture that are not covered by this measure. Particularly, holders of smaller farms often consider farming a minor activity and rely on other income sources outside the sector to raise and stabilise their incomes (EC, 2015[46]). To get a full picture of farmers' incomes – and thus be able to assess their living standards and make comparisons to other sectors – would require considering the whole disposable income of the farm household. This includes farm-related as well as income from other sources outside the sector (Marino, Rocchi and Severini, 2021[47]; Rocchi, Marino and Severini, 2020[48]).

Figure 2.9. Evolution of agricultural income in the European Union, 2005 to 2020



Notes: FNVA: farm net value added; AWU: annual working unit. EU27. Agricultural income can be expressed as average FNVA/AWU, equal to gross farm income minus the depreciation costs. It takes into account agricultural support on the one hand and income taxes on the other. The measure per AWU allows accounting for the different farm scales and provides a better measure on agricultural labour productivity.
Sources: Eurostat (2022[49]), accessed January 2023; FADN (2022[50]), accessed January 2023.

The most recent data suggest that farm incomes are higher than they have ever been. While COVID-19 and the war in Ukraine, among other crises, have decreased EU agricultural output (-3.5%) and increased input prices (e.g. 82.8% for fertiliser) (Eurostat, 2023[51]), entrepreneurial income in EU agriculture has increased by 25% between 2021 and 2022 (Eurostat, 2023[52]), in part due to agricultural support measures implemented by the European Union and its Member States in the wake of the aforementioned crises. This raises questions regarding the extent of the support provided and whether it has exceeded the needs arising from events that have affected the agricultural sector (Matthews, 2023[53]).

As discussed in Chapter 3, one of the key challenges for future agricultural policies will be related to the increased availability of data, since only sound data allow designing effective policies aimed at maintaining farmers' incomes and assuring a fair standard of living for farmers. Only a few Member States, for example Ireland and the Netherlands, report farm household income data. Furthermore, approaches vary widely and do not allow for comparisons across countries.

Migrant workers

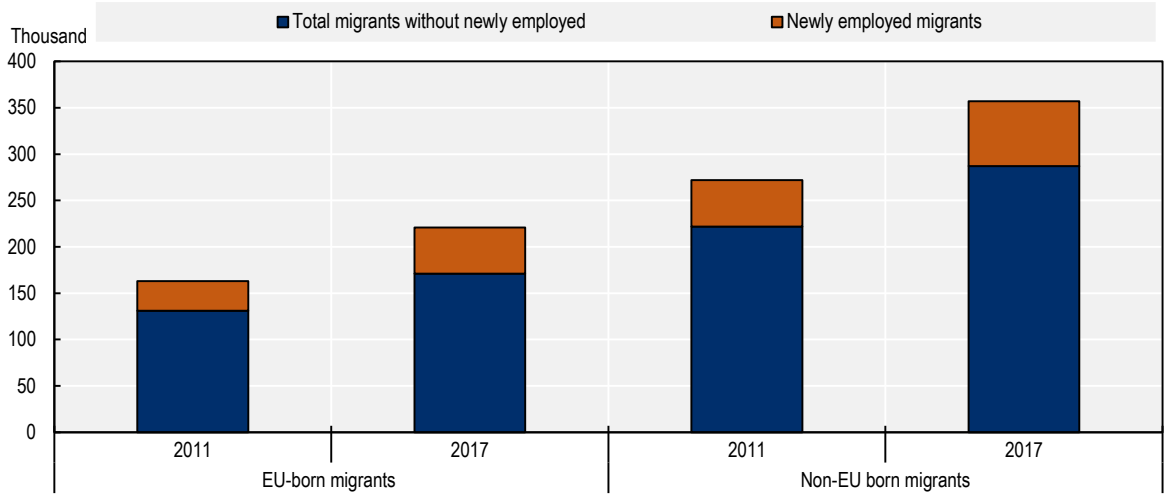
Although the European Union hosts fewer migrants than other OECD countries, numbers have increased considerably in the past decades. In particular, during the 2000s, the population of foreign-born inhabitants

in the European Union increased comparatively faster thanks to a robust immigration rate. Today, this population plays an essential role in the EU workforce (OECD, 2016[54]).

In the agricultural sector, foreign labour, notwithstanding undocumented workers whose number is difficult to quantify, accounts for a sizeable and increasing amount of the agricultural workforce, partially compensating for the outflow of local labour.[1] The COVID-19 crisis and the related imposed mobility restrictions on foreign workers highlighted the European Union's dependence on foreign agricultural workers and their importance to the functioning of the sector (Kalantaryan, Mazza and Scipioni, 2020[55]). Migrants, particularly non-EU born ones, take on an increasingly important role in food production and natural resource management while constituting a strategic asset in combating labour shortages and fostering the sector's resilience (Nori, 2017[56]).

In 2017, the EU agricultural sector counted 221 000 EU-born and 357 000 non-EU-born migrants, respectively 36% and 31% more compared to 2011 (Figure 2.10). Together, they accounted for 6.4% of total agricultural employment (3.5% in 2011), with a particularly high share in Denmark, Italy and Spain. Most migrant workers in EU agriculture sustain labour-intensive crop production, particularly harvesting fruits, vegetables and horticulture. Between 2011 and 2017, the number of newly employed migrants in agriculture increased significantly, by 56% for EU-born migrants and 40% for non-EU born migrants, to inflows of 50 000 and 70 000 people in 2017 (Martin, 2016[57]; Kalantaryan et al., 2021[58]). Migration flows, however, differ widely across Member countries, as do the activities they perform. In the case of Denmark, for example, most employed migrants in agriculture are from another EU Member State, mainly working in forestry, pig farming and horticulture (Refslund, 2016[59]). Italy and Spain, in contrast, rely on higher numbers of non-EU migrants who work in crop picking on fruit and vegetable farms (Corrado, 2017[60]).

Figure 2.10. Existing and newly employed workers in the European Union, 2011 and 2017



Source: Kalantaryan,Mazza and Scipioni (2020[55]).

Despite the increasing importance of migrants in EU agriculture, their working and living conditions give reasons for concern. Generally, foreign workers are more likely than locals to work in low-skilled jobs, be employed and follow temporary occupations while receiving lower incomes and facing a higher risk of poverty (Kalantaryan et al., 2021[58]). Limited rights, unsatisfactory working standards and illegality often accompany those conditions, further provoking difficulties in receiving residence permits, operational licenses and general citizenship rights (Augère-Granier, 2021[61]). As discussed in Chapter 3, social conditionality will be an important tool that potentially could raise labour standards in EU agriculture since CAP beneficiaries will have to respect elements of European social and labour laws to receive CAP funds.

The conditions of migrant workers in the EU agricultural sector pose a clear policy need that will become increasingly acute in the coming years as foreign labour inflows increase (OECD, 2022[62]). The consideration of socio-economic conditions and the assurance of social rights compliance, particularly for migrant workers, is therefore essential for the future. However, data availability is a key first step to finding a targeted and adapted policy response.

The role of women

There are many differences in how women and men participate in the agricultural labour force, but generally women are less likely than men to own and manage an agricultural family business in OECD countries (Giner, Hobeika and Fischetti, 2022[63]). According to official statistics, in 2019 women accounted for 40.1% of the total EU27 agricultural labour force (EC, 2019[64]). As many farms are family-run, women often work as family labour that may not be registered in statistics. In addition, women are an essential backbone for EU agriculture, but they often follow seasonal or part-time activities in the lowest paid and most insecure jobs (European Institute for Gender Equality, 2016[65]; European Institute for Gender Equality, 2022[66]).

Current data show that 42% of female agricultural workers are over the age of 65, compared to 29.2% for males – creating a high risk of a widening gender gap in the future (EC, 2021[67]; Kovačićek and Franić, 2019[68]). This comparatively greater share of older women is not least because women in the farms are generally less recognised in the agricultural context than men (e.g. due to lower salaries, less land ownership or lack of farm entitlement), thus making agricultural careers unattractive to younger women.

Wide discrepancies exist between the role of women and men. While they contribute significantly to the sector, women's role in agricultural decision making and farm and land ownership remains minor. In 2016, only 28.7% of farm managers were female, while the figure increased to 31.6% in 2020, showing a slight improvement. On average, they operate significantly smaller and more diversified farms, with female managers accounting for low shares of the more profitable specialised farming holdings (Eurostat, 2021[37]) In addition, females often undertake assisting functions in which they receive less or no income and, in many cases, are not entitled to social security.

Gender-disaggregated data are often missing, making women's contributions difficult to acknowledge and assess. A broader range of gender-disaggregated data can contribute to increasing the visibility of women in the sector (Giner, Hobeika and Fischetti, 2022[63]). For example, a significant gender-related data gap prevails in the overarching 2021-2027 Multiannual Financial Framework policies and programmes. Although the European Commission's impact assessment guideline puts attention on gender equality, gender analysis is incorporated in only a few programmes with small consideration (the CAP assessment, for example, provides a brief reflection on gender) (ECA, 2021[69]). The upcoming transition from the FADN to the Farm Sustainability Data Network (FSDN) will include a broader range of gender-disaggregated data, but broader assessments of the role of households in EU agriculture and rural areas are needed once more information on the range of new variables is available.

2.2.3. Innovation

The Farm to Fork (F2F) Strategy identifies research and innovation as key to accelerating the transition to sustainable, healthy and inclusive food systems across the European Union. Fostering knowledge and innovation is also a cross-cutting objective of the CAP 2023-27 and food, bioeconomy, natural resources, agriculture and the environment are important elements in the European Union's research and innovation policy Horizon Europe. The innovation dynamics is a complex process involving multiple actors and policy levers, as analysed in Chapter 5. This section introduces the Agricultural Knowledge and Innovation System (AKIS) as an approach to better connect agricultural practice and science and boost knowledge generation, exchange and innovation.

The European Union's AKIS is very diverse, involving numerous actors at the EU, national and regional levels

The concept of AKIS has gained increasing importance in the European Union in the past decade. It aims to benefit farmers, as well as society, in particular by empowering them to co-create and adopt innovative, sustainable agricultural practices. Farmers, as the centrepiece of the AKIS, are key to fostering modernisation, innovation and knowledge flows in the agricultural sector (EU SCAR AKIS, 2019[70]).

The complexity of the EU AKIS is partly due to the existence of 27 national AKIS and their regional AKISs, with their set of actors and initiatives operating at the EU level within a single European common knowledge and innovation area. Each EU Member State has developed an individual AKIS that corresponds to its particular situation, actors and needs and is embedded in national laws, institutions and cultures. So far, national AKIS within the European Union differ greatly from each other, for example in terms of the fragmentation and strength (invested budgets) as well as in the number of actors, the type of institutions, governance levels and systems, funding types, and the characteristics of the farming sector. The systems thus require flexible, country-adapted framework conditions offering co-ordinated arrangements, in particular in countries with a strong regional structure such as Germany, Italy and Spain, and a national-wide approach in countries with a more centralised system, e.g. Cyprus and Finland (PROAKIS, 2015[71]).

In view of these differences between national AKIS, the European Commission's (EC) role is to foster innovation by providing an overarching regulation on Member States' AKIS strategic approach and a number of services to generate and exchange knowledge across countries, thus allowing for cross-border spillover effects in a larger innovation geographical area (Détang-Dessendre et al., 2022[72]). The scale and interconnectedness of the AKIS affect its capacity to find solutions, exchange experiences and knowledge, and facilitate adoption. The EU common knowledge and innovation area can help enhance the knowledge flows across regions and countries. Spain provides an interesting example of a fragmented agri-food research landscape where regional research centres vary greatly in terms of research capacities and areas of interest but are well connected outside Spain through Horizon Europe and other European programmes. However, Spain added a number of national efforts to the regional initiatives to interconnect the regions, such as regular networking events, national technology platforms and national European Innovation Partnership innovation projects, national focus groups and synergies through research legislation which increase the impact in agricultural practice.

2.3. General policy environment

2.3.1. Trade policies

The European Union is the largest single market in the world, and its treaties and legal frameworks ensure a functional internal market, with full free trade and competition across all Member States. The European Union manages its trade and investment relations with non-EU countries through its common commercial policy, whose rules are set out in Article 207 of the Treaty on the Functioning of the European Union (EU, 2012[73]). Extra-EU trade is an exclusive competence of the European Union, not a shared competence with the national governments of its Member countries. This means the EU institutions make laws on trade matters and negotiate and conclude international trade agreements. The common commercial policy covers trade in goods (including agriculture) and services; the commercial aspects of intellectual property, such as patents; public procurement; and foreign direct investment and trade defence (such as anti-dumping measures). The European Union is a founding member of the World Trade Organization (WTO) and promotes trade through numerous bilateral trade agreements and unilateral trade preferences to developing countries. Despite the reduction in market price support to agriculture in the last decades, the European Union's trade policies still protect agro-food products more than other goods and services: for example, the 2021 simple average applied most favoured nation rate for agricultural goods was 11.7%,

compared to 4.1% in the case of non-agricultural goods (WTO, 2022[74]) (Chapter 3 provides a more detailed discussion of agricultural trade policy).

In October 2015, in its Communication on "Trade for All", the European Union laid out its vision for a more responsible approach to adapting EU trade policy to new economic realities, in line with its foreign policy. The top priority remains to re-energise the WTO and pursue bilateral and regional trade agreements with a high level of ambition. The Communication describes free trade agreements as a "laboratory for global trade" and commits to developing future WTO proposals to "fill the gaps in the multilateral rulebook and reduce fragmentation from solutions achieved in bilateral negotiations". More recently, the European Union has continued to support the multilateral trading system, including through its engagement towards the adoption of a Declaration on Food Security and an Agreement on Fisheries Subsidies at the 12th WTO Ministerial Conference (June 2022), its active promotion of several initiatives on trade and the environment, and its commitment to reforming the WTO (EEAS, 2022[75]).

The European Commission monitors the progress of 42 trade agreements with 74 partners (EC, 2022[76]), which in 2021 accounted for over EUR 1 trillion in EU exports and over EUR 800 billion in imports. In 2021, over 44% of the European Union's trade took place with partners with trade agreements in place, and an additional 3% corresponds to trade agreements that are yet to be adopted or ratified (such as the EU-MERCOSUR agreement, for which negotiations were concluded in 2019). In the agri-food sector, free trade agreements accounted for roughly 35% of EU agri-food trade with third countries – 30% and 40% of total EU agri-food exports and imports, respectively.

The United Kingdom's decision to withdraw from the European Union has been one of the most significant disruptions to EU trade policies. After 31 December 2020, the free movement of people, goods, services and capital with the European Union ended, and EU trade agreements no longer applied to the United Kingdom. The EU-UK Trade and Cooperation Agreement – concluded on 24 December 2020 and in force since 1 May 2021 – lays down the rules governing the bilateral relation. Of relevance to agriculture, the trade component of the agreement includes duty-free and quota-free imports on all goods that comply with rules of origin provisions (EU and UK, 2020[77]). The OECD assessed the impacts of this agreement. The results of the simulations carried out with the OECD METRO CGE model show that real GDP losses in the European Union in the worst-case scenario are expected to be around 0.6% in the medium term but would vary markedly across countries (van Tongeren et al., 2021[78]). EU Member States are expected to import fewer professional services such as financial services and insurance, communication, and other business services. UK exports are estimated to fall by about 6.3% and imports by 8.1% in the medium term. The overall medium-term loss in UK real GDP could amount to 4.4%. The study also shows that agriculture is among the top sectors facing increased trade costs, especially due to non-tariff measures, such as technical barriers to trade and sanitary and phytosanitary measures, as well as costs from rules-of-origin and border-crossing costs.

In addition to the bilateral and regional trade agreements, the European Union grants unilateral trade preferences to developing countries under its Generalised Scheme of Preferences (GSP). The EU GSP comprises three arrangements: the "standard" GSP, which grants lower import duties to about two-thirds of tariff lines from countries classified as low- and lower middle-income countries and that do not have preferential access to the EU market through other agreements; the GSP+, which fully eliminates import duties for the same goods for countries that implement a number of international conventions on human rights, labour, governance and other sustainable development aspects; and Everything but Arms, which grants duty-free and quota-free access to all imports from least developed countries, except arms and ammunition. The current GSP Regulation will expire on 31 December 2023, and the European Union is revising its GSP to enter into force in 2024.

On 18 February 2021, the European Commission adopted the Communication "Trade Policy Review: An Open, Sustainable and Assertive Trade Policy" (EC, 2021[79]). This Communication sets out a new trade strategy that takes into account the lessons learnt from the COVID-19 crisis, focusing on economic

recovery, climate change, growing international tensions and greater recourse to unilateralism. The Communication includes several elements of relevance to food and agriculture, such as the proposal to add a chapter on sustainable food systems in future trade agreements and to require that imported products comply with certain production requirements through autonomous measures" (see Chapter 3 for further details).

2.3.2. Competition policy

The European Union plays a determinant role in the competition policy in the internal market. Competition policy aims to encourage companies to offer consumers goods and services on the most favourable terms. It encourages efficiency and innovation and reduces prices. Beyond regulation of exclusionary practices such as anti-trust, EU competition policy seeks fairness as a factor in determining what is anti-competitive, for example through regulation of unfair trading practices and exemptions.

The disparity in the number and size of farmers compared to inputs of suppliers, food retailers and other food chain actors has long created tensions between the CAP's objectives and EU competition policy. For decades CAP regulations have provided for derogations from EU competition rules for some sectors (e.g. dairy, pork, sugar, fruit and vegetables, wine) to allow farmers to co-operate through producer organisations, their associations and interbranch organisations. The Omnibus Regulation (EU) No. 2017/2393 extended to all production sectors the possibility for producer organisations and associations of producer organisations to collectively negotiate contracts for the supply of agricultural products, including price contracts.

The two major impacts of competition policy on the EU agri-food sector relate to the external competitiveness of the sector and the well-functioning of the EU internal market and its links with global food systems. A Commission-funded report in 2016 on "The competitive position of the European food and drink industry" (ECSIP, 2016[80]) provided an assessment of the competitive position of the food and drink industry, taking into account the 2008-10 economic crisis. The study also investigated how the food and drink industry could strengthen its position in the coming years. The European Union showed a positive development on the trade-related indicators (relative trade advantage and world market share) in the light of the weakening of the other indicators like value added and labour productivity. The likely explanation was the ability of EU industry to differentiate itself from other regions by offering a higher quality next to differentiated products, meaning that the impact of developments in the cost base, like labour productivity, had less of an impact on the international competitive position. The report commented that the focus on high-quality products is supported by the EU regulations and the high food safety requirements set by EU food law, thereby conferring a comparative advantage for EU manufacturers.

In June 2015, the European Commission established the High-Level Forum for a Better Functioning Food Supply Chain, which led to various initiatives regarding unfair trading practices in the food chain and retail sectors. In 2019, the forum adopted its final document (HLF, 2019[81]), which provides two sets of policy recommendations: 1) a list of barriers affecting the single market of food and concrete ways to address them; and 2) an assessment on the proportionality of cases of compositional differentiation of identically branded food products.

To improve the position of both farmers and small and medium-sized businesses in the food supply chain, the European Union has adopted legislation that bans 16 unfair trading practices. EU Directive 2019/633 distinguishes between "black" and "grey" practices. Whereas black unfair trading practices (e.g. short-notice cancellations of perishable agri-food products, unilateral contract changes by the buyer, risk of loss and deterioration transferred to the supplier, misuse of trade secrets by the buyer) are prohibited, no matter the circumstances, grey practices (e.g. return of unsold products; payment of the supplier for stocking, display and listing; payment of the supplier for promotion, marketing and advertising) are allowed if the supplier and the buyer agree on them beforehand in a clear and unambiguous manner. The Directive also protects weaker suppliers against stronger buyers, which includes any supplier of agricultural and food

products with a turnover of up to EUR 350 million with differentiated levels of protection provided below that threshold. This covers farmers, producer organisations and distributors below the threshold. It also applies to suppliers and buyers located outside the European Union, provided one of the parties is located within the European Union.

2.3.3. Cohesion policy

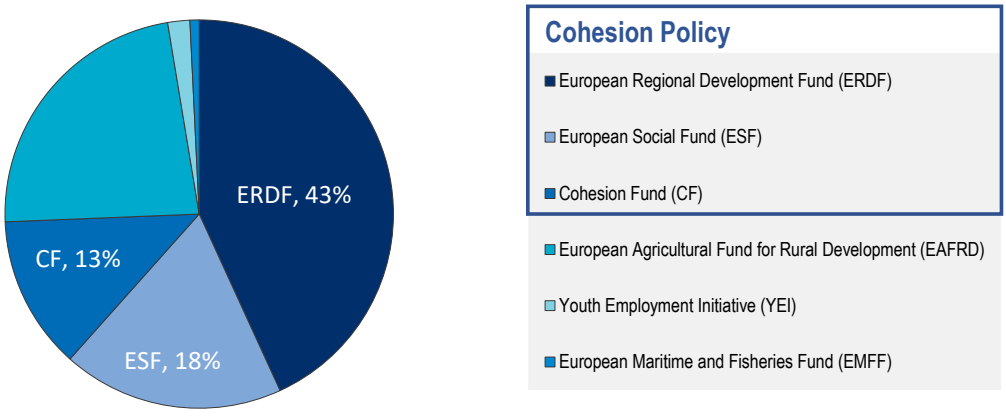
European Structural and Investment Funds (ESIF) are the European Union's main investment policy tool to support job creation and sustainable economic growth. In particular, Cohesion Policy – funded through the European Regional Development Fund (ERDF), the European Social Fund (ESF) and the Cohesion Fund – accounts for a substantial portion of public investment in the European Union and plays a critical role in achieving EU and EU-Member State development objectives.

In the 2014-20 programming period, EUR 461 billion, or over half of the total EU budget, was allocated to the ESIF, which supports over 500 programmes (EC, 2023[82]). This allocation represents a 4.4% increase over the previous programming period in which the planned amount for the ESIF was EUR 441 billion (EC, 2022[83]).

The funds make it possible to advance national- and subnational-level investment in competitiveness, growth and jobs in EU Member States. The majority of the ESIF – EUR 351.8 billion – is dedicated to funding EU Cohesion Policy through the ERDF, the ESF and the Cohesion Fund (Figure 2.11). In particular, this policy aims to support balanced economic, social and territorial development and cohesion across its Member States. Administrative capacity has been identified as a fundamental factor behind the performance of this policy (OECD, 2020[84]). All these funds should work together to support economic development across all EU countries, but while every EU region may benefit from the ERDF and the ESF, only the less developed regions may receive support from the Cohesion Fund. ESIF funds also include the European Agricultural Fund for Rural Development, which focuses on resolving the particular challenges facing rural areas (Chapter 3).

As for the 2021-27 programming period, the European Commission has proposed an allocation of EUR 373 billion to fund the Cohesion Policy, channelled through the ERDF, the European Social Fund Plus (ESF+) and the Cohesion Fund (ECA, 2019[85]).

Figure 2.11. Overview of the European Structural and Investment Funds for 2014-20



Source: EC (2023[82]).

The investment financing provided through the ESIF is significant for a number of reasons. First, while it aims to reduce inequalities between EU countries, it can also help reduce disparities within countries through targeted and, ideally, place-based investment. Second, encouraging productivity growth is critical to ensuring greater well-being, as it can have a positive impact on income and jobs, health, and access to services. As reported in the latest *OECD Economic Survey for the European Union* (OECD, 2021[86]), since 2000, achievements on regional convergence have been mixed: regional disparities in GDP per capita declined significantly until the global financial crisis, but much more slowly afterwards. Moreover, regional inequalities within countries have remained broadly flat, even increasing somewhat. This may be explained by the different performance of rural areas, small cities or metropolises: the proportion of regions that are among the 25% richest is much higher among metropolitan regions than among non-metropolitan or remote ones.

Different sets of rules at EU level and different managing agencies and responsible political authorities at national or regional levels have often led to poor co-ordination between Cohesion Policy and rural development programmes (Kah, Georgieva and Fonseca, 2020[87]). However, since many lagging regions still have a large agricultural sector, exploiting the complementarities between the two policies and strengthening their co-ordination could lead to efficiency gains and administrative simplification (OECD, 2021[86]).

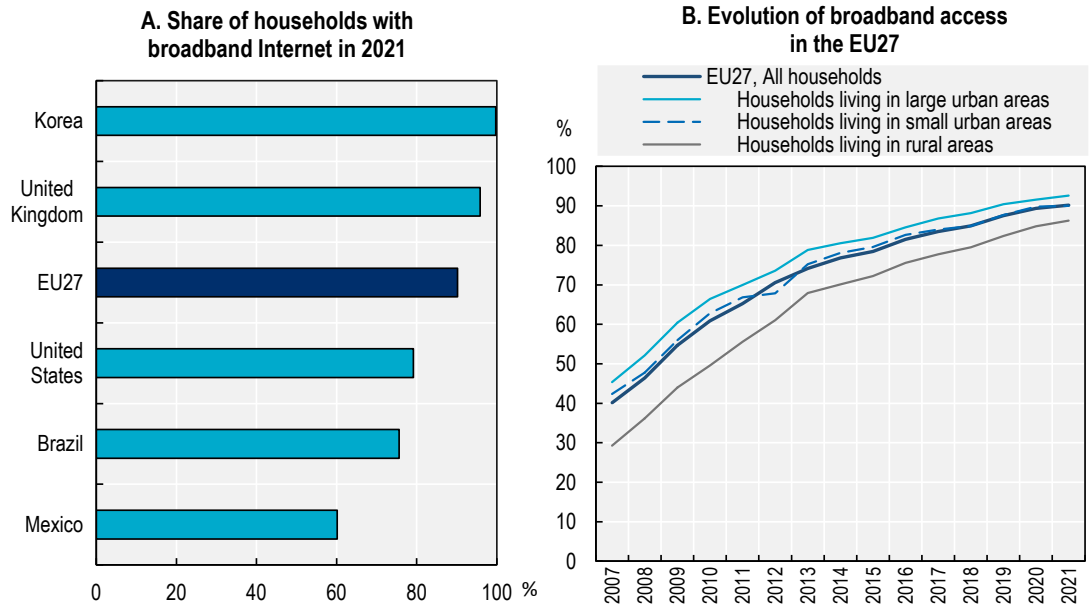
2.3.4. ICT and new technology policies and regulations

Digitalisation, and the twin digital and green transitions in particular, are high on the EU agenda, including in the field of agriculture and rural areas, as it is well reflected in multiple strategic documents under the European Green Deal (EC, 2019[88]) and in the European Commission priority “A Europe fit for the digital age” (EC, 2022[89]). This includes, for instance, the F2F Strategy (EC, 2020[90]), the Organic Action Plan Plan (EC, 2021[91]), the European Strategy for Data (EC, 2020[92]), and the Long-term Vision for Rural Areas, which includes a flagship on ”rural digital futures” and actions to continue suppor ting digitalisation of agriculture in its action plan (EC, 2021[93]).

The European Union currently reaches 90.2% of households with broadband Internet access at home: this is less than 10% below the most advanced country, Korea, where almost 100% have broadband access, but is significantly higher than in the United States (79.2%) (Figure 2.12, Panel A). The share of households with such access more than doubled during the decade 2007-17 (from 40.2% to 83.5%) and continued to grow, albeit at a slower pace, to reach around 90% of households in 2021. Although the gap between urban and rural areas has been gradually closing, in 2021, 86.3% of rural households had broadband Internet access at home, 6.3 percentage points less compared to households living in large urban areas (Figure 2.12, Panel B). However, rural areas are lagging behind in coverage with very high-capacity network (EC, 2022[94]).

Several policy instruments at different governance levels support the promotion of and the uptake and effective deployment of digital technologies in agriculture and rural areas. As discussed in Chapter 5, the CAP includes many tools aimed at the “enabling potential” of digital technologies to contribute to sustainability, competitiveness and enhanced quality of life. This is reflected in the so-called cross-cutting objective of “Modernising the sector by fostering and sharing knowledge, innovation and digitalisation in agriculture and rural areas, and encouraging their uptake”.

Figure 2.12. Share of households with broadband Internet access at home



Source: OECD (2022[95]).

Other EU programmes supporting digitalisation in agriculture and rural areas include the Digital Europe Programme (DIGITAL), a new EU funding programme focused on bringing digital technology to businesses, citizens and public administrations. In March 2021, the European Commission also presented a vision and avenues for Europe's digital transformation by 2030 (EC, 2021[96]). In addition to the focus on skills, digital transformation of businesses, and secure and sustainable digital infrastructures, the Digital Compass for the European Union's digital decade also includes the digitalisation of public services.

As shown in the next section, following a cross-sectoral approach, the digital transformation in the European Union is also supported by legal initiatives to increase the better use and reuse of data, as announced in the European Strategy for Data, including the EU Data Governance Act. Trust is crucial for the adoption of these technologies (McFadden, Casalini and Antón, 2022[97]). Privately held data supplemented by publicly held data will present new opportunities for monitoring and evaluation and will contribute to achieving the objectives of the EGD and CAP.

2.3.5. Data-related initiatives

The European Commission has presented a number of initiatives to support the achievement of data-related goals. The Communication on "A European Strategy for Data" calls for accelerated action due to the growing volumes of data, the importance of data for the economy and society, and transformative practices data could fuel (EC, 2020[98]). The strategy aims to unlock data from their silos to increase their use and re-use, thereby creating a single market for data so that it can flow freely within the European Union and across sectors to the benefit of citizens, business and public administrations. The realisation of the vision for a "genuine single market for data" includes actions pursuing a cross-sectoral governance framework for data access and use and calls for both the Data Governance Act, adopted by the parliament and Council in May 2022, and the Data Act (proposed regulation) (EC, 2022[99]). Furthermore, in the European Strategy for Data, the European Commission announced the creation of a common European agricultural data space,[2] which could induce an innovative data-driven ecosystem by establishing a neutral platform to pool agricultural data.

While the Open Data Directive regulates the public sector-held data that fall under the open data category (EC, 2019[100]), the Data Governance Act extends its scope to both personal and non-personal non-open data and aims to increase data availability by fostering data sharing through regulating data intermediaries and data sharing for altruistic purposes. The initiative intends to increase confidence in data sharing by establishing safeguards and reducing technical barriers to use the data in a variety of sectors, including agriculture (EC, 2022[101]). The Data Governance Act, which will be applicable from September 2023, will also benefit the use of data for research. It has been identified as a positive development for researchers, which helps to overcome the challenges of sharing sensitive data between researchers induced by the EU General Data Protection Regulation[3] (Shabani, 2021[102]).

The Data Governance Act proposes a set of rules to determine who can use and access data generated by the use connected devices, with the goal of making more data available. The European Commission's intention is that the Data Governance Act stimulates competition and innovation, new opportunities to use services relying on data access and better access to devices' data (EC, 2022[103]). This should strengthen users' rights concerning the digital data they generate by handling objects or devices and facilitate digitisation and value creation by allowing users to take full advantage of data. The Data Governance Act also has an implication for the EU farming sector since it aims to address the information asymmetry resulting from the transfer of data generated by farm machinery to the manufacturer, who could use information about the farm's performance to their advantage (EC, 2022[104]).

Many EU policies and research projects draw on agricultural statistics, e.g. CAP, including cross-compliance, agri-environmental measures, and rural development programmes (handled mainly by the European Commission's Directorate-General [DG] for Agriculture and Rural Development); air quality-related directives, including national emissions ceiling and integrated pollution and prevention control (handled mainly by the DG for Environment); or food safety, plant protection, animal health and animal welfare regulations (handled mainly by the DG for Health and Food Safety) (EC, 2015[105]).

Eurostat provides a broad range of data and statistics on Europe and co-ordinates statistical activities within the European Union and the European Commission. Under the European Statistical System, Eurostat co-operates with national statistical institutes and other statistical authorities of Member States for statistics to be reliable and comparable. This partnership not only extends to EU Members, but encompasses the entire European Free Trade Association and candidate countries. The European Statistical System provides the framework for harmonising statistics and co-operation with national statistical authorities, and its work has extended from main EU policy areas to a near to complete coverage of all statistical fields.

Eurostat's agricultural statistics include more than 50 different data sets covering thematical areas such as farm structure, crop and animal production, economic accounts for agriculture, agricultural prices, organic farming or agri-environmental characteristics. The data collection architecture is based on the Agricultural Census and Farm Structure Surveys. While the Agricultural Census is carried out once every ten years (most recently in 2020), the Farm Structure Surveys, a large-sample survey, take place every three or four years. Regulation (EU) 2018/1091 on integrated farm statistics (European Parliament and European Council, 2018[106]) established the legal framework for agricultural statistics in the European Union. Subsequent regulations offer possibilities to define the list of variables and their description for the following reference periods. For instance, Regulation (EU) 2021/2286 introduces several questions on the use of precision technology on farms (EC, 2021[107]).

Other data-related initiatives relevant to the farming and food sector include the stakeholder code of conduct on agricultural data sharing, which provides guidance on agricultural data use and defines roles and processes in agricultural data sharing, to which Copa-Cogeca, the umbrella organisation for European farmers and co-operatives, adheres. It not only addresses questions of data ownership, but also establishes principles on privacy, security and liability (Copa-Cogeca, 2018[108]). Additionally, European data-relevant policies in the agricultural sector may benefit from the joint declaration of co-operation "A

smart and sustainable digital future for European agriculture and rural areas". Signed by 26 EU Member States, it aims to strengthen research, innovation and data infrastructure in the field of agriculture. The signatories express their support for initiatives encompassing the CAP's transition towards a result-based policy, the promotion of EIP-AGRI, increasing uptake of digital technologies and driving efforts to strengthen AKIS (EC, 2019[109]).

Horizon Europe may also support data-related initiatives. Work under Cluster 4 "Digital, Industry and Space", which pursues a cross-sectoral approach, is relevant for developing digital technologies which can later be capitalised in a sector-specific context under Cluster 6 "Food, Bioeconomy, Natural Resources, Agriculture and Environment". The key issues addressed in the first work programme 2021/22 concern the support of sustainable agricultural production and the development of data-based solutions for the sector. In addition, Horizon Europe refers to many specific challenges, such as the use of digital tools on small farms, the application of blockchain or the assessment of the performance of digital technologies. Furthermore, the Commission has also proposed a new large-scale European Partnership "Agriculture of Data" to be set up under Horizon Europe. It is to support the development of solutions for the sustainability of agricultural production and strengthen the capacity to monitor and evaluate policies. For this purpose, the partnership will generate EU-wide data sets and information by harnessing the potential of digital technologies combined with Earth observation and other environmental and agricultural data (EC, 2022[110]).

The European Commission approaches both data and digital tools in agriculture in parallel, highlighting that the former relies on the latter. To draw on this, further development and implementation of digital tools in agriculture rely on enhanced data collection, harmonisation and management. Strengthening digital components within AKIS could lead to gains in farmers' abilities to analyse business models and performance through digital tools, and increase farmers' willingness to supply the data needed to maximise the technologies' effectiveness.

2.3.6. Food system initiatives

As discussed in Chapter 1, with the primary objective of meeting the EGD's "healthy and affordable food" goal, the F2F Strategy aims to pave the way to formulating a more sustainable, holistic food policy through which the European food system would accelerate its transition to sustainability. The F2F was accompanied by the Biodiversity Strategy, another key component of the EGD with direct implications for the CAP, and on its future role of ensuring a competitive as well as socially and environmentally sustainable farming sector.

The food system-driven approach to policy making is structured towards the interaction between the multiple policy areas, such as agriculture, the environment and health, that share links to food systems (OECD, 2021[111]). The F2F Strategy sets out an action plan with actions for the food chain actors "between the farm and the fork" and beyond. The nature of those actions is diverse, both legislative and non-legislative, and includes voluntary measures. Trade policy will also be used to support and be part of this transition. The European Union will seek to ensure that there is an ambitious sustainability chapter in all EU bilateral trade agreements (EC, 2021[79]).

The F2F Strategy underlines the importance of consumer behaviour change in food system transformation and climate change mitigation. Among the measures advocated are empowering consumers by better front-of-pack nutrition labelling; strengthening educational messages in schools around sustainable eating; promoting food-based dietary guidelines that incorporate sustainability aspects and encourage Member States to use fiscal policy tools to promote healthy and sustainable diets; an active change in food environments in institutions, including minimum mandatory criteria for sustainable food procurement by schools, hospitals and other public institutions; and setting a legally binding target to reduce food waste.

Furthermore, the strategy recognises the importance of complementing domestic actions with an external dimension designed to promote global action, to avoid externalising the negative environmental impacts of EU consumption and to use access to the EU market as leverage to raise global standards (Chapter 3, Section 3.3.2).

One of the F2F's flagship initiatives is a proposal for a legislative Framework for Union Sustainable Food Systems, which is expected to be adopted by the end of 2023 (EC, 2022[112]). The objective of this horizontal framework law is to establish new foundations for future food policies by introducing sustainability objectives and principles on the basis of an integrated food system approach. This legislative framework aims to accelerate and facilitate the transition to sustainable food systems. For example, this will be done by laying down common definitions and general principles and objectives. It will also include push and pull mechanisms, such as sustainability labelling of food products and minimum criteria for sustainable food public procurement.

The Commission's view is that (environmental) sustainability is already established as a guiding principle in sectoral policies such as the CAP or the Common Fisheries Policy, but this is not the case for the food system as a whole, where the General Food Law focuses primarily on protecting human health and consumers' interests in relation to food. It lists a series of regulatory and market failures that arise due to the absence of an overarching instrument to ensure that sustainability objectives are considered across the food system as a whole. The proposed legislation would create harmonised rules directly applicable in Member States to ensure the sustainability of food systems and of food. While the nature of the rules that might be proposed will be subject to consultation and an impact assessment, additional sustainability demands and objectives for the food system and food consumption will feed back directly into the demand for farm produce. Even in the absence of direct legislative interventions affecting primary agriculture, these demands transmitted through the food chain will have an impact on future food production.

Besides this legislative framework, a broad range of initiatives showcase the European Commission's comprehensive approach to move to sustainable food systems. While Table 2.4 provides a non-exhaustive selection of these initiatives, additional initiatives deriving from both the F2F and the Biodiversity Strategies with higher relevance for the environmental sustainability objectives are analysed in greater detail in Chapter 4.

Table 2.4. Selected initiatives in the context of the Farm to Fork and Biodiversity Strategies

	Initiative	Type	Date
Food production	Legislative initiatives to enhance co-operation of primary producers to support their position in the food chain	Regulation	2021
	Evaluation and revision of the existing animal welfare legislation, including on animal transport and the slaughter of animals	Directive	2023
Processing, wholesale and retail	EU Code of Conduct on Responsible Food Business and Marketing Practices	Voluntary commitments	2021
	Proposal for a revision of EU marketing standards for agricultural, fishery and aquaculture products to ensure the uptake and supply of sustainable products	Directive	2022 (delayed)
Food consumption	Proposal for a sustainable food labelling framework to empower consumers to make sustainable food choices	Regulation	2023
	Determine the best modalities for setting minimum mandatory criteria for sustainable food procurement to promote healthy and sustainable diets, including organic products, in schools and public institutions	Regulation	2023
Food loss and waste	Proposal for EU-level targets for food waste reduction	Directive	2023
	Proposal for a revision of EU rules on date marking ("use by" and "best before"' dates)	Regulation	2022

Note: The dates in the table are subject to change due to potential delays.
Source: EC (2020[90]).

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Notes

[1] Migration data, however, should be considered with care as they tend to be highly fragmented; numbers on illegal migration and irregular workers are hard to track. These migrants, however, are particularly essential to the sector. It is, therefore, highly probable that the presented data underestimate the actual level of migration and thus should be considered an orientation rather than a concrete indication (Kalantaryan, Mazza and Scipioni, 2020[55]).

[2] A common European agriculture data space is one of nine data spaces identified in “A European Strategy for Data”.

[3] The General Data Protection Regulation imposes obligations concerning data privacy and security. While the Regulation intends to protect personal data, it may have adverse effects on research as it creates barriers to data processing necessary for scientific research.

3 The agricultural policy setting

This chapter provides an overview of the developments of the EU Common Agricultural Policy (CAP) from its establishment to the most recent 2023-27 reform, together with an analysis of the evolution of support to the EU farming sector up to 2022, based on OECD Producer Support Estimate and related indicators. Successive CAP reforms have led to a significant drop in the overall level of support and the changes in its composition with greater market orientation and increasing integration of environmental and climate objectives. Despite substantial reforms, most-distorting and potentially most environmentally harmful forms of support still represent nearly a quarter of support to producers. The chapter also provides an overview of EU agricultural trade policies and a more in-depth analysis of CAP instruments and their relation to productivity and resilience objectives.

Key messages

- The Common Agricultural Policy (CAP), the central agricultural policy package in the European Union, is broken down into two categories of measures: Pillar 1 and Pillar 2. CAP Pillar 1 finances direct payments to farmers and market support measures, while CAP Pillar 2 co-finances rural development activities together with Member States. The budgetary process largely pre-allocates CAP amounts between Member States based on history.
- Successive agricultural policy reforms in the European Union have significantly changed how support is delivered to farmers. Levels of trade protection and producer support have been reduced since the mid-1990s, and new instruments, such as payments that do not require production, have replaced price support policies. Overall support to producers significantly decreased from 38.4% of gross farm receipts in 1986-88 to 18.8% in 2019-21.
- The evolution of support shows direct progress towards market orientation, which is reflected in the presence of less production and trade-distorting measures, as well increasing integration of environmental and climate objectives, reflected in the increasing scope of both mandatory and voluntary input constraints that are attached to payments.
- Despite substantial reform of support for the sector, most-distorting and potentially most environmentally harmful forms of support still represent 23.1% of support to producers.
- Direct payments make up the bulk of CAP spending. These are mostly decoupled from production and are an important part of farm income, but are not targeted to household income and are not the most efficient tool for achieving productivity and socio-economic objectives. They can slow structural and generational change and could weaken renewal.
- Although the ongoing process of conversion of the Farm Accountancy Data Network to the Farm Sustainability Data Network (FSDN) is a positive development, the paucity of data on farm household income, as well as on the environmental and social sustainability performance of farms, may undermine the capacity to design, implement and monitor current and future EU agricultural policy to target and deliver its objectives on the ground.
- The new delivery model for 2023-27 introduced a significant change in the governance of the CAP. Combined with the ambitious environmental goals of the European Green Deal (EGD), the 2023-27 CAP has the potential to ensure that the agriculture sector contributes to the European Union's global sustainability goals, but this will ultimately depend on the individual efforts of Member States.

The CAP is one of the founding policies of the European Union and has significantly evolved over time. This chapter analyses how successive agricultural policy reforms in the European Union have progressively and significantly reduced levels of government support and changed how it is delivered to farmers. Section 3.1 provides an overview of agricultural policy reforms since the Treaty of Rome in 1957, as well as an overview of the main CAP budget mechanisms. Section 3.2 provides an analysis of the level and composition of support using OECD indicators of support, in particular the Producer Support Estimate (PSE), while Section 3.3 provides an overview of EU agricultural trade policies. Section 3.4 is dedicated to a more in-depth analysis of the past CAP instruments related to productivity and resilience objectives, while Section 3.5 examines the CAP 2023-27, highlighting what is new relative to the previous CAP, especially the new delivery model. The final section reviews policy pathways for the programming period post-2027.

3.1. Agricultural policy framework and objectives

3.1.1. Overview of CAP developments

The CAP has been the European Union's agricultural policy framework since its institution in 1962, although the mix of policy instruments has evolved substantially over time (Table 3.1). As highlighted in Chapter 2, since its establishment, membership to the European Union has considerably enlarged, almost doubling in 20 years, from 15 countries in 1995 to 25 in 2004, 27 in 2007 and 28 in 2013. Following the United Kingdom's exit in 2020, there are now 27 EU Member States. While the Common Market has become larger and more diversified, environmental and societal concerns around agricultural production practices and food processes have become more prominent in the policy debate.

As for many other policy areas, agricultural policy is a shared competence between the European Union and Member States under the EU Treaties. Member States exercise their own competence where the European Union does not exercise, or has decided not to exercise, its competence. However, the European Union has always intervened more extensively in agricultural policy than in other areas. Agriculture is one of the few areas where the treaties establish a Common Policy. The basic framework of rules is set down in the CAP established under Article 38 of the Treaty on the Functioning of the European Union (Tracy, 1989[1]).

The Treaty of Rome that established the European Community outlined the CAP in 1957 (OECD, 2011[2]; European Parliament, 2021[3]); European Parliament, 2021[170]). Agriculture made up a much larger share of Europe's economy at that time, and the income gap between rural and urban households was increasing. Moreover, the region was a net food importer with concerns about securing adequate food supplies during the Cold War (Grant, 2020[4]).

The founding principles of the CAP include market unity, community preference and financial solidarity. Its objectives set out in Article 39 of the Treaty on the Functioning of the European Union are to increase agricultural productivity by promoting technical progress, and thus to ensure a fair standard of living for the agricultural population; to stabilise markets; to ensure the availability of supplies; and to ensure that supplies reach consumers at reasonable prices. These objectives have not changed since the CAP was launched over 60 years ago. In practice, the CAP now addresses additional objectives such as the environment, climate change, rural development and animal welfare, but these Treaty objectives remain as the legal statement of the policy's objectives (Chapter 1, Box 1.1). Measures targeting these objectives were originally financed by the European Agricultural Guidance and Guarantee Fund.

Table 3.1. Overview of the most recent CAP reforms

Years	Main milestones	Key policy features
Pre-1992	**Market support phase** CAP financed by the European Agricultural Guidance and Guarantee Fund (EAGGF), European Communities with 12 members[1]	• Support prices greater than world prices • Unlimited buying guarantee • Production quotas for certain products, including dairy and sugar
1992-1999	**1992 (MacSharry) Reform** CAP, EU Expansion 1995 (Austria, Finland, Sweden), Uruguay Round Agreement on Agriculture	• Shift from product support through prices to producer support through income-supporting measures, with the reduction in intervention prices compensated by increased direct aid per hectare or livestock headage payments • Establishment of set-aside payments to encourage land retirement • Tariffication of border measures and gradual reductions in bound tariffs
2000-2002	**Agenda 2000 CAP Reform** CAP divided into Pillar 1 and Pillar 2 (Rural Development)	• Further reduction of EU market support prices in closer alignment with world prices, partly offset by direct aid to producers in the form of increased area or headage payments • First introduction of environmental cross-compliance • Introduction of Rural Development Regulation as a second pillar of the CAP
2003-2008	**2003 (Fischler) Reform** **(also known as the "Mid-term Review")** CAP Pillars 1 (financed by European Agricultural Guarantee Fund (EAGF) and 2 (financed by the European Agricultural Fund for Rural Development EAFRD), EU Expansion 2004 (the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, the Slovak Republic, Slovenia) and 2007 (Bulgaria and Romania)	• Decoupling much of CAP support from the volume of production, with the fixed single farm payment introduced based on historical references • Cross-compliance for environmental and public health objectives compulsory for receiving full payments • Single Common Market Organisation introduced • Reform programmes initiated for cotton, hops, olive oil, tobacco, sugar, fruit and vegetables, and wine regimes
2009-2013	**2009 (Fischer Boel) Reform** **(also known as "Health Check")** CAP Pillars 1 and 2	• Further reduction of EU market intervention for certain products • Phasing out of milk quotas initiated • Abolition of set-aside • Integration of nearly all payments into the single farm payment • New cross-compliance requirements introduced
2014-2020	**2013 (Ciolos) Reform** CAP Pillars 1 and 2, EU Expansion 2013 (Croatia) and Contraction 2020 (United Kingdom)	• Decoupled aid converted to multifunctional support (including basic payment, greening payment, small farmer payment, etc.) • Consolidation of the two pillars of CAP, with direct payments and market measures under Pillar 1 • Consolidation of Common Market Organisation tools, abolition of supply control measures (including ending milk and sugar quota schemes) • External and internal convergence, with payment envelopes gradually adjusted to move toward a uniform minimum per hectare payment
2021-2022	**Transitional rules**	• Continuity of the 2014-2020 CAP rules, while also including new elements to ensure a smooth transition

1. When the Maastricht Treaty establishing the EU was signed in 1992, Belgium, Denmark, France, Germany, Ireland, Italy, Greece, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom were part of the Union.
Source: European Parliament (2021[5]); OECD (2011[2]).

A key achievement of the CAP has been the creation of a free agricultural market without tariffs and other restrictions on the movement of foodstuffs within the European Union as well as the harmonisation and mutual recognition of regulations that might act as trade barriers, as part of the single market that was completed in 1992. Rules on state aid prevent distortions in competitive conditions between farmers in

different Member States. Agricultural markets and practices are also influenced by environmental and health legislation.

From the CAP's institution until the 1990s, support prices were high compared to world market prices due to tariffs and other trade measures. Combined with an unlimited buying guarantee, European farmers produced increasing surpluses. The budgetary cost of these policies became increasingly high, leading to measures to limit expenditure in the 1980s that included quantitative production restrictions in the form of quotas on milk production.

The CAP's first major reform occurred in 1992, in conjunction with negotiations on the General Agreement on Tariffs and Trade (GATT) and following the result of the US-EU oilseeds panel. The MacSharry Reform brought about a major shift: instead of supporting production, the regime shifted to supporting producer incomes directly through area payments, avoiding surpluses and reducing overall expenditures (European Parliament, 2021[5]).

The Agenda 2000 reform further aligned EU and world prices, offsetting the reduction of price support with increased direct aid to producers (European Parliament, 2021[5]). In addition, the Rural Development Regulation was introduced as Pillar 2 of the CAP, and the first environmental cross-compliance conditions were required. As discussed in Chapter 4 (Section 4.3.1), cross-compliance aims at making European farming more sustainable by creating a link between the full payment of support and the EU standards for public, plant and animal health and welfare.

The 2003 Fischler Reform introduced the single payment scheme, decoupling most support from any requirement to produce (European Parliament, 2021[5]). For most of the Central and Eastern European countries that acceded to the European Union in 2004 and 2007, the decoupled payments were made under the Single Area Payment Scheme. The reform included further cross-compliance and modulation, more financial discipline, and splitting the budget into two separate funds for Pillar 1 and Pillar 2.

Measures taken under the 2009 Health Check sought to continue the direction of the 2003 reform. Decoupling of aid continued and nearly all payments (with the exception of suckler cow, sheep and goat premia) were transformed into decoupled direct payments: the single payment scheme. It further reduced market intervention for a number of products, abolished set-aside and announced the phasing out of milk quotas.

The CAP 2014-22, while in many ways the continuation of the CAP 2007-13, offered a number of novel features (OECD, 2017[6]), including a new system of decoupled payments with seven components; the introduction of safety nets in case of market disruption or price crisis; as well as a more integrated, targeted and territorial approach to rural development (Section 3.4). The main policy tools of the CAP 2014-20 are analysed throughout the study since they applied until 2022.

Based on a 2018 proposal from the European Commission, the political agreement on the current reform (CAP 2023-27) was formally adopted in December 2021, with new legislation covered later in the chapter. This reform entered into force in January 2023 after transitional rules that allowed the continuation of the CAP 2014-20.

3.1.2. The budget process

The CAP is organised into two pillars. Pillar 1 finances direct payments to farmers as income support as well as some market measures and is fully funded by the European Union through the European Agricultural Guarantee Fund (EAGF). Pillar 2 finances rural development activities, including structural measures and agri-environment-climate schemes through the European Agricultural Fund for Rural Development (EAFRD), but requires co-financing by Member States. Member States programme EAFRD expenditures in national or regional rural development programmes that reflect their specific priorities and

needs within a menu defined by the European Commission. Some principal differences in the management of the two funds include:

- Expenditure under the EAFRD was programmed against specific objectives, whereas this was not the case for EAGF expenditure on direct payments.
- Expenditure under the EAFRD only partially finances rural development interventions under shared management, with Member States required to make a co-financing contribution.
- The EAGF operates on an annual basis and commitments to Member States must be spent within that year. The EAFRD operates on a multiannual basis, where unspent commitments in one year can be carried forward to later years within rules established in the CAP regulation.
- EAGF expenditure that is recovered where the expenditure is not in conformity with Community legislation and no entitlement existed is paid back to the EAGF and becomes assigned revenue in the EU budget. In the case of the EAFRD, sums recovered or cancelled following irregularities remain available to the approved rural development programmes of the Member State concerned.

The absolute budget figure for the CAP more than doubled from 1990 to 2010 (partially related to additional Member States joining the European Union), but has remained relatively stable in absolute terms since then. At the same time, CAP expenditures as a share of the total EU budget declined sharply, from 65.5% in 1980 to 33.1% in 2021 (European Parliament, 2022[7]). The overall budget for the CAP during the years 2014-20 was EUR 408 billion (USD 465 billion), of which 76% was initially allocated to Pillar 1 and the remaining 24% to Pillar 2.

The budgetary mechanism is largely based on pre-allocated CAP amounts between Member States. The budgetary allocations are decided as part of the complex negotiation process of agreeing on the European Union's Multiannual Financial Framework (MFF), which is decided every seven years. Member States' main focus during the MFF negotiation process is the net budgetary envelope. This process is characterised by the *juste retour* principle, where each Member State compares its financial contribution to the EU budget with the money that flows back into the country. EAGF (Pillar 1) direct payments are allocated to farmer beneficiaries on the basis of their eligible hectares, but the funds are not distributed in line with the shares in the EU-eligible area. The Member States' shares originally reflected the relative amounts of coupled support that was received under the rules put in place after the MacSharry Reform, implicitly benefiting countries with higher levels of production intensity. Direct payment levels per hectare thus differed between Member States. These disparities were exacerbated with successive enlargements in the 2000s. Recent reforms achieved convergence and greater uniformity in payment levels between Member States, while the issue continues to be contentious in the European Union's MFF negotiations.

The basis for distributing EAFRD (Pillar 2) funds among Member States also depends on history. There are striking differences in the relative importance of EAGF and EAFRD funds across Member States. The EAFRD has a wider range of objectives than the EAGF, including cohesion objectives, since it is part of the European Structural and Investment Funds, which seek to transfer funds to more disadvantaged EU regions. EAFRD spending is increasingly focused on environmental and climate expenditure, although modernisation expenditure remains a priority in the newer Member States. This raises the question of whether the current distribution of EAFRD funds across Member States and regions is well aligned with EU priorities. In its impact assessment for the 2013 CAP reform, the European Commission examined the implications of using different criteria for the distribution of EAFRD support (EC, 2011[8]). The analysis concluded that distribution based on objective criteria would allow for a better fit between the policy objectives and the resources made available, thus a better use of the EU budget, but pointed out that any such change would need to be phased in to avoid disruption and ensure a smooth transition.

3.2. Agricultural support policies

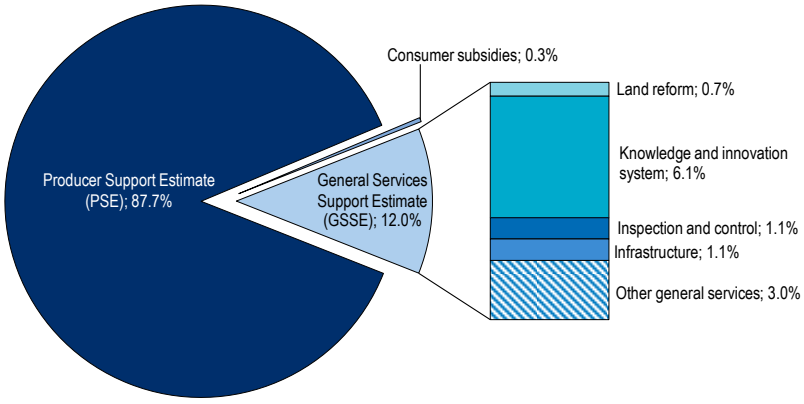
3.2.1. Level of support

OECD indicators of support estimate all monetary transfers associated with agricultural policy and is calculated for the European Union as a whole, not at Member State level. In addition to EU CAP expenditures, these estimates include national and regional expenditures both associated with the co-financing of CAP Pillar 2 measures and purely national measures such as research expenditure, state aid and tax rebates. They also include transfers from market price support (MPS)[1] measures.

The broadest OECD indicator of support is the Total Support Estimate (TSE), which includes support to producers individually (PSE) or collectively (the General Services Support Estimate, GSSE) and direct budgetary transfers to consumers. As a percentage of gross domestic product (GDP), it measures the total burden of agricultural support for the economy. The European Union's TSE decreased from 2.5% of GDP in 1986-88 to 0.6% in 2019-21, a percentage point lower than the OECD average (OECD, 2022[9]). The vast majority of support (87.7% in 2019-21) is allocated to individual farmers and most of the remainder is designated for general services (GSSE) to the sector, which averaged 12% of total support – a decrease compared to 2000-02 and below the OECD average (Figure 3.1).

While the relative importance of the GSSE has slightly declined over the past two decades, the composition of GSSE expenditures has shifted. Expenditure on agricultural knowledge and innovation systems grew nine percentage points to 51% of total GSSE expenditures in 2019-21, equivalent to 6.1% of total support to agriculture. Expenditures on marketing and promotion also rose (now responsible for 25% of the GSSE), while support for the development and maintenance of infrastructure and public stockholding has remained static in absolute terms since 2000-02.

Figure 3.1. Composition of total support to agriculture in the European Union, 2019-21



Note: European Union refers to EU28 for 2019; EU27 and the United Kingdom for 2020; and EU27 for 2021.
Source: OECD (2022[10]).

3.2.2. Changes in the composition of support

Overall, the changes in the composition of support to EU agriculture correspond to three principal axes of reform, discussed below: greater market orientation; greater integration of environmental and climate objectives; and a broader focus on structural policy and rural development. The first two axes are reflected in the evolution of the European Union's PSE.

Greater market orientation

The original CAP heavily emphasised the role of price transfers (market price support) to achieve its policy objectives, particularly the objective of supporting farm income. In this, it reflected the national policies of the six original Member States that were in place prior to the creation of the CAP (Martiin, Pan-Montojo and Brassley, 2016[11]). However, the level of MPS for grains that emerged from the political negotiations around the launch of the CAP set the initial level at the upper end of the range. This early political decision resulted in producer prices in the early decades of the CAP that were two or even three times higher than world market prices. High internal EU market prices were maintained by variable import levies, intervention purchasing of domestic supplies when producer prices fell below the high guaranteed minimum levels, and variable export refunds that enabled the disposal of surpluses at world market prices and which became increasingly important as EU production exceeded levels of domestic consumption.

Pressures to reform this policy came from its budgetary cost and the increasing trade tensions – particularly with the United States – arising from subsidised EU exports. Attempts were made during the 1980s to control budgetary costs, notably through the introduction of a quota regime for milk production in 1984. However, the first real reform of the CAP (the MacSharry Reform) took place in 1992 during the General Agreement on Tariffs and Trade Uruguay Round negotiations. This led to a lowering of the guaranteed intervention prices, which underpinned producer prices and introduced a system of coupled direct payments to compensate farmers for the anticipated loss in market income. This reform initiated a gradual movement toward greater market orientation with lower intervention support prices compensated by higher direct payments. This process was completed in 2012 following the Health Check Reform of 2009. Since then, intervention prices have been set at levels that provide a "safety net" in the case of a particularly severe drop in producer prices, but do not usually play a role in the formation of producer prices.

A further step towards greater market orientation was introduced with the Mid-Term Review/Fischler Reform in 2003, which decoupled direct payments from production. Farmers now were entitled to receive a lump-sum payment per hectare of eligible land regardless of the level of production on that land or, indeed, even whether the land was used for agricultural production at all (provided it was maintained in a state where it could be used for agricultural production).

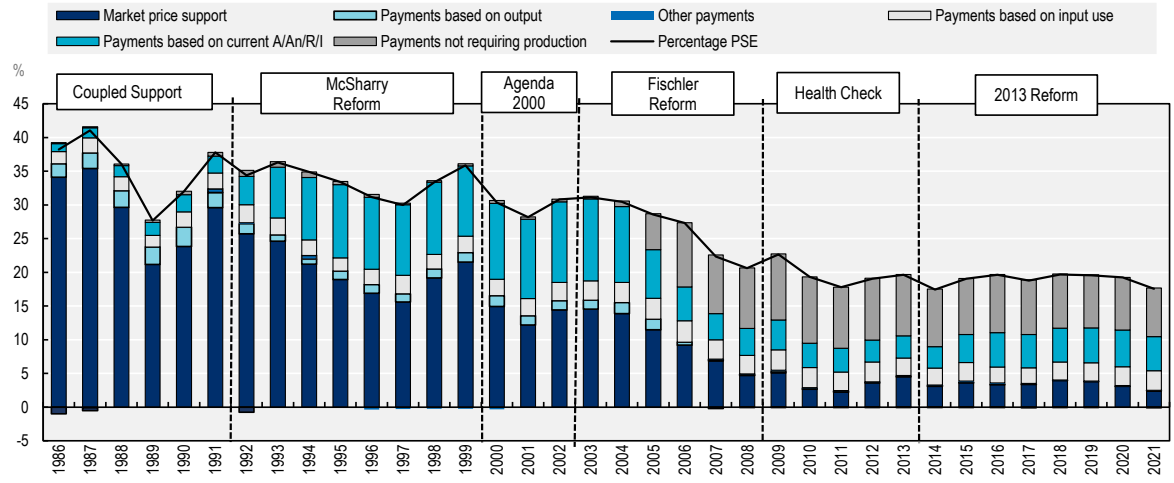
Not all direct payments are decoupled. Member States are allowed to target aid to specific sectors facing difficulties, with a view to preventing the escalation of these difficulties that could lead to the abandonment of production. In the original Regulation (EU) 1307/2013, coupled support should only be granted to the extent necessary to create an incentive to maintain current production levels in the sectors or regions concerned. This restriction was removed in the Omnibus Regulation (EU) 2017/2393. Coupled support is still defined as a production-limiting scheme, but this only means that it should be based on either a fixed area or a fixed number of animals, not necessarily limited to the current production level. It must also respect financial ceilings intended to limit the extent of market distortion. The basic rule in the CAP 2014-22 is that coupled support should not exceed 8% of a Member State's direct payments envelope, but this ceiling could be increased to 13% or even more with Commission approval, and by a further 2% to specifically support the production of protein crops. All EU Member States, except for Germany, decided to use voluntary coupled support during the 2014-22 programming period, with an annual monetary allocation of around EUR 4.2 billion per year. This represented 11.2% of the direct payments budget. The animal-based sectors have always been the largest beneficiaries of coupled payments: in 2022, 22 Member States decided to grant coupled support for beef and veal and 18 Member States to the milk and milk products sector (EC, 2022[12]).

The various reform stages in the CAP are clearly visible in Figure 3.2, which shows the changing level and composition of producer support (as measured by the PSE) over time. While at the end of the 1980s most CAP expenditures financed MPS measures, in particular market interventions and export refunds, the share of those measures in total support decreased gradually as the share of direct payments increased. At the same time, these reforms have also affected the level of support. Overall, the %PSE, which relates

support to producers to the value of gross farm receipts, significantly decreased over time, from 38.4% in 1986-88 to 18.8% in 2019-21. Despite these substantial reforms of support for the sector, potentially most-distorting forms of support still represent 23.1% of support (OECD, 2022[9]). Reducing the most distorting producer support measures would most likely contribute to achieving environmental policy objectives across a range of areas (Chapter 4), since often the most-distorting measures also correspond to the most environmentally harmful type of support from a nitrogen pollution perspective (Henderson and Lankoski, 2019[13]; DeBoe, 2020[14]), or for biodiversity (DeBoe, 2020[14]; Lankoski and Thiem, 2020[15]).

Figure 3.2. Level and PSE composition by support categories in the European Union, 1986 to 2021

As a percentage of gross farm receipts



Notes: PSE: Producer Support Estimate; A/An/R/I: Area planted/Animal numbers/Receipts/Income.
Payments not requiring production include payments based on non-current A/An/R/I (production not required) and payment based on non-community criteria. Other payments include payments based on non-current A/An/R/I (production required) and miscellaneous payments. European Union refers to EU12 for 1986-94, EU15 for 1995-2003, EU25 for 2004-06, EU27 for 2007-13, EU28 for 2014-19, EU27 and the United Kingdom for 2020, and EU27 for 2021.
Source: OECD (2022[10]).

In the mid-1980s, producer prices were maintained above world market levels by a combination of minimum intervention prices, import tariffs and export subsidies. The significance of MPS has been greatly reduced as successive CAP reforms moved agricultural policy in a more market-oriented direction, though its share has remained largely unchanged since 2010. The fall in MPS was originally compensated by coupled budget payments based on current area, animals, receipts or income (A/An/R/I) and then subsequently by decoupled payments not requiring production. However, in the recent CAP programming period, coupled payment support has again grown in importance. Payments based on input use represent only 16.5% of support, but its share has also grown over time.

From 1992, the share of MPS decreased and the share of payments based on current area and animal numbers increased following the implementation of the MacSharry Reform. This wide-ranging reform included reducing cereal intervention prices, introduced compensatory payments per hectare for cereals or per head for livestock as well as a mandatory set-aside scheme to take land out of production. In conjunction with the reform of budgetary support measures through the MacSharry package, MPS also declined thanks to EU commitments under the 1994 Uruguay Round Agreement on Agriculture. Namely, bound tariffs were gradually reduced and other border measures were implemented (including replacing variable import levies with ad valorem or specific tariffs and tariff rate quotas) (OECD, 2011[2]).

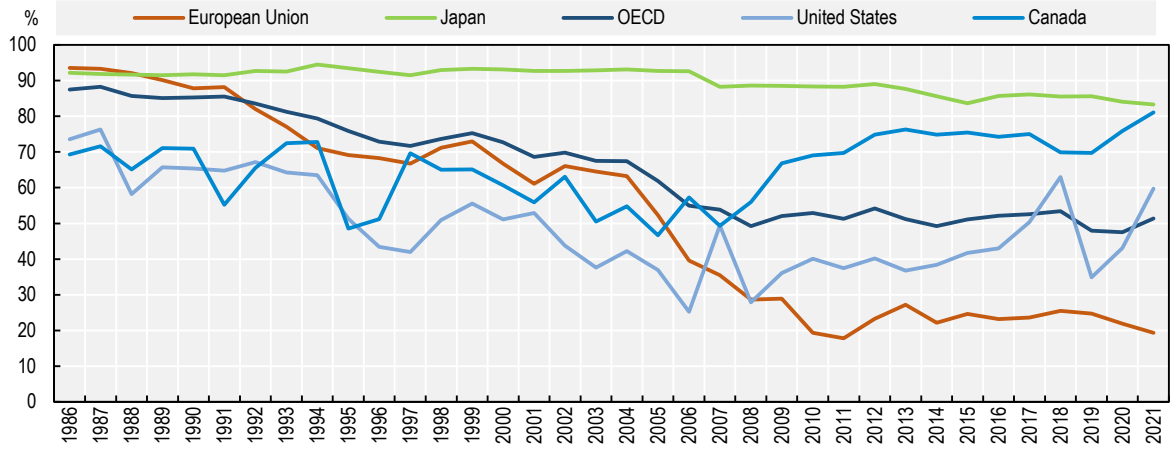
These movements were reinforced with the implementation of Agenda 2000, but the second substantial change to PSE composition began in the mid-2000s after the Fischler Reform decoupled most payments to farmers from production: MPS continued to decrease while a large share of payments lost their link with current factors of production and did not require any production to be granted. No further market orientation reforms have taken place in the last decade since the Health Check, in the 2013 reform or the CAP 2023-27.

Measures that support commodity markets represented 4.7% of the overall agriculture and rural development budget in 2021, but 26.6% of support. Prices paid to EU domestic producers averaged 4% above world market prices in 2019-21. The possibility for public intervention for cereals (namely common and durum wheat, barley, and maize), dairy and other products still exist. However, the last intake of cereals into public storage occurred during the 2009/10 marketing year (EC, 2013[16]) (EC, 2022[17]), the European Union may provide support to operators of private storage of products, such as olive oil, white sugar and more recently also pig meat (EC, 2022[18]).

The Single Commodity Transfer is the OECD indicator used to capture product-specific support. Its evolution shows that successive CAP reforms have reduced the link between payment entitlements and commodity production (Figure 3.3) and data confirm that the 1992 MacSharry Reform can be considered the turning point. Since the early 1990s, support started to be less linked to domestic prices or animal numbers. Another important step was the introduction of the single (decoupled) payment scheme (from 2005 or 2006, depending on the country). The Single Commodity Transfer of the European Union accounted for only 21% of the total PSE in 2019-21, which is well below the OECD average (49%) and the US average (46%), and considerably lower than the averages of Canada and Japan.

Figure 3.3. Single commodity transfers in selected economies, 1986 to 2021

As a percentage of Producer Support Estimate

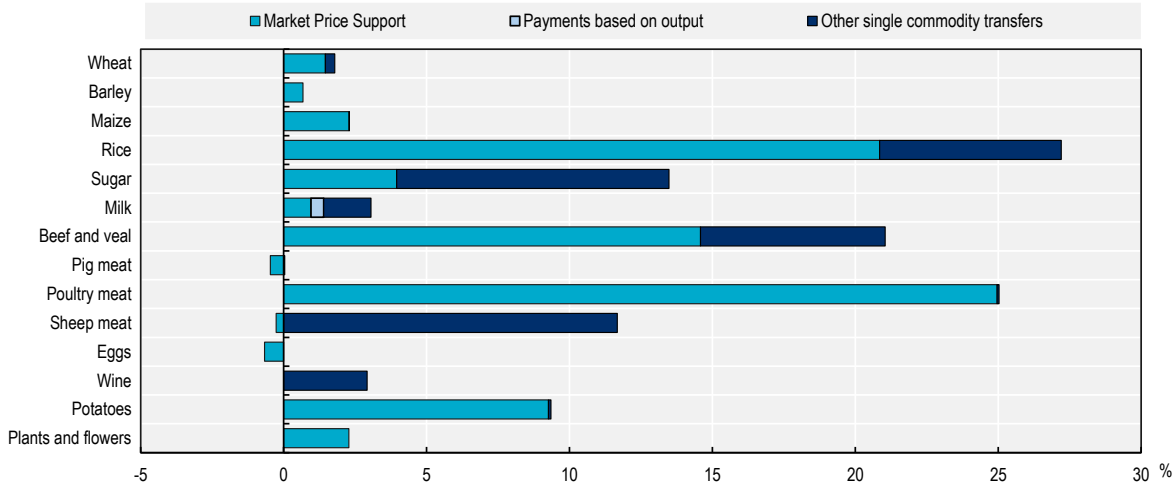


Notes: European Union refers to EU12 for 1986-88; EU15 for 2000-02; EU28 for 2019; EU27 and the United Kingdom for 2020; and EU27 for 2021. The OECD total does not include the non-OECD EU Member States. Due to data availability, Chile only included from 1990, Colombia and Slovenia from 1992, Costa Rica and Israel from 1995, Luxembourg from 2001, and Latvia and Lithuania from 2004.
Source: OECD (2022[10]).

Over time, CAP payments have also become less commodity specific. Only a few commodities are characterised by non-zero transfers and for most of them, MPS is the dominant component of their single commodity transfers (Figure 3.4). Among them, the per cent of budgetary support on farm receipts is higher than the per cent of MPS only for sugar, milk, sheep meat and wine.

Figure 3.4. Commodity-specific transfers in the European Union, 2019-21

As a percentage of commodity gross farm receipts



Notes: EU28 for 2019; EU27 and the United Kingdom for 2020; EU27 for 2021. Only commodities with non-zero transfers are presented.
Source: OECD (2022[10]).

Greater integration of environmental and climate objectives

During the 1980s, policy increasingly focused on the environmental impact of agriculture, both to avoid damaging negative impacts on the environment and to promote and support agricultural practices that had a positive environmental impact. The Single European Act 1987 made the environment a shared Union competence for the first time, and the Commission published its first Communication on the Environment and Agriculture in 1988 that put an emphasis particularly on the problems caused by large-scale intensive livestock rearing and intensive crop production in zones at risk of pollution of surface and ground waters by nitrates.

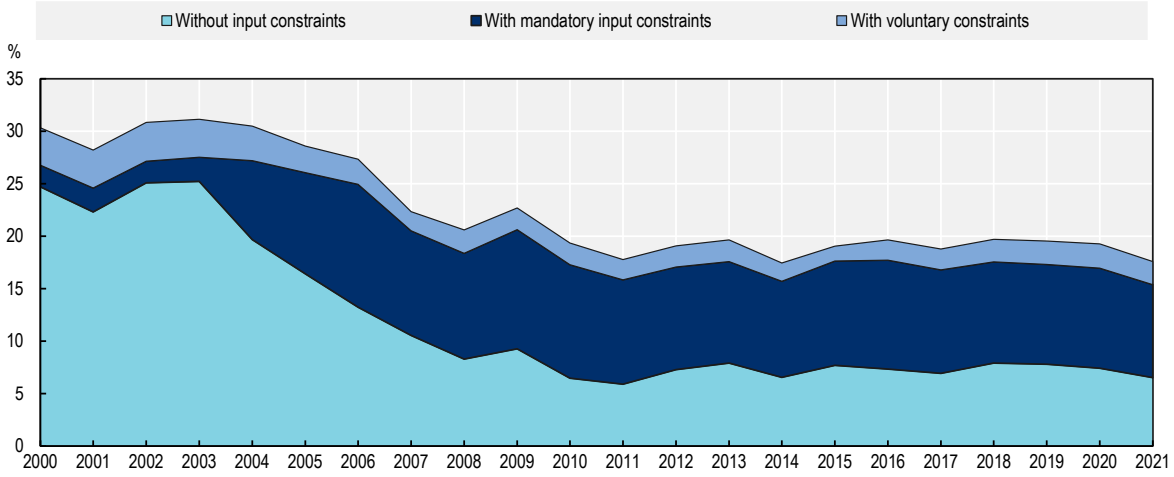
Agricultural pollution issues were addressed mainly by regulation. Again, the 1992 MacSharry Reform can be considered an important turning point, since the agri-environmental Regulation (ECC) No. 2078/92 that was introduced as part of the accompanying measures of this reform was more oriented towards a model of paying farmers to provide desired environmental outcomes. This regulation differed from earlier measures since it made it mandatory for all Member States to implement an agri environmental programme. It also included a wider range of measures and, above all, provided for co-financing of agri-environmental schemes from the guidance section of the European Agricultural Guidance and Guarantee Fund, thus setting the agri-environmental measures on an equal footing with the CAP's commodity programmes (Latacz-Lohmann and Hodge, 2003[19]).

The Fischler 2003 CAP Reform introduced mandatory environmental cross-compliance for those receiving CAP payments. Climate action has been an explicit objective of the CAP since the 2007-13 programming period. The CAP 2014-20 saw the introduction of a greening payment in Pillar 1, requiring farmers to follow three specific practices seen as beneficial for climate and the environment (Matthews, 2013[20]). EU Member States had to allocate 30% of their income support to this green payment. The CAP 2023-27 introduces a new delivery model with a performance and results based approach, as well as new instruments (e.g. the eco-schemes) to incentivise the adoption of specific farming practices with higher environmental benefits. See Chapter 4 for a more comprehensive analysis of the EU agri-environmental regulations and policy.

The increasing integration of environmental and climate objectives in the CAP is reflected in the increasing scope of input constraints that are attached to payments (Figure 3.5). The share of support with mandatory input constraints becomes significant with the introduction and generalisation of cross-compliance to all CAP payments after the 2003 reform, while the developments in payments with voluntary input constraints are linked to Pillar 2 and, in particular, to the agri-environmental payments that are granted on the condition that farmers change their farming practices (usually to adopt more extensive ones).

Figure 3.5. Payments conditional on the adoption of specific production practices in the European Union, 2000 to 2021

As a percentage of gross farm receipts



Notes: While the "with mandatory input constraints" label may generally be considered to refer to environmental cross-compliance requirements, programme descriptions often do not provide specifics on what those mandatory input constraints entail. They may or may not be related to environmental externalities or public goods. Similarly, the label "with voluntary input constraints" may describe programmes with input constraints not obviously associated with externalities or public goods.
Source: OECD (2022[10]).

Broader focus on structural policy and rural development

The modernisation of agricultural structures had been seen as a necessary complement to the market policy of the CAP. It led to the introduction of a socio-structural policy in the early 1970s, followed by various integrated development programmes, particularly for Mediterranean countries. Furthermore, a scheme of payments to farmers in less favoured areas was introduced following the United Kingdom's accession to the European Union in 1975. These early structural policy interventions later broadened into a wider rural development policy following the publication of a Commission Communication on the Future of Rural Society in 1988 (EC, 1990[21]).

Since the 1990s, there has been increasing acknowledgement of the fact that EU agriculture is embedded in the wider fabric of rural communities with mutual synergies between them, recognising that agricultural production is no longer the main economic activity in many rural areas. Rural areas vary greatly in economic and demographic terms, and their challenges are extremely diverse. Various rural development initiatives were included in the newly created Structural Funds during the 1990s. As discussed in Chapter 2, other EU structural and investment funds, such as the European Regional Development Fund and the European Social Fund, also provide support to rural areas, while national policies relating to regional development, urban and spatial planning, and the provision of infrastructure and public services, are the dominant policy influence on rural development trends.

The importance of rural areas was fully recognised in the context of the Agenda 2000 Reform, when rural development policy was made an integral part of the CAP by designating the set of measures subsumed under this term the "second pillar". The main innovation in the policy was that measures had to be included in a Rural Development Plan, which followed programming methods previously known from the Structural Funds programmes. Member States could choose from a set of measures set out in the governing Regulation (EC) No. 1750/1999, which included, *inter alia*, a scheme of investment aids, aid for young farmers, support for vocational training, an early retirement scheme, support for farms in less favoured areas, compensation for agri-environment measures, support for the processing and marketing of agricultural products, and forestry. These measures were co-financed by the CAP and by Member States, in contrast to direct payments, which were fully financed from the CAP budget. Member States were given some flexibility to transfer resources between the pillars within limits set down in the CAP legislation. Most of these funds are allocated to farmer beneficiaries, with only a very small share allocated to other rural enterprises and organisations (ADE, 2020[22]).

3.3. Agricultural trade policies

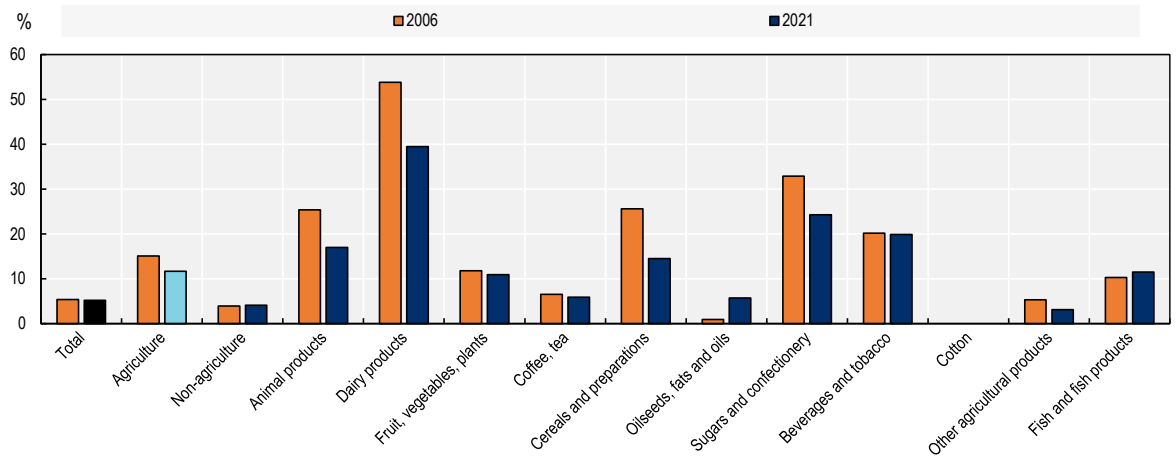
3.3.1. Despite the reduction of market price support, tariffs on agriculture double the average and negatively impact trade

Up to the mid-2000s, MPS generated by trade and other market measures was the main component or producer support in the European Union (Figure 3.2). This changed after the Fischler Reform, and since then, decisions regarding agricultural trade policies have been mostly separated from those concerning domestic policies. Decisions on overall import protection, including the European Union Common External Tariff, the opening of tariff rate quotas (TRQs), and the conclusion of multilateral and bilateral trade agreements, are mainly under the purview of the Common Commercial Policy. Nevertheless, trade policy, as reflected in the European Union's market price support, has consequences for the productivity, sustainability and resilience of the EU's agricultural sector.

The European Union extensively applies TRQs in agricultural trade. The Uruguay Round Agreement on Agriculture established TRQs to maintain market access conditions and create minimum access for products with very high bound tariffs. There are also TRQs with specific regional trade agreements. Overall, more than 15% of EU agricultural tariff lines are covered by a TRQ, and more than 20% of agricultural imports enter the European Union under a TRQ regime (Matthews, Salvatici and Scoppola, 2017[23]).

The European Union is the world's largest agricultural importer and tariffs are still significant in this sector: the simple average most-favoured nations-applied tariff rate for agricultural products was 11.7% in 2021, down from 15.1% in 2006, showing a slow but steady decreasing trend in the last decade and a half (WTO, 2022[24]). This applied tariff rate for agricultural products remains nearly three times the average applied tariff rate for non-agricultural products, calculated at 4.1% for 2021, slightly higher than 15 years ago (3.9%). They are also higher than in other OECD countries such as the United States (5.2%) and Australia (1.2%). The products with the highest most-favoured nation-applied tariffs are sugars and meat preparations, while lower tariffs are in place for products not produced in the European Union (e.g. coffee and tea) as well as for cereals and meats (Figure 3.6).

Figure 3.6. Applied most-favoured nations tariffs in the European Union by product groups, 2006 and 2021



Note: MFN: most-favoured nations.
Source: WTO (2022[25]).

Preferential access for developing countries has only a limited impact

The European Union maintains preferential tariffs for imports from certain countries pursuant to its reciprocal and non-reciprocal preferential agreements. It is the largest trading partner for many of the world's developing countries, and trade preferences make up one of the central policies for improving integration between the European Union and these countries.

The European Union grants unilateral trade preferences to developing countries through the Generalised System of Preferences (GSP), which has been in force since 1971. The GSP seeks to create economic opportunities in developing countries and promote sustainable development. It consists of three non-reciprocal arrangements.

- The standard GSP, which offers access to the EU market at zero or reduced tariffs on two-thirds of the EU tariff lines – currently benefiting 15 countries.
- GSP+, which reduces to zero the tariffs on the goods covered by the standard GSP if the beneficiary country has ratified and implemented 27 major international conventions and meets certain criteria related to the share and diversification of its exports to the European Union – currently benefiting nine countries.
- Everything but Arms (EBA), which provides access free of tariffs and quotas to all products except arms and ammunition from 48 least developed countries (LDCs) (EC, 2021[26]).

As of 2019, total EU imports under the GSP amounted to EUR 62 billion, or 39% of all imports from GSP beneficiary countries. In the case of the LDCs, imports under the EBA were EUR 25 billion, or 67% of EU imports from the LDCs. Agri-food products represent only a small share of the European Union's imports from the LDCs: in 2020, only 12% of total imports from these countries were from the agri-food sector (including fisheries), while 57% of imports were of textiles. The GSP utilisation rates[2] for LDC agri-food imports ranged between 74% for vegetable products and 95% for fats and oils (UNCTAD, 2022[27]).

EU assessments have found that the GSP has made a modest contribution to export diversification in developing countries, which partly relates to its concentration in a limited number of beneficiaries: in 2019, five developing countries (Bangladesh, India, Indonesia, Pakistan and Viet Nam) accounted for 80% of total EU GSP imports (EC, 2021[26]). The current EU GSP regulation will expire at the end of 2023, and the

system is currently undergoing a revision that seeks to address this and other identified problems and better exploit the GSP's potential to promote sustainable development.

The proposed new GSP regulation for 2024-34 would keep the current structure of three arrangements. The modifications include adjustments of import criteria to guarantee that the system has more space for poorer developing countries relative to large, industrialised beneficiaries and that countries graduating from LDC status have a smoother transition from the EBA to the GSP+. It also enlarges the list of international conventions that must be implemented in order to benefit from GSP+ preferences to include the Paris Agreement on Climate Change (among others) and introduces an urgent procedure to withdraw preferences when a beneficiary country is found in violation of international standards (EC, 2021[28]).

A recent assessment of the impact of EU tariffs on imports to the European Union in the agricultural sector (Cipollina and Salvatici, 2020[29]) found that, on average, these tariffs have lowered agricultural imports by 14% and that the protectionist impact is larger than the trade creation due to preferential treatment, since the various agreements have increased extra-EU imports by about 10%.

The European Union applies numerous non-tariff measures, such as sanitary and phytosanitary measures and technical barriers to trade, on agri-food products. As of 2016, only 0.5% of food products, 1% of vegetable products and 4% of animal products were not subject to non-tariff measures (WITS, 2018[30]). Non-tariff measures applied by the European Union include requirements on food production and safety, animal and plant health, animal welfare, alien organisms, and gene technology. A 2014 study found that the sanitary and phytosanitary measures applied by the European Union present an important burden for low-income countries, leading to a 14% reduction in their exports (Murina and Nicita, 2014[31]).

3.3.2. The EGD has significant trade implications, and the European Commission intends to use external policy to globally promote higher sustainability standards

One of the objectives of the European Green Deal is to build a more sustainable and healthier food system. Implementing the necessary measures to achieve this objective will have a significant impact on the competitiveness of EU producers as well as on international trade in food, most likely reducing EU production (Petsakos et al., 2022[32]; Beckman et al., 2020[33]; Henning and Witzke, 2021[34]). The European Union has acknowledged that this transformation includes an important external policy dimension to also support the global transition to sustainable agri-food systems (EC, 2019[35]). The Green Deal Communication included an agenda of actions covering diplomacy, trade policy, development support and other external policies to make the European Union an effective advocate focused on convincing and supporting others to take on their share of promoting more sustainable development. It proposed to use its economic weight to shape international standards in line with EU environmental and climate ambitions.

The European Union has identified a particular need to take greater account of sustainability issues in trade policy and to bring about greater coherence between its own agricultural policy, trade policy and Green Deal policies. The Commission's Trade Policy Strategy emphasised the need to make supply chains more sustainable, in particular, by promoting sustainability standards across global value chains (EC, 2021[36]). Several initiatives were highlighted, including improvements in the multilateral trade framework; promoting the sustainability dimension in the European Union's trade and investment agreements; the introduction of autonomous measures such as the Carbon Border Adjustment Mechanism and requiring imports to comply with EU production requirements in line with WTO rules; the introduction of legislation addressing deforestation and forest degradation; and sustainable corporate governance, including mandatory environmental, human and labour rights due diligence. The Farm to Fork (F2F) Strategy (EC, 2020[37]) further underlines the importance of these initiatives.

The objectives of these upcoming trade policies are to avoid that EU consumers offshore the negative environmental consequences of their consumption through existing or increased imports and to ensure that EU producers compete with imports on a level playing field. Direct policies like regulations are likely

to generate "pollution leakages" (Gruère et al., 2023[38]). These policies aim to raise global sustainability standards by leveraging access to the EU market to provide a stimulus to exporting countries to raise their standards. Its implications for market access are likely to be controversial.

The European Union has recognised the importance of multilateral initiatives to promote international standards in relevant international bodies and to encourage the production of agri-food products complying with high safety and sustainability standards. It has committed to supporting small-scale farmers in meeting these standards and accessing markets through its development co-operation policy. The F2F Strategy proposed to pursue the development of green alliances on sustainable food systems with all its partners in bilateral, regional and multilateral fora. One example is the Alliance on Sustainable Cocoa announced in June 2022 between the European Union, Côte d'Ivoire, Ghana and the cocoa sector, which, among other objectives, will help producing countries and the cocoa sector prepare for the implementation of EU legislation on deforestation and corporate sustainability due diligence.

Sustainability is now part of all EU Free Trade Agreements, with an expanding scope of provisions and of upcoming mandatory due diligence regulations

Sustainability as an objective of EU trade policy has also been reflected in a specific chapter on trade and sustainable development in all the European Union's bilateral free trade agreements since the EU-Korea Free Trade Agreement in 2011. The Commission has recently proposed enhancing the contribution of EU trade agreements to promoting the protection of the environment and labour rights worldwide (EC, 2022[39]). Additional potential commitments include a chapter on sustainable food systems, respect of the Paris Agreement and Nationally Determined Contributions, and a more active role of the chief trade enforcement officer in implementing the sustainability dimension of existing agreements. The revision of the GSP currently underway could also be used to promote greater respect for the environment as well as core human and labour rights.

In line with the objective to make global supply chains more sustainable, two legislative initiatives extend the scope of mandatory due diligence obligations for companies. Political agreement on a regulation to prevent trade in commodities and products associated with deforestation and forest degradation was reached in December 2022 between the Council and European Parliament. The regulation will require operators that place specific commodities on the EU market that are associated with deforestation and forest degradation – soy, beef, palm oil, timber, rubber, cocoa and coffee and some derived products such as leather, chocolate, and furniture – to ensure that only deforestation-free and legal products (according to the laws of the country of origin) are allowed on the EU market. Operators will be required to keep strict traceability to ensure that only deforestation-free products enter the EU market – and that enforcement authorities in Member States have the necessary means to control that this is the case. Although the regulation is seen as mainly preventing the import of agri-food and timber products at risk of contributing to deforestation, it will apply to both domestic and imported products, so they are measured by the same standards.

The Commission also published a proposal for a Directive on Corporate Sustainability Due Diligence on 23 February 2022, which will require Member States to adopt national legislation obliging larger companies to conduct human rights and environmental due diligence. Such companies will be required to identify actual or potential adverse impacts, prevent and mitigate these impacts, and bring these impacts to an end. To ensure compliance, companies would be liable for damages if they fail to comply with their respective obligations. A further Commission proposal in September 2022 would prohibit all products made with forced labour on the EU market.

The application of EU health and environmental standards for imported agricultural products is on the agenda and faces opposition from trading partners

Of particular importance for the agri-food aspects of the Green Deal is the commitment by the European Council, Parliament and the Commission as part of the 2021 CAP political agreement to require that imported agricultural products comply with certain production requirements to ensure the effectiveness of the health, animal welfare and environmental standards that apply to agricultural products in the European Union and to contribute to the full delivery of the European Green Deal and F2F Strategy (European Parliament, 2021[40]).[3] In its communication on the Future of Food and Farming in 2017, the European Commission (2017[41]) acknowledged that in "the Union's highly diversified farming and climatic environment, neither top-down nor one-size-fits-all approaches are suitable to delivering the desired results and EU added value".

In June 2022, the Commission published a report entitled *Application of EU Health and Environmental Standards to Imported Agricultural and Agri-food Products* (EC, 2022[42]). The report was informed by a public consultation, to which stakeholders from 30 countries, 17 of which were non-EU Member States, submitted their comments; the orientation debate in the Agriculture and Fisheries Council in February 2022; and the Resolution of the European Parliament on the F2F Strategy (European Parliament, 2021[43]). The report concluded that there is some scope to extend EU production standards to imported products, provided this is done in full respect of the relevant WTO rules. The report showed that before applying production standards to imports, it is always essential to make a case-by-case assessment. This report, in addition to assessing the legal and technical feasibility of doing this, and explaining the constraints that apply, also indicated a wide range of areas where the European Union has already extended its domestic production standards to imported products, be it via multilateral, bilateral or autonomous instruments. The prohibition on the import of beef produced with growth hormones is an early example of the application of reciprocity measures to imported agricultural products and, more recently, the European Union has extended its domestic regulation on veterinary medicinal products[4] to the import of animals and products derived from animals where antimicrobial drugs were used for growth promotion, or antimicrobials reserved for human health were administered.

There have been debates about the application of EU health and environmental standards for imported agricultural products, particularly when EU farmers no longer have access to active substances for use as pesticides or herbicides, even if in the past there have been some derogations for some Member States. Imports produced with the aid of these substances compete with EU producers. In the F2F Strategy, the Commission stated that it would, in compliance with WTO rules and following a risk assessment, take into account environmental aspects when assessing requests for import tolerances for pesticide substances no longer approved in the European Union. In the first implementation of this principle, the Commission proposed to lower all the current maximum residue limits for two neonicotinoid insecticides, clothianidin and thiamethoxam, to the limit of determination. There has been significant opposition to this unilateral adoption of environmental criteria when setting maximum residue limits from the European Union's trading partners.[5]

3.4. CAP 2014-22: Overview of selected tools to achieve PSR objectives

In many ways, the CAP 2014-22 – which includes the 2014-20 Reform and the 2021-22 transitional rules (Table 3.1) – can be characterised as a continuation of the CAP 2007-13, since the overall funding was almost constant and the two-pillar structure maintained (OECD, 2017[6]). The three main novel features of the CAP 2014-22 can be synthesised in the following (European Parliament, 2021[5]).

- Converting decoupled aid into a multifunctional support system with aid directed toward specific objectives. Accordingly, the single payment scheme was replaced by a system of decoupled

payments with seven components: 1) a basic payment; 2) a greening payment for environmental public goods; 3) an additional payment for young farmers; 4) a "redistributive" payment for first hectares of farmland; 5) support for areas with specific natural constraints; 6) aid coupled to production; and 7) a simplified system for small farmers. These options also applied in countries implementing the Single Area Payment Scheme.

- Consolidating Common Market Organisation tools into safety nets in case of market disruption or price crisis, and ending other supply control measures, namely the milk and sugar production quotas in 2015 and 2017, respectively.
- A more integrated, targeted and territorial approach to rural development, including simplifying the range of available instruments to focus on six priority areas: 1) fostering knowledge transfer and innovation; 2) enhancing the competitiveness of all types of agriculture and the sustainable management of forests; 3) promoting food chain organisation, including processing and marketing, and risk management; 4) restoring, preserving and enhancing ecosystems; 5) promoting resource efficiency and the transition to a low-carbon economy; and 6) promoting social inclusion, poverty reduction and economic development in rural areas.

For the 2014-20 period, agricultural expenditure totalled EUR 408.3 billion: EUR 291.3 billion for direct payments (71.3% of the CAP total), EUR 99.6 billion for rural development (24.4%) and EUR 17.5 billion for market measures (Common Market Organisation) (4.3% of the total) (European Parliament, 2022[7]). Table 3.2 shows the distribution of the different types of expenditure by scheme (direct payments and market expenditure), and for priority areas (rural development expenditure).

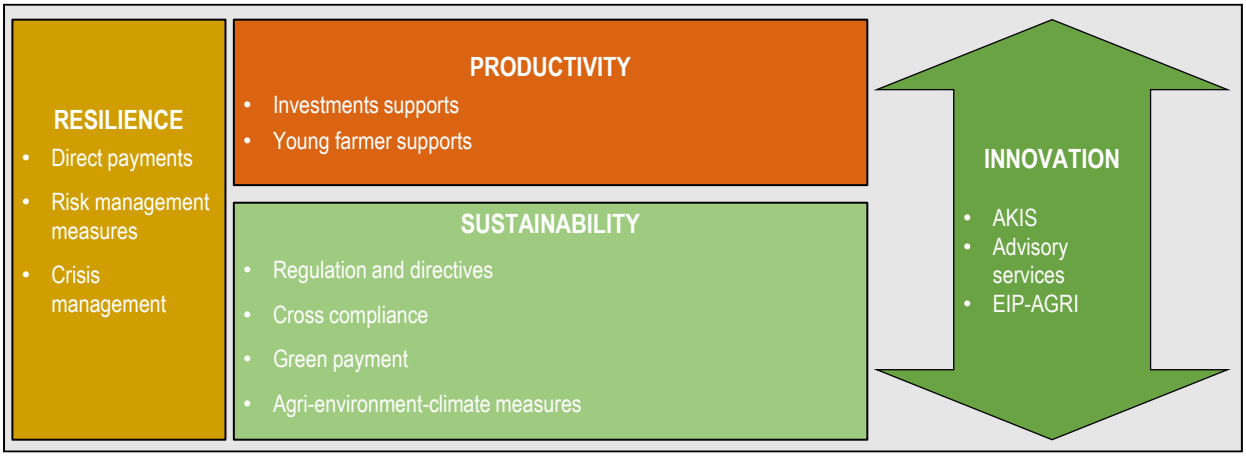
Table 3.2. Distribution of CAP expenditures, 2015-20

Direct payments		Rural development		Market expenditure	
Scheme	%	Priority area	%	Scheme	%
Basic payment scheme	40.0	Ecosystems	48.0	Wine	37.9
Greening	29.1	Competitiveness	23.4	Fruit and vegetable	34.3
Single area payment scheme	11.8	Social inclusion	13.5	POSEI[2]	8.6
Voluntary coupled support	10.8	Food chain organisations	10.3	School schemes	6.1
Redistributive payment	4.3	Resource efficiency	4.9	Promotion activities	4.6
Other	4.0	Knowledge and innovation[1]	–	Other	8.5

1. No financial allocation is shown for Priority 1 as the expenditure is distributed across other focus areas.
2. The programme of options specifically relating to remoteness and insularity (POSEI) supports the European Union's outermost regions, which face specific challenges due to remoteness, insularity, small size, difficult topography or climate. It also supports those that are economically dependent on only a few products.
Source: EC (2022[44]).

Figure 3.7 shows the selected policy instruments that are analysed in greater detail in this study amongst the broad portfolio of tools available in the CAP 2014-22, categorised according to the PSR objectives of productivity, sustainability and resilience and the overarching innovation driver. The next subsection reviews agricultural policy tools for productivity and resilience. Measures to promote sustainability and innovation are analysed in Chapters 4 and 5, respectively.

Figure 3.7. The main CAP instruments categorised according to the PSR objectives



Notes: AKIS: Agricultural Knowledge and Innovation System; EIP-AGRI: European Innovation Partnership for Agricultural Productivity and Sustainability. The categorisation was made considering the main objective of each instrument, although some instruments may also have effects on different categories (e.g. AKIS design, advisory service, investment supports, generational renewal; the EIP-AGRI may have effects on productivity and sustainability).

3.4.1. Direct payments

Direct payments make an important contribution to farm income, but their distribution is uneven and is not based on farm households' disposable income and living standards

Originally, direct payments were introduced to compensate farmers for income losses arising from the reduction in high market support prices (with the implication that they would be transitional or temporary payments). As decoupled payments became a permanent feature of the CAP, various justifications have been advanced: to increase farm income, stabilise farm income, compensate farmers for higher regulatory standards compared to overseas competitors, compensate farmers for the delivery of public goods and ecosystem services, or ensure food security. Certainly, direct payments make an important contribution to farm income, representing 24% of agricultural income in 2015-20 and 12.2% of gross farm receipts in 2021 (OECD, 2022[9]). These percentages are higher for specific sub-sectors (e.g. beef farming) and can be higher or lower for individual countries, even if these cross-country variations cannot be analysed by the PSE database in its current form.[6]

The distribution of Pillar 1 aid is uneven, since the distribution of direct payments follows the distribution of land use in the European Union, which is highly skewed. Despite all the corrective measures introduced, in 2015, 20% of farms received 80% of this aid (EC, 2022[45]). Moreover, it has been found that land concentration is correlated with the level of direct payments concentration (Severini and Tantari, 2014[46]) and that a high share of direct payments goes to larger farms, where the need for income support is not obvious (Guth et al., 2020[47]; Matthews, 2016[48]; 2017[49]; Ciliberti et al., 2022[50]). Modalities envisaged so far to address this problem, such as higher payments to the first hectares or degressivity above certain thresholds, have witnessed limited take-up by Member States (OECD, 2020[51]).

While some evidence exists on the association between the CAP and the reduction of poverty at the sub-national level (World Bank Group, 2018[52]), there is not enough information or analysis of the impact of direct payments on improving income distribution among farm households, or its role in alleviating low levels of income among farmers. Indeed, direct payments are not targeted to low-income producers. A flat-rate payment per hectare inevitably benefits larger farms whose incomes are often well above the average non-farm income in the relevant country. Some steps to limit payments to very large holdings and to focus payments more on smaller farms have been taken, but their impact on the distribution of payments between

farms has been limited to date. Furthermore, it is not farm income but household income that matters for policies that target equity. The untargeted nature of the income support granted by direct payments underlines the potential to make more effective use of these funds (Matthews, 2016[48]) (Marino, Rocchi and Severini, 2023[53]).

Direct payments are no longer the most efficient instrument for achieving resilience objectives

Several studies have found that direct payments stabilise farm income because their coefficient of variation is smaller than market income and smaller than farm income as a whole (Severini, Tantari and Di Tommaso, 2016[54]; Knapp and Loughrey, 2017[55]). To the extent that direct payments improve either the level or stability of farm income, they may contribute to absorption resilience capacity. The extent to which they contribute to adaptation and transformation resilience capacities is more doubtful (Sauer and Antón, 2023[56]). Direct payments may even have negative consequences on the resilience of some farming systems, especially on adaptability and transformability capacities (Buitenhuis et al., 2020[57]), by negatively affecting farm efficiency, total agricultural production and salaried employment (Žičkienė et al., 2022[58]).

However, direct payments are neither the most efficient nor the most equitable instrument to achieve resilience objectives (Matthews, 2016[48]; Matthews, 2017[49]). Leakages to unintended beneficiaries reduce the value of this support to farmers (OECD, 2003[59]; Ciliberti et al., 2022[50]). Direct payments have a short-run effect in raising farmers' income, but ultimately, the effect of the transfer is to maintain a higher number of people working in agriculture than would otherwise be the case. In the longer run, the effect of the transfer is to slow down the structural transformation of agriculture rather than improve individual farm incomes that mainly respond to productivity trends (Matthews, 2017[49]).

The effectiveness of direct payments in stabilising farm income relative to other risk management instruments can also be questioned. They are not designed to deal with variations in income over time. Payments are made to farmers when prices are low, but when prices are high as well. Simulation analyses undertaken by the OECD found that highly decoupled payments (such as the EU single farm payment/basic farm payment) have very limited crowding-out effects on other risk management strategies, but also have a very limited effect in reducing income variability (OECD, 2011[60]). They are also not necessarily targeted to those farms and farm systems that experience the greatest income variability (Severini, Tantari and Di Tommaso, 2016[54]). To the extent that direct payments do contribute to stabilising farm income, this resilience stabilisation function could also be provided using more targeted payments (Matthews, 2017[49]).

Effects of CAP payments on agricultural employment are uncertain

The literature does not agree on the impact of CAP payments (decoupled, coupled and rural development payments) on agricultural employment. Some studies find a positive impact (though varying by type of payment), while others find a negative impact (for reviews, see Bojnec and Fertő (2022[61]) and Schuh et al. (2022[62]). However, the studies generally agree that the effects are small. One of the more recent studies that addresses some methodological deficiencies of previous studies found that CAP subsidies reduce the outflow of labour from agriculture, but the effect is almost entirely due to decoupled Pillar 1 payments (Garrone et al., 2019[63]). These authors estimated that the budgetary costs of preserving jobs in agriculture are high, putting the estimated cost at more than EUR 300 000 per year per job saved in agriculture. If the policy objective is to create jobs and maintain employment in rural areas, it would seem preferable to use a policy instrument directly aimed at preserving agricultural employment. Helming and Tabeau (2018[64]) simulated the impact of transferring 20% of the 2020 reference scenario Pillar 1 budget per Member State to finance a subsidy on agricultural labour use (independent of the type of labour – family labour, hired labour or contract work). They concluded that the social cost would be about EUR 1 400 per full-time work

equivalent in agriculture (their model assumes full employment, the cost would be lower if unemployed labour exists). The lower cost per job maintained may reflect the more targeted nature of a labour subsidy rather than subsidies linked to land, production or investment.

CAP payments can be capitalised in land rents and can also deter generational renewal

In some cases, the benefits of CAP direct payments do not remain with the farmer beneficiary but leak out to benefit other stakeholders. This is particularly likely where the decoupled area-based or coupled payments are capitalised into the value of land and especially land rents, or where payments encourage additional production that decreases agricultural prices, which benefits consumers. Empirical studies agree that capitalisation takes place, although they disagree on the scale of the phenomenon (Baldoni and Ciaian, 2021[65]; Varacca et al., 2022[66]).

Higher land prices and rents can make entry for younger farmers more difficult and thus slow the rate of generational renewal. However, a more important impact may be to delay the exit of older farmers who would otherwise lose their direct payment if they handed over the farm (Schuh et al., 2022[62]). Some Member States required (Austria, Germany, Poland) or still require (France) to cease farming if they wish to receive the state pension (or at least the non-contributory part), which can encourage the transfer of land to the next generation where the state pension is attractive. But in many Member States, the state pension is low. Farmers would suffer an income loss if they ceased farming and lost their entitlement to direct payments, so extending this national legislation may have a limited effect. It may also run into constitutional objections, as was the case in Germany in 2018. However, the effect of CAP payments being used as a social payment to elderly farmers would be to slow down generational renewal.

3.4.2. Other measures to promote resilience

Risk management measures are underused

The European Union has progressively introduced subsidised agricultural risk management measures. Progressive liberalisation of the CAP, via the reduction of price support measures, increased EU farmers' exposure to market volatility. This led to greater interest in the development of risk management measures, particularly insurance and mutual fund schemes. EU schemes were originally designed with the strict conditions set out in the WTO Agreement on Agriculture to be classified as "green box" payments. These conditions have been gradually relaxed over time to encourage greater uptake. The Commission's conditions for a national government to subsidise risk management instruments have also been relaxed.

The EU framework to support risk management includes both CAP instruments and state aid rules (Bardají et al., 2016[67]). The first step was taken in 2007 with the reform of sectoral regulations for fruit and vegetables, as well as the wine sector, which allowed introducing prevention and crisis management mechanisms, including support to crop insurance or setting up mutual funds. In the 2014-22 programming period, a risk management toolkit was included in the menu of rural development programmes financed by Pillar 2. Support could be given through financial contributions to insurance premiums; mutual funds compensating production losses due to climatic, sanitary and environmental risks, or an income stabilisation tool which *de facto* operates as a mutual fund compensating income losses due to production and/or price risks. Additionally, Member States provide *ex post* natural disaster aid under state aid provisions. It is not clear the extent to which these programmes compete with each other and overlook the recommendation that government support for risk management is best concentrated on addressing market failures, with subsidies limited to covering programme administrative costs and, at most, losses from catastrophic risks (Glauber et al., 2021[68]).

Giving Member States the option to fund insurance schemes and mutual funds in rural development programmes (RDPs) and state aids means that there is no harmonised EU-wide agricultural risk management scheme. While the use of funded risk management presents intra-EU challenges and could

have other unintended consequences depending upon programme design, its use remains limited due, at least in part, to the effect of direct payments. Farmers' access to these instruments varies widely across Member States. Finally, evidence suggests that the expectation of free assistance is important for decisions about risk management measures: if producers believe that the government will bail them out in the event of a disaster, they may be willing to forego participation in existing insurance programmes or to engage in other risk-reducing and managing practices (Glauber et al., 2021[68]; Deryugina and Kirwan, 2017[69]).

There is also a risk that public subsidy of risk management instruments could discourage farmers from adapting to new climate conditions and from increasing self-reliance and preparedness (OECD, 2019[70]). Still, less than 2% of RDP funds were programmed for risk management in RDPs in the 2014-22 period. More generally, the EU risk management toolkit has remained largely underused (Cordier and Santeramo, 2020[71]). Even if improvements are made to increase the availability of risk management options for farmers, there may be limited interest among farmers, given the important role of direct payments in stabilising farm incomes. Additionally, excessive governmental support might crowd out private and market-based risk management solutions by overcompensating for normal business risks and incentivising risky and unsustainable farming practices (OECD, 2019[70]).

Crisis management

The CAP includes several measures that can be activated in the context of market and economic crises. While there is no definition of what such crises are, and therefore no clear threshold exists, the scope of these measures has grown since 2013. In particular, the traditional instruments of public intervention and support for private storage were augmented by provisions for exceptional measures in the event of a market disturbance in Articles 219-222 of Regulation (EU) No. 1308/2013 for all products. These articles provide considerable discretion to the European Commission to handle market crises, including the use of voluntary supply controls and financial support packages. In addition, Member States can be authorised to provide national assistance to their farmers under state aid rules. In recent years, in response to the COVID-19 pandemic (Box 3.1) and the energy price hike induced by the Ukraine war (Box 3.2), a broad range of exceptional crisis management measures and aid packages have been adopted both at the Member State and EU level.

The Commission can use public procurement interventions and aids for private storage for a selected number of commodities such as wheat, rice and beef for public buying interventions, and white sugar, olive oil, and pig meat in the case of private storage. Removing products from the market can give a more sustained boost to prices but is a more costly option. Producer organisations in the fruit and vegetables and wine sectors have long been able to institute market withdrawals, green harvesting[7] and non-harvesting[8] in crisis periods. The Commission was recently given the power to authorise market withdrawals by producer organisations and recognised interbranch organisations for other products (Article 222 of the Common Market Organisation Regulation), and by co-operatives (Omnibus Regulation (EU) No. 2017/2393). This implies that these measures are no longer considered measures of last resort.

The Commission can also grant financial support packages to producers affected by a sudden market crisis. Advance payments can be made from the CAP budget to improve farmers' liquidity. Funding for additional aid may be available within the financial ceilings for the CAP budget laid down in the MFF (particularly in the past when assigned revenue from fines and disallowances on Member States boosted budget revenue). The CAP 2014-22 also created a special crisis reserve by withholding an amount of direct payments (EUR 400 million in 2011 prices) to fund emergency measures. If the crisis reserve funding was not used in a particular year, it was returned to farmers the following year and a further cycle of withholding was initiated. However, even in a crisis, Member States in the Council were reluctant to activate this mechanism because it implies the redistribution of funds from one group of farmers to another. The mechanism was activated for the first time in 2022 to make up for a shortfall in available funding elsewhere

in the CAP budget to fund the EUR 500 million package to support farmers in light of rising input costs, such as energy and fertilisers, further accelerated by Russia's war of aggression against Ukraine.

An evaluation of crisis measures in the CAP noted that public intervention and private storage measures have become less effective over time as EU producer prices have become increasingly aligned with world market prices (Wageningen Economic Research and Ecorys, 2019[72]). It also pointed to weaknesses in the supply management measures, partly because they are voluntary (giving rise to a free rider problem [see also Mahé and Bureau (2016[73])] and partly because the entities authorised to engage in co-ordination measures may be too small to influence market prices under increasingly open markets.

On the other hand, state aid was seen as flexible and effective, albeit raising issues of fairness between farmers in different Member States and a lack of transparency on risks covered by this *ad hoc* assistance. The evaluation concluded that there is no need for additional instruments, neither for crisis prevention, preparation or crisis response and recovery.

Mahé and Bureau (2016[73]) were more critical, noting that the European Union lacks financial resources in times of crisis. They proposed legal changes to budgetary rules to allow the crisis reserve to build up to a sizeable war chest. They also suggested the eligibility for particular emergency aid programmes should be conditional on producer participation in risk mitigation schemes and better defined thresholds.

Box 3.1. European and Member States' policy responses to the COVID-19 pandemic

The COVID-19 pandemic plunged the European Union into its worst-ever recession and raised multiple challenges that often compounded the European Union's existing weaknesses (OECD, 2021[74]). The COVID-19 emergency also caused huge disruptions in food and agricultural markets, but the European food and agricultural systems proved resilient in ensuring that consumers could access food. This is also the result of the broad range of measures that have been adopted on this front at the EU level, including flexibility under the Common Agricultural Policy (CAP), exceptional market measures, and direct support to farmers and rural areas.

In this framework, Member States responded with their own policy packages, targeting the most affected sectors. In particular, spending on state aid initiatives under the Temporary State Aid Framework soared in 2020 and early 2021, with 22 countries implementing sector-specific aid packages totalling nearly EUR 6.2 billion (USD 7.1 billion), equivalent to more than 11% of CAP expenditure in 2020 (OECD, 2021[75]). Member States also put in place their own regulatory flexibilities, tax concessions and social contribution measures, investment assistance, and allowances to farm households to help farmers and agro-food enterprises cope with the financial impacts of the COVID-19 emergency. Response measures also responded to labour concerns within the sector, ensured minimal interruptions to food supply chains and helped to ensure that affected consumers had adequate access to food.

The European Union also put in place some trade measures in response to COVID-19, but most were unrelated to agriculture. One measure that did impact agricultural supply chains was the designation of Green Lanes to ensure that trans-European trade in goods under a functioning single market could continue even in the presence of internal border controls erected to protect public health (EC, 2020[76]).

Finally, some policies were implemented to facilitate longer term recovery and sector transformation, such as the Recovery Plan for Europe, a long-term recovery initiative from the COVID-19 emergency. In particular, the Next Generation EU initiative under this plan funds some activities for the agricultural sector to support Member States in recovering, repairing and emerging stronger from the crisis.

Recent experience has shown that, beyond the crisis reserve mechanism, the MFF has limited financial headroom to fund emergency aid packages. Thus, in response to the COVID-19 pandemic and, more recently, Russia's war of aggression against Ukraine, the Commission has introduced temporary state aid packages that authorise Member States to give national aid, *inter alia*, to farmers and food companies. The regulations include conditions and stipulations designed to minimise any distorting impact of these packages on competitive conditions within the single market. While they helped in the recovery, these *ad hoc* measures likely do not encourage preparedness.

In the framework of the F2F Strategy, in November 2021, the European Commission published a Communication on a Contingency Plan for Ensuring Food Supply and Food Security in Times of Crisis (EC, 2021[77]), which outlines areas for improvement that were identified during the COVID-19 pandemic and previous crises, as well as principles that should be adhered to in times of crisis. It also proposed the creation of the European Food Security Crisis Preparedness and Response Mechanism, which has been useful and active, both as follow-up to the Communication as well as in response to the food security challenges caused by Russia's war of aggression against Ukraine (Box 3.2). Overall, while the EU food supply chain has proved resilient and there were no enduring supply problems or food shortages, the pandemic highlighted the key role of migrant workers both at the farm level in harvesting and in processing plants since border closures and lockdowns affected the availability of migrant workers in labour-intensive food value chains such as meat processing and fruit and vegetables (Matthews, 2020[78]; Wieck et al., 2021[79]).

Following Russia's war of aggression against Ukraine in February 2022, food security issues were back at the top of the EU political debate. Countries that rely heavily on cereal imports from Ukraine and Russia (mainly North Africa and the Middle East) are at heightened risk of food insecurity due to supply chain disruptions. In response, on 23 March 2022, the Commission published a Communication (EC, 2022[80]) which outlined a number of measures being taken to safeguard global food security and support EU farmers and consumers that have been impacted by Russia's war of aggression against Ukraine.

Box 3.2. Ukraine war and the implication for the European Union's agricultural policies

Russia's war of aggression against Ukraine (hereinafter referred to as the "war") and related policy responses and economic consequences have shaped global agricultural markets. At the time of the annexation of Crimea in 2014, Russia banned imports of meat, dairy products, and fruits and vegetables from the European Union, North America and several other countries. On 24 February 2022, this long-standing situation escalated into an open war when Russia invaded Ukraine, further affecting global markets and threatening global food security at a time of already elevated global commodity prices.

Ukraine and Russia are among the most important producers and exporters of arable crops in the world, particularly wheat, barley, maize, sunflower seed and rapeseed. Russia also plays an important role in global energy and fertiliser markets. Russia is the world's top natural gas exporter, second-largest oil exporter and third coal exporter, accounting for 10%, 11% and 18% of global exports, respectively, in 2021 (FAO, 2022[81]). Russia is also the world's top exporter of nitrogen fertilisers, the second leading exporter of potassic fertilisers and the third leading exporter of phosphorous fertilisers (FAO, 2022[81]), accounting for over 15% of total global fertiliser exports in 2020 (UNTAD, 2022[82]).

Several scenarios have been conducted with the Aglink-Cosimo model that assumes different impacts on the harvest and export levels of all crops in Ukraine, and on the export levels of wheat in Russia for the next marketing season (2022/23) (OECD/FAO, 2022[83]). Table 3.3 shows the impact of these scenarios on international wheat prices. The full loss of Ukraine's capacity to export would lead to a 19% increase in global wheat prices. This highlights the importance of maintaining Ukraine's production and export capacity. In the extreme scenario where Russian exports are also affected, wheat prices

would be 34% higher than without the war. In this scenario, Russia and Ukraine would jointly export 36 million tonnes (Mt) less wheat, but other countries would increase their exports by 16 Mt due to the higher international prices.

Table 3.3. Relative change in global wheat prices: Scenarios with Aglink-Cosimo for marketing year 2022/23

		Restriction of wheat exports by Russia			
		0%	-10%	-25%	-50%
Reduction of Ukraine wheat exports	0%	0	2%	5%	11%
	-25%	4%	6%	10%	16%
	-50%	9%	11%	15%	21%
	-100%	19%	22%	26%	34%

Notes: The upper left cell in the table refers to the hypothetical situation where exports from both countries are at the same levels as in the past years, not the data presented in the *OECD-FAO Agricultural Outlook*. Vertically, the production and export of cereals in Ukraine are reduced. Horizontally, the wheat exports of Russia are restricted.
Source: OECD (2012[84]).

A Commission Communication that presented options for addressing rising food prices and the issue of global food security concluded that the European Union's agricultural production potential should be maintained (EC, 2022[80]). It proposed allowing Member States to derogate from certain rules for ecological focus areas in 2022 by allowing for the production of any crops for food and feed on fallow land that is part of ecological focus areas while maintaining the full level of the greening payment (Commission Implementing Decision (EU) 2022/484). Subsequently, Member States were authorised to derogate the application of Good Agricultural and Environmental Conditions (GAEC) Standards 7 and 8 in 2023 eliminating the need to maintain a minimum share of non-productive area, including fallow land. Fallow land that is brought back into production cannot be used for the production of maize or soya for animal feed (Commission Implementing Regulation (EU) 2022/1317). The Communication also recommended that Member States revise their CAP strategic plans with a view to supporting farmers in adopting practices optimising the efficiency of fertilisers, thus reducing their use, and prioritising investments that reduce dependency on gas and fuel.

The Communication cautioned against any increase in the use of food and feed crops as feedstock for biofuel and supports Member States to reduce the blending proportion of biofuels to reduce the use of EU agricultural land for the production of biofuel feedstocks, thus easing pressure on the markets for food and feed commodities.

3.4.3. Measures to promote productivity

Investment support

The CAP provides investment support for farms to stimulate farm modernisation and productivity.[9] This support is manly provided through RDPs, with the overall objective of stimulating technical progress and labour productivity in agriculture.[10] Farmers can face liquidity constraints when they seek to use advanced technological innovations. CAP payments can help to overcome these constraints. Access to credit at competitive rates is difficult, as banks consider potential loans to farmers and many other rural businesses – especially smaller ones – as risky.

A study by the European Commission and the European Investment Bank estimated that the EU agricultural sector financial gap for short-term loans is EUR 1.56 billion to EUR 4.12 billion and for medium- and long-term loans EUR 5.50 billion to EUR 14.48 billion (EC and EIB, 2018[85]). CAP income support

payments can help relieve these constraints. Guastella et al.'s (2013[86]) empirical analysis suggests that on-farm investment levels are positively related to the receipt of direct payments. However, the overall impact of direct payments on agricultural productivity depends on the use of these payments. There is little evidence that partially coupled subsidies in place prior to 2005 have lowered farm productivity, but that the change to decoupled payments after 2005 has eliminated this negative effect and may have even contributed to a positive productivity effect (Antón and Sauer, 2021[87]). The potential positive effect of fully decoupled payments on productivity was confirmed by Sauer et al. (2021[88]), who compared the impacts of reforms largely decoupling payments in the United Kingdom to the minimum decoupling approach in France (Box 3.6). Still, most studies find that the impact of decoupling of CAP direct payments on productivity is limited (Matthews, Salvatici and Scoppola, 2017[23]; DeBoe, 2020[14]).

Investment programmes under Pillar 2 of the CAP have been widely used to incentivise investments in innovation by improving the liquidity position of farmers, with the expectation that this would lead to increased production and higher productivity. Empirical studies provide some evidence that these investment programmes have helped to scale up and speed up farm modernisation and restructuring (Fertő et al., 2017[89]). Kirchweger and Kantelhardt (2015[90]) concluded that publicly supported farm investment activities in Austria fostered farm growth significantly, with both total livestock units and utilised agricultural area increasing significantly more on investing farms than on non-investing farms. In a recent study on the effects of investment support from RDP measures on Swedish farms, it has been observed that farms receiving support go through a period of adjustment before they see an increase in productivity performance, confirming the presence of time lags between investments and effects that need to be considered to avoid misleading conclusions and policy recommendations (Nilsson and Wixe, 2022[91]) In a study of farms in Central and Eastern European countries, Czubak, Pawłowski and Sadowski (2021[92]) found that investing farms, including those co-financed by CAP investment grants, were much larger than average and were the only farms to experience an improvement in technical efficiency in the study period. At the same time, a study by the Directorate-General for Agriculture and Rural Development concluded that the effectiveness of CAP investment programmes on agricultural productivity in the European Union is hampered by the fact that only 2.5% were expected to receive such support. The programme's effectiveness in generating farm-based growth potential could also be impeded by the lack of integration with business development advice (DG AGRI, 2019[93]).

Another tool used in the EAFRD is financial instruments (FIs). These are EU measures providing financial support in the form of equity or quasi-equity investments, loans or guarantees, or other risk-sharing instruments. FIs may be combined with grants, where appropriate. Loan funds and guarantee funds have been the most common FIs used in the agricultural sector. FIs have been part of EAFRD funding since the 2000-06 programming period, but interest among RDP managing authorities has been growing in recent years (54 RDPs included this option during the CAP 2014-20 period compared to 14 during the 2007-13 period). Nevertheless, FIs' full potential continues to be largely untapped. By June 2017, EUR 460 million of RDP funds were allocated to FIs, barely contributing to overcoming the EUR 7 billion-EUR 19 billion loan financing gap for agricultural small and medium-sized enterprises. This could be attributed to a lack of awareness among managing authorities of the potential of FIs (EC and EIB, 2018[85]).

Young farmers support

The CAP includes several measures that support young farmers, seeking not only generational renewal in the agricultural sector but also increased adoption rates of agricultural innovations. Under the first pillar of the CAP 2014-22, young farmers received a 25% supplement (top-up) to the direct support allocated to their farm for a period of five years as part of the "Young Farmer Scheme", which Member States were obliged to implement. Member States could choose to strengthen the eligibility criteria by defining further requirements (such as adequate training or submission of a business plan). Under the second pillar, young farmers had access to a start-up grant while they could also be granted more favourable access to other

measures, e.g. investment support or extra support for farm advisory services specifically addressing the needs of young farmers.

There is little evidence that these CAP measures helped young farmers set up or improved generational renewal and the viability of the supported holdings. Several studies suggest that the Young Farmer Support under the CAP had little impact on young farmers' decisions on whether to enter farming or not, and it recommended alternative approaches to support young farmers that better address the challenges and barriers to entry, such as targeted agricultural training and education and specific support with access to the land market and credit for investments (Vigani et al., 2017[94]; Coopmans et al., 2021[95]; Coopmans et al., 2020[96]). The start-up programme under Pillar 2 had some positive effects, since it was directed to more qualified farmers who committed to implementing a business plan intended to demonstrate the viability of the business and sped up the transition process for becoming the manager of a farm as well as increasing income from farming and the prospects for farm survival (Nordin and Lovén, 2020[97]).

Overall, current policies have been assessed to be ineffective in supporting the farm transfer process and providing aid during farmers' early career, they do not target the stage preceding farm take-over, during which possible entrants develop a successor identity (Coopmans et al., 2020[96]). In particular, existing CAP payments may deter access to land for young farmers. A report for the European Parliament (Zagata et al., 2017[98]) recommended re-evaluating the direct payment scheme and creating new incentives for older farmers to pass on their farms. It also suggested that supports further focus on additional barriers, such as access to capital, lack of business skills and insufficient succession plans. Additional research suggested that the financial support schemes aimed at encouraging young people to participate in agricultural activities can be offset by other CAP measures, which contribute to increasing land prices, thereby creating a barrier to entry for young farmers (Đurić, Kuzman and Prodanović, 2019[99]). The challenge is to find the right balance between encouraging additional entrants to farming and encouraging a process of structural transformation, which is a necessary step to creating more profitable and attractive professional perspectives in farming (Ryan, 2023[100]).

3.5. From compliance to performance: The ambition of the CAP 2023-27 Reform

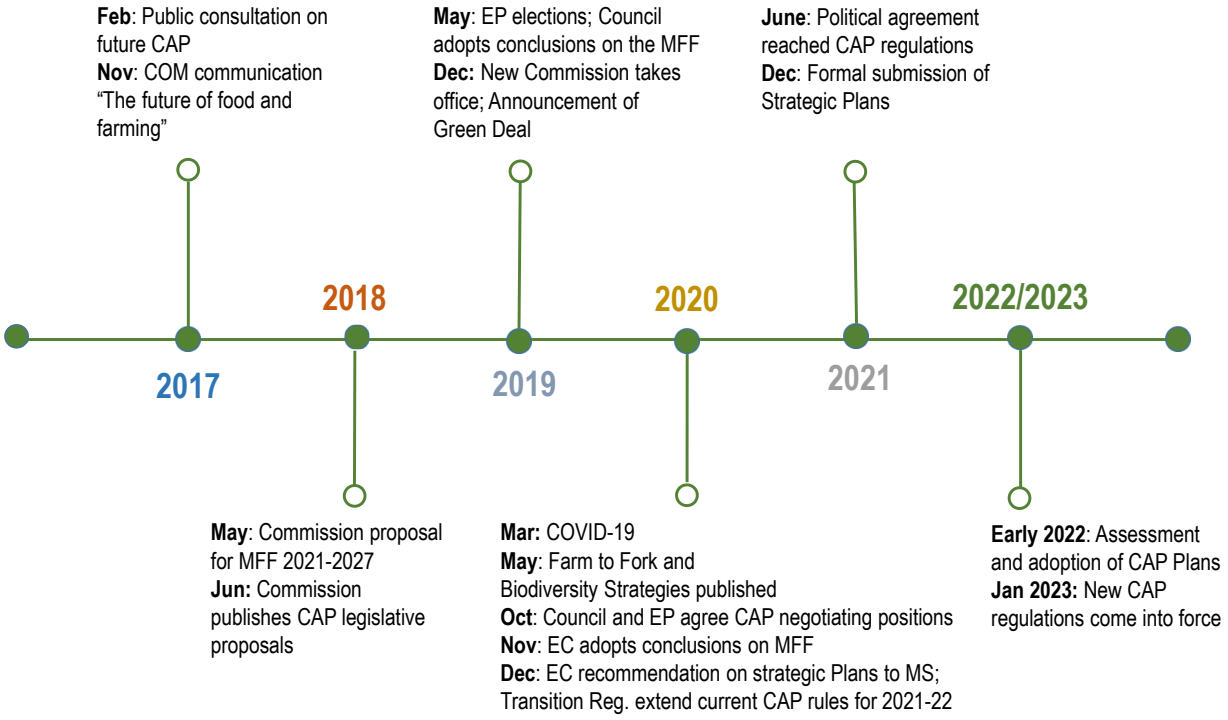
3.5.1. Negotiating the CAP in the context of the European Green Deal

The European Commission presented its proposal for the CAP reform in 2018 in the context of its MFF proposal for the period 2021-27, along with an impact assessment. The key initiatives in the legislative package had previously been flagged in a Communication on the Future of Food and Farming published by the Commission in November 2017 (EC, 2017[41]), which in turn took into account the results of a public consultation on the future CAP earlier in 2017 (Ecorys, 2017[101]). After the presentation of the European Commission's proposals, several factors delayed the progress in the protracted negotiations' key events and dates (Figure 3.8).

The discussions on the future CAP took place in a restrictive budget context, due partly to the departure of the United Kingdom, which was a net contributor to the EU budget, and partly to the growing importance of other priorities that the European Union wished to fund (Matthews, 2018[102]; Matthews, 2020[103]). The Commission's initial MFF proposal put forward in May 2018 would have reduced the budget allocation for the CAP by around 5% in current prices. The MFF negotiations made little progress in resolving divisions between Member States until early 2020. In March 2020, Europe had become the epicentre of a global pandemic caused by the COVID-19 coronavirus. The European Council tasked the Commission to come forward with a proposal for a recovery fund targeted towards the sectors and geographical parts of Europe the most affected. It subsequently tabled an amended MFF proposal together with a proposal for a regulation establishing a recovery instrument (Next Generation EU) for 2021-24 to support recovery in the aftermath of the COVID-19 pandemic. This enabled MFF conclusions to be agreed upon in July 2020,

which slightly raised the CAP budget above the Commission's original proposal, including a contribution from the new recovery instrument to EAFRD funding (Massot, 2021[104]). With the budget agreed upon, both the Council and Parliament quickly reached their first reading negotiating positions on the CAP legislative proposal in October 2020 and the trilogue process could begin.

Figure 3.8. Timeline of the CAP 2023-27 Reform



Notes: CAP: Common Agricultural Policy; MFF: Multiannual Financial Framework; EP: European Parliament; MS: Member States.
Source: Martinos et al. (2022[105]).

Another factor that delayed negotiations was the European Parliament elections held in May 2019, which resulted in a change in political composition. A new College of Commissioners took up office in December 2019 and, in the same month, the Commission published the Communication on the European Green Deal (EC, 2019[35]). The Commission spelt out implications for agriculture in the F2F Strategy in the spring of 2020, which was designed to accelerate the transition to a fair, healthy and more environmentally friendly food system (EC, 2020[37]). It was accompanied by a Biodiversity Strategy that also has implications for agricultural land use (EC, 2020[106]). Agriculture will also be affected by other EU legislative and other initiatives linked to the EGD, notably the European Climate Law (EC, 2020[107]), a new Circular Economy Action Plan (EC, 2020[108]), and the updated EU Bioeconomy Strategy (EC, 2018[109]). These ambitions and the new targets set out in the F2F and Biodiversity Strategies should be integrated into the future CAP, as discussed in Chapter 4.

Table 3.4 shows a selected and non-exhaustive list of targets and initiatives of relevance to agriculture. It also lists the main directorates-general responsible for action to meet these targets. While the Directorate-General for Agriculture and Rural Development (DG AGRI) is responsible for some of the targets and actions, other Directorates-General such as Environment (DG ENVI), Health and Food Safety (DG SANTE) and Climate Action (DG CLIMA also play a major role. The growing influence on agricultural policy of these non-traditional actors is an important driver of change and requires increased attention to co-ordination within the Commission as well as with Member States.

Table 3.4. Main targets and actions relevant to farming in the European Green Deal

Area	Activity	Ambition 2030	Lead Directorate-General
Climate	Total greenhouse gas emissions reduction (European Climate Law)	50-55% emissions reductions compared with 1990 levels[1]	DG CLIMA
	Carbon farming initiative (Farm to Fork [F2F] Strategy)	Regulatory framework to be developed to certify carbon removals	DG AGRI
Water, soil and air quality	Reduce nutrient loss and fertiliser use (F2F Strategy)	Reduce fertiliser use by at least 20% and reduce losses of nitrogen and phosphorus by at least 50%	DG AGRI
Biodiversity	Increase organic farming (Biodiversity Strategy)	At least 25% of agricultural land under organic farming by 2030	DG AGRI
	Restore habitat (Biodiversity Strategy)	At least 10% of agricultural area under high-diversity landscape features	DG ENVI
Health and pollution	Reduce antimicrobial use (F2F Strategy)	Reduce overall EU sales of antimicrobials for farmed animals by 50%	DG SANTE
	Reduce pesticide use and related risks (F2F Strategy)	Reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% by 2030	DG SANTE
Animal welfare	Improve animal welfare standards (F2F Strategy)	Evaluate and revise existing animal welfare legislation	DG SANTE
Resource use	Reduce food waste (Circular Economy and F2F Strategies)	Existing target to halve per capita food waste at retail and consumer levels by 2030. The new proposal will cover food waste along the entire food value chain	DG SANTE and DG AGRI
	Encourage water reuse in agriculture (Circular Economy)	Water Reuse Regulation setting minimum requirements for water reuse in agricultural irrigation will enter into force in June 2023	DG ENVI
	Develop an Integrated Nutrient Management Plan (Circular Economy and F2F Strategies)	Ensure more sustainable application of nutrients and stimulating the markets for recovered nutrients, linked to the objective of reduced chemical fertiliser use	DG ENVI and DG AGRI

Notes: DG AGRI: Directorate-General for Agriculture and Rural Development; DG ENVI: Directorate-General for Environment; DG SANTE: Directorate-General for Health and Food Safety; DG CLIMA: Directorate-General for Climate Action.
1. As shown in Chapter 4, agricultural emissions are only to a very small extent covered in the Fit for 55 proposal.

By definition, a Communication from the European Commission is not itself a legislative or policy proposal and is published when the Commission wishes to set out its position on a topical issue. While certain aspects of the quantitative targets in the F2F Communication have been criticised (Copa-Cogeca, 2020[110]), in particular the realism of the proposal to increase the EU area under organic farming from 9.1% in 2020 (Eurostat, 2022[111]) to 25% by 2030 (Box 3.3) an impact assessment is not required for Communications from the European Commission, and for some targets, legislative proposals are planned. It is once the Commission wishes to make EU legislative proposals that proposals must be accompanied by an impact analysis to allow the environmental, social and economic consequences of specific targets to be assessed.

When the Council and Parliament negotiating mandates were agreed in October 2020, there was considerable push-back from those who argued that they were inadequate to ensure that the CAP would sufficiently contribute to achieving the EGD targets (see, for example, IEEP (2020[112]). The Commission's view was that the CAP legislative package was compatible with the EGD (EC, 2020[113]) while identifying certain aspects of the proposals from the co-legislatures that did not match with the new CAP delivering on the EGD objectives (EC, 2020[114]). The Commission was particularly concerned about proposals that would weaken conditionality relative to what it had proposed, weaken the ring-fencing of Pillar 2

expenditure for climate and the environment, and weaken the effectiveness of the performance monitoring framework.

Following extensive negotiations between the European Parliament, the Council of the European Union and the European Commission, agreement was reached, and the new CAP was formally adopted on 2 December 2021. For 2021 and 2022, a transitional regulation was in place, bridging the gap between the two programming periods. The CAP 2023-27 is built around ten objectives (Chapter 1, Figure 1.2), which are also the basis upon which EU Member States have designed their CAP strategic plans (CSPs). Such objectives are linked to common EU goals for social, economic and environmental sustainability in agriculture and rural areas.

The 2023-27 CAP reform covers three main regulations: one setting out rules for support in CSPs (EU Regulation 2021/2115); one horizontal regulation establishing rules for the financing, management and monitoring of the CAP (EU Regulation 2021/2116); and the third amending the Common Market Organisation Regulation, the rules on quality schemes and aid measures for agriculture in the outermost regions (EU Regulation 2021/2117). The final regulations are not very distant from the Commission's draft CAP legislative proposal of 2018, which was published prior to the more ambitious targets set out in the EGD. The new CAP delivery model for 2023-27 has the potential to be a milestone to ensure that the CAP contributes to the EU's global sustainability goals, but this will ultimately depend on how Member States implement it and the results it will be able to deliver on the ground.

Box 3.3. Organic farming

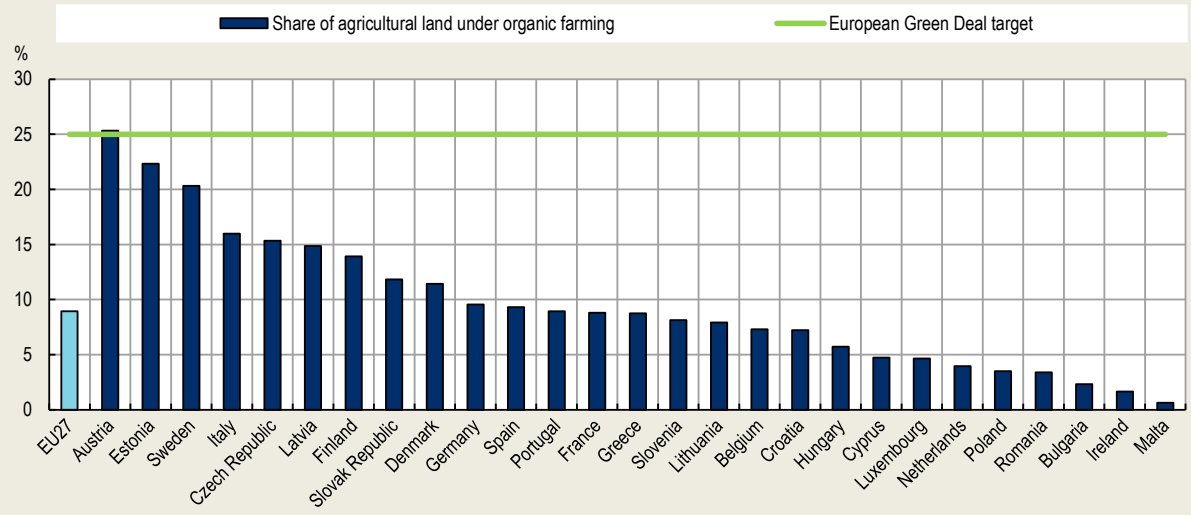
Organic production is an overall system of farm management and food production that contributes to the preservation of natural resources and applies high animal welfare and production standards. Since 1 January 2022, Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 is the applicable legislative act, also known as the basic act, laying down the rules on organic production and labelling of organic products in Europe.

Through the F2F and the Biodiversity Strategies, the European Commission has committed to reaching a target of 25% of the European Union's agricultural land being under organic farming by 2030. This target aims to both improve the sustainability of the food system and reverse biodiversity loss. To meet this target, and help the organics sector reach its full potential, the Commission has set out an Action Plan for the Development of Organic Production (EC, 2021[115]). The action plan is divided into three interlinked axes that reflect the structure of the food supply chain and the EGDs sustainability objectives:

- Axis 1: Stimulate demand and ensure consumer trust
- Axis 2: Stimulate conversion and reinforce the entire value chain
- Axis 3: Organics leading by example – improve the contribution of organic farming to environmental sustainability.

Recent production and market trends show the importance that organics have gained over the last decade in Europe. Agricultural area under organic certification has consistently expanded, reaching around 14.7 million hectares of agricultural land in the European Union in 2020, corresponding to 9.1% of the total utilised agricultural area. This represents a steep rise from the 9.5 million hectares used for organic agricultural production in 2012 (Eurostat, 2022[116]). Nevertheless, there is great variability among countries and only Austria has already reached the 25% target. Most countries are well below the target, with only eight countries, in addition to Austria, with an area cultivated with organic methods above the 10% level (Figure 3.9).

Figure 3.9. Share of land under organic production in the European Union and EU Member States, 2020



Source: Eurostat (2022[117]), accessed July 2022.

3.5.2. The new delivery model

The most paradigmatic change of the CAP 2023-27 is that a great responsibility for the design and implementation of this policy has been transferred to Member States, which were required to present their proposed interventions in the form of CSPs. The Commission's main justification for this New Delivery Model was as follows: "The current CAP delivery system relies on detailed requirements at the European Union level, and features tight controls, penalties and audit arrangements. These rules are often very prescriptive, down to the farm level. In the Union's highly diversified farming and climatic environment, however, neither top-down nor one-size-fits-all approaches are suitable to delivering the desired results and European Union added value" (EC, 2017[41]).

The Commission proposed instead that the European Union set the basic policy parameters (objectives of the CAP, broad types of intervention, basic requirements), while Member States should bear greater responsibility and be more accountable for how they meet the objectives and achieve the agreed targets. This is summarised as a shift in Member States' implementation responsibilities from a compliance-based to a performance-based or results-based CAP. The CAP objectives would include those set out in the Treaty, but also other agreed objectives and targets set in the context of climate policy and the United Nations Sustainable Development Goals. Greater subsidiarity allows Member States and regions in federal states to better take account of local conditions and needs against such objectives and targets. Member States can decide how to tailor CAP interventions to maximise their contribution to EU objectives.

Member States were required to develop CSPs to be able to draw down CAP funding. In developing these plans, Member States analysed their specific situation and needs through a SWOT analysis (Strengths, Weaknesses, Opportunities and Threats), set targets linked to achieving the objectives of the CAP in light of these needs, and designed the interventions which will allow those targets to be reached (EC, 2022[118]). An important innovation is that this programming approach should be applied to interventions under both pillars of the CAP, not only to rural development interventions as was the case previously. There is one CSP for each Member State (except for Wallonia and Flanders in Belgium) for a total of 28 plans. This compares to 118 rural development plans in 2014-20 that included regional plans in several countries (e.g. France, Germany, Italy and Spain).

The process started in 2021 with the preparation of the CSPs by Member States. Ultimate responsibility for drafting the plan rests with the relevant ministry, usually the Ministry for Agriculture. An important innovation in the process is that relevant non-CAP measures, including related national interventions, should be described in the intervention strategy to give a complete picture of how the targets should be achieved.

The plans were developed in partnership with the relevant authorities at the regional and local levels; economic and social partners, including representatives of the agricultural sector; as well as relevant bodies representing civil society and, where relevant, bodies responsible for promoting social inclusion, fundamental rights, gender equality and non-discrimination. Specific rules were laid down for how this partnership process should operate, including a requirement for widespread consultation. While it is not within the scope of this review to evaluate the extent to which these procedural requirements were met in practice, a preliminary overview of the CSP is available (EC, 2022[118]).

The achievement of the ten specific objectives of the CAP 2023-27 is strongly dependent on the quality of CSPs that Member State administrations were able to prepare, with technical assistance provided by the Commission, and their capacity to implement and monitor the programmes at the farm level. Ministry officials may require a new mindset, skills and capacities, as well as the institutional capacity to undertake the required strategic planning.

The key governance challenge of the New Delivery Model is to ensure that the incentives and targets at the Member State level are also well designed and transmitted at the farm level. Only with actual changes in farming practices will these efforts sum up to the required changes at the EU level. As shown in the next section, this will depend on several factors, including the governance structures put in place by the legislation as well as the effective improvement of monitoring and evaluation systems, including the availability of data.

3.5.3. Achieving sustainability targets

A new role for Member States to achieve environmental targets and social sustainability

The new CAP aims at a higher level of environmental and climate ambition and, since the publication of the EGD, it is also expected to help achieve the targets set out in the F2F, Biodiversity and other relevant strategies in the climate and energy domains. The CAP 2023-27 contains a revised “green architecture” with instruments that Member States can use to achieve their sustainability goals (Chapter 4), and puts a greater emphasis on the importance of innovation (Chapter 5).

Over time, the environmental sustainability elements have been increasingly accompanied by social sustainability considerations and an increased emphasis was placed on employment, gender equality, social inclusion and local development in rural areas. For the first time, CAP payments will be linked to compliance with certain European labour law provisions under the new social conditionality mechanism (Box 3.4). While these new provisions on highly socially resonant elements, such as the working conditions of migrant workers, represent an important innovation for the CAP (Erjavec and Erjavec, 2021[119]), some of the shortcomings observed for the environmental conditionality (Chapter 4) – linked to the difficulties to enforce rules and monitor results – could also apply to this new mechanism.

Box 3.4. Social conditionality

Future Common Agricultural Policy (CAP) payments will be linked to compliance with certain European labour law provisions. In particular, payment beneficiaries can be subject to an administrative penalty if they do not comply with the requirements related to applicable working and employment conditions or employer obligations arising from legal acts referred to in the regulation (concerning transparency and predictable working conditions and health and safety conditions at work). Because of the complexity of setting up systems at the national level which respect the autonomy and specificity of national systems, Member States are allowed to delay the implementation of social conditionality, but they will have to implement it by 1 January 2025.

The new mechanism will cover directives on:

- Transparent and predictable employment conditions: farm workers must be informed of employment conditions in writing, regardless of the hours worked. This includes place and type of work; beginning and, where relevant, end of employment; information on probation period; paid leave; notice periods; remuneration; work pattern/schedule; and social security information.
- On-farm safety and health: employers must ensure the safety and protection of farm workers with regard to farm machinery and equipment, protective clothing and equipment, or dangerous substances.

Social conditionality will operate differently than the other conditionality elements. Paying agencies have no role in ensuring that social conditionality rules are enforced. They will receive annual information about the outcome of controls; administrative and legal procedures from the competent enforcement authority; and information on the breach, its severity and extent. The paying agency will then interpret what that information means for the administrative penalty to be applied to the farmer.

Labour organisation on farms is changing rapidly and this brings new challenges. Introducing social conditionality implies that farm advisory services must provide information to farmers on working conditions and on information to be provided to workers (Laurent and Nguyen, 2022[120]), and that Member States have the opportunity to promote the improvement of working and employment conditions as part of their sectoral interventions.

The feasibility of including provisions for the free movement of workers will be assessed by 2025. As the social conditionality mechanism is being created for the first time, an evaluation of its functioning by the European Commission is foreseen after two years of implementation to see whether possible adjustments are necessary.

Additionally, CSPs will support farmers to improve working conditions on farms through the farm advisory system and under interventions in the different sectoral programmes.

Given that when the CSPs were approved before a decision has been taken on whether to include relevant targets for agriculture in the F2F, the Biodiversity Strategy and the Climate Law, and that there is no EU-wide legally required reduction in agricultural emissions, the level of ambition to date is determined by the targets that Member States included in their CSPs.

The New Delivery Model introduces a significant change in the governance of the CAP. The use of CAP funds in Member States is no longer primarily evaluated on the basis of whether paying agencies and managing authorities have complied with detailed legislative rules. Instead, the focus is on setting targets based on a needs assessment against the ten CAP objectives and, based on an intervention logic, deploying interventions and allocated CAP resources to achieving those targets. Evaluation of the use of CAP funds will be based on how well countries achieve the targets they set for themselves.

In December 2020, the Commission issued recommendations to each Member State as part of its structured dialogue in the preparation of their plans. These identified specific priorities that the Commission felt should be addressed in their plans. The recommendations also covered the environmental and climate objectives addressed in the EGD. The Commission asked Member States to determine specific national values for six F2F and Biodiversity Strategy targets and to align their strategic plans with these targets. A requirement for a target for reductions in agricultural GHG emissions was not included (EC, 2020[121]).

The European Commission's approval process involved external and internal validation. For the external validation, the Commission is required to assess "its completeness, its consistency and coherence" with the CAP Regulations and EU law. It should also assess its effective contribution to achieving the CAP's nine specific and one cross-cutting objective, its impact on the functioning of the internal market and any potential distortions of competition, and its level of administrative burden on beneficiaries and the administration. The internal validation assesses the adequacy of the plan's strategy and whether the corresponding specific objectives, targets, interventions and the allocation of budgetary resources meet the specific plan's objectives through the proposed set of interventions based on the SWOT analysis and the *ex ante* evaluation.

The challenge of monitoring and evaluating policy impacts

Under previous CAPs, most payments to EU farmers have not been performance-based, and farmers have not been paid for achieving performance targets (Lankoski, 2016[122]). The new CAP 2023-27 has adopted a common practice of assessing the achievement of performance targets on the basis of a set of common indicators. The quality of monitoring and evaluation is very dependent on the quality of the indicators chosen (Wieck and Hausmann, 2019[123]) and may depend on how closely indicators are linked to objectives and on the reliability and robustness of the data behind the indicators.

When drafting their CSPs, Member States have been required to demonstrate the alignment with and appropriateness of the choices made to EU priorities and objectives. In line with the performance-based intervention strategy structured around the specific objectives of the CAP, the CSPs also include quantified targets and milestones for relevant result indicators in relation to those objectives.

Plan approval is one element of governance. Monitoring progress and adjusting strategies in light of outcomes is equally important. The Commission's legislative proposal recognised that a shift towards a more performance-oriented policy required the establishment of a more solid performance framework that would allow the Commission to assess and monitor the performance of the policy based on a set of common indicators. The legislation introduced a new Performance Monitoring and Evaluation Framework that covers all instruments of the future CAP. Performance is measured in relation to the specific objectives of the policy using a set of common indicators. Member States will provide an annual performance report to the Commission on the implementation of the CSP in the previous financial year by reference to financial data and output and result indicators (Article 134, EU Regulation 2021/2115).

According to the legislation, the plan's targets will be set for result indicators, but not necessarily in terms of impacts (although the Commission has requested national values for six impact indicators related to the EGD). A result indicator measures, for example, the share of agricultural area under management contracts to sequester soil carbon, but not necessarily the amount of carbon that will be sequestered because of these actions (ECA, 2018[124]). A lack of appropriate impact indicators – and therefore of quantified targets – may then undermine the capacity of current models to assess the environmental performance of farming and, above all, the full spectrum of the environmental impacts of the CAP (Guyomard et al., 2020[125]). Impact indicators are also very important for *ex ante* modelling to support policy planning, particularly considering the wide range of policy options Member States dispose of in the CAP 2023-27 (Petsakos et al., 2022[32]). Even though it has been observed that the majority of result indicators rather reflect outputs and that several "impact indicators" do not address impacts (IEEP, 2019[126]), cost and feasibility considerations also need to be taken into account.

In September 2022, the Commission adopted EU Regulation 2022/1475, providing a common framework for monitoring and evaluating the CAP achievements. The new evaluation framework builds on existing experience and provides a common understanding of key concepts and elements for monitoring and evaluating the implementation of CSPs. When evaluating their CSPs, Member States are expected to assess their factors of success, for example the decrease of greenhouse gas emissions in agriculture, the stability or increase of the agricultural income, the improvement of nutrient balance on agricultural land, or the growth of rural businesses. In the framework of the Annual Performance Report, Member States will share with the Commission aggregated data at the national level, offering an overview of the level of implementation of CSPs at the national level.

Farm-level data are gaining importance with agricultural policy shifting away from market interventions and direct payments to farmers requiring more precise and efficient measures. They are a prerequisite for carrying out policy impact assessment and are necessary to gain insights into drivers of farms' performance. However, obtaining access to individual data and cross-country analysis is challenging due to confidentiality requirements and the lack of cross-country harmonisation of definitions. In 2008, the OECD established the Farm-Level Analysis Network (FLAN) with the aim of "improving the quality and relevance of policy analysis applied to the agricultural sector through the use of micro-level data" (Box 3.5).

In the European Union, the range of farm-level data currently available limits which indicators can be developed and the capacity to design outcome based eco-schemes that are known to be more effective (OECD, 2022[127]). Together with the indicators of environmental sustainability and innovative practices that promote more efficient use of natural resources and the resilience of farmers, the social sustainability of farms is one of the dimensions that needs the most development of indicators in the future (Latruffe et al., 2016[128]). Disaggregated data per beneficiary and intervention will help these efforts, but will only be available in 2025, reflecting data for 2023 and 2024 (EC, 2022[129]).

Box 3.5. Drivers of farm performance: Conclusions from the OECD Farm-Level Analysis Network

The OECD Farm-Level Analysis Network (FLAN) brings together experts in the field representing both agricultural economics research institutes and government bodies. It provides its members with a platform to share experiences using micro-level data, draw attention to emerging policy issues and raise awareness for the need for improved data at farm level. FLAN activities enrich OECD agricultural policy analysis by using micro-level data and expertise, which has resulted in number of analytical projects and publications, including on drivers of productivity, sustainability and resilience on the farm level described below.

In "Dynamics of farm performance and policy impacts", Sauer et al. (2021[88]) used case studies from seven countries, six of which are European, to evaluate farm performance based on an analysis of farm-level data. They concluded that the development of the gap in productivity growth between high- and low-performing crop farms differs between countries. While the most productive farms in Australia have widened the gap to the worst performers, the opposite applies in many European countries, where the gap has decreased. In the case of dairy farms, a widening gap between the most productive and least productive farms was shown in all analysed countries. To provide further policy insights, a counterfactual analysis was conducted. While France implemented the single farm payment scheme making use of the maximum possible share of payments as coupled (25%), the United Kingdom decoupled the payments entirely (only Scotland maintained partial decoupling). The results showed that complete decoupling had a positive effect on farm productivity performance, hence English farms displayed stronger productivity increases than French farms.

In "Drivers of farm performance", Sauer and Moreddu (2020[130]) looked at drivers of environmental sustainability and productivity performance of farms through empirical country case studies. The analysis suggests mixed results: while the gap in the productivity performance between low- and

high-productivity performers is widening in some countries, it is narrowing in others. Looking into the links between environmental sustainability and productivity, the authors conclude that trade-offs and synergies depend on the type of farming. For instance, dairy, pig and poultry farms show a negative relationship between sustainability and productivity, while crop farms benefit from strong synergies. The authors identify innovation and technical change as key drivers of farm productivity and environmental sustainability. The innovation-cooperation-commercialisation index was used to reflect purchases of new technologies and engagement in new activities, among others. This index was shown to have particularly strong positive effects on productivity in a variety of production types. For practical design and implementation of policies, more country-specific, in-depth analyses would be needed.

Source: OECD (2023[131]).

The need for data and evidence

To design, monitor and evaluate the CAP, the Commission receives and processes a large volume of data. Consolidated data are published on the Agri-food Portal (EC, 2022[132]), which offers information from many data sets, including Eurostat agricultural statistics, through interactive visualisation and dashboards. In line with its Data Policy (Chapter 2, Section 2.3.5), the Commission is expanding data sources and encouraging data sharing to tackle data gaps, also by improving data infrastructure and data used for the CAP. Nevertheless, several barriers exist and are related to different stages of the data collection and analysis cycle.

Calls have been made for the Commission to make better use of data and data analytics for the CAP. Although there is an increasingly more effective use of data, in some areas, current data and tools do not sufficiently deliver elements of information that are needed for well-informed policy making (ECA, 2022[133]). One of the main barriers is related to data availability, especially on farm income, farming inputs and farming practices.

Concerning the measurement of farm income, the available statistical tools – namely the Economic Accounts for Agriculture and the Farm Accountancy Data Network (FADN) – seem inadequate for several reasons already identified by the European Court of Auditors (ECA, 2016[134]). First, there are no representative data available on the disposable income of farm households, which would facilitate assessing the achievement of the Treaty's objective of ensuring a fair standard of living for farmers. Only a few Member States, for example Ireland and the Netherlands, have started gathering farm household income data. Yet, the approaches vary widely and do not allow comparisons across countries. Second, there is no reliable system to allow comparisons between agricultural incomes and those in other sectors of the economy, which could justify EU income support for farmers. Finally, the Economic Accounts for Agriculture and the FADN do not fully account for other farm-related income of farmers beyond primary agriculture.

With regard to sustainability indicators, information available may be of low quality and high uncertainty and the information included in existing databases, like the FADN, has not allowed a coherent and inclusive set of impact indicators to be developed. To address this limitation, the Commission has proposed in the framework of the F2F Strategy to enlarge the scope of the FADN, which hitherto has focused on financial and production information, to also include information on sustainability indicators in a new Farm Sustainability Data Network (EC, 2022[135]). This could help produce more robust data, although some limitations still persist and the timeline for its implementation may impede its systematic use in the 2023-27 programming period.

Looking at farmers as the data suppliers, one major point arises. The increasing degrees of conditionality for payments to farmers are accompanied by the need for data to monitor progress and results. The farm-level data crucial to these efforts need to be transferred from the farm to other relevant parties. While trust issues and costs associated with data collection have been discussed, the inherent value of the data itself

is not reflected in the Commission's efforts to attain them. Payment schemes currently do not address the absence of incentives for farmers to hand over the data generated on the farm.

As for the accessibility of data, the Commission has limited access to Member States' Integrated Administration and Control System (IACS),[11] which is the main building block of the management of CAP payments in Member States. The IACS' decentralised approach limits the integration and crosslinks with other Commission data sources (EC, 2022[132]). However, DG AGRI has recently undertaken steps to improve the integration of the IACS, for instance, through enhanced sharing of spatial data via the INSPIRE geoportal (EC, 2021[136]). A key component of the IACS is the spatial identification of agricultural parcels, for which purpose Land Parcel Identification Systems (LPIS) have emerged. Member States were forced to establish a corresponding system as a part of the 2003 CAP reform. While land parcel identification systems have become an important tool in supporting farmers' subsidy applications through the IACS, methodologies vary widely between Member States, hindering data accessibility (EEA, 2015[137]).

Regulatory obstacles further exacerbate data accessibility issues. On the one hand, the General Data Protection Regulation seems to induce rising concerns over confidentiality infringements and hinders Member States' efforts in supplying data to the European Commission. On the other hand, some Member states have "gold-plated"[12] data regulations such as the General Data Protection Regulation, making it increasingly difficult to comply with the added restrictions imposed on data-responsible entities.

Moreover, it has been pointed out that the aggregation of data may limit the potential for the data to be reused for policy design or policy assessment purposes (ECA, 2022[133]). Especially for socio-economic aspects, there is often not an adequate disaggregation and some data (e.g. on age or gender of CAP beneficiaries) are available only at Member State level and not accessible to the Commission (Eurostat, 2011[138]; ADE, 2020[22]).

Finally, a more effective combination of data sources is one of the main data challenges that needs to be addressed to ensure there are appropriate data to evaluate the CAP. The lack of common references, such as a unique identifier, makes it difficult to combine farm-level data from different data sources for CAP analysis. The IACS, which manages and controls CAP payments to farmers, collects information on compliance with farming and conservation practices that are often the basis for the payments. This information overlaps with data needs addressed in the transition from the FADN to the FSDN (Box 3.6) and offers a cost-effective opportunity for increasing data availability (Rega, 2022[139]).

Box 3.6. Conversion of the Farm Accountancy Data Network to the Farm Sustainability Data Network

The Farm Accountancy Data Network (FADN) is the most important information source for understanding the impact of the measures taken under the Common Agricultural Policy (CAP). The FADN is a unique source of microeconomic and accountancy data collected from more than 80 000 farms in the European Union every year. Data are collected through national surveys and are harmonised through bookkeeping principles to provide a comprehensive source of microeconomic data. The collected data have allowed for estimations of income trends and enabled assessments of the financial situation of farms since the network's inception in 1965.

However, the available data do not cover all data needs, and the FADN has been found to have limitations: farm-level data on farming and conservation practices have so far not been collected (Rega, 2022[139]). Reflecting the CAP's evolution towards more environmental and social policies, the European Commission has proposed a process of converting the FADN to the Farm Sustainability Data Network (FSDN) (EC, 2022[135]). The FSDN's objectives are to improve policy analysis along the environmental and social sustainability dimensions and provide feedback and advice to farmers. For this purpose, the FSDN introduces new environmental and social variables to its data collection. The FSDN also plans

to use a farm ID, which could help link this data set to other farm-level data sources, such as the Integrated Farm Statistics.

The Farm Level Indicators for New Topics in policy evaluation (FLINT) project has demonstrated the increase in public value of the FADN data set when data on the sustainability performance of farms are included, but it also highlighted several challenges for the practical implementation of this transition in relation to the availability, collection and management of data.

Vrolijk and Poppe (2021[140]) estimated that collecting the sustainability data from all farms included in the FADN would increase costs by about 40%. While a reduction in the overall number of surveyed farms could reduce costs, there are several drawbacks in reducing the sample size and associated issues. This and other concerns over a transition from the FADN towards the FSDN should, however, not impair the ability of the network to provide a better understanding of the sources of sustainability performance, in order to overcome the lack of adequate data that imposes limitations on the evaluation of the CAP's performance.

Building upon the FLINT work, a pilot project conducted by a consortium including several organisations and experts assessed the relevance and feasibility of 85 variables on environmental (35 variables), social (39) and economic sustainability (11). The basic legislative act for establishing the FSDN is projected to enter into force in 2023, with the secondary legislation foreseen to be finalised in 2023 or 2024.

The first FSDN data set will reflect 2025 data and will be publicly available in 2026 or 2027 (EC, 2022[141]). Therefore, information on farmers' performance will only be available towards the end of the new CAP and not be synchronised with the needs of the current CAP period. The added variables should cover considerable amounts of previously identified gaps in the data. For instance, the pilot project collected data on the share of farming income on household income. It should, however, be noted that the consortium concluded that collection feasibility for this variable is only moderate and that the variables for which a collection feasibility has been determined will not necessarily be the new variables added to the FSDN (Ecorys, 2022[142]).

3.6. Future policy pathways

The possible future pathway of the CAP will be determined by the complex interaction between different stakeholders and factors in the European Union's institutional decision-making process. This includes the timing of European elections and the MFF, the need for greater co-ordination among Member States, the structure of the new Commission, the balance between sustainability and productivity priorities in a changing international scenario, the external dimensions of the EGD and the upcoming Sustainable Food Systems Framework legislation, as well as other EU priorities.

The CAP 2023-27 entered into force on 1 January 2023. The next MFF programming period will begin in 2028. If the customary timeline were followed, the European Council would have an initial discussion on priorities and ask the Commission to forward its proposal for the next MFF sometime in 2025. There will be elections to the European Parliament in May 2024 and a new Commission will take up office on 1 December 2024. Given the evidence of growing political mobilisation around food and agricultural issues both at European Union and national levels, the new Commission may take office with specific commitments around future agricultural policy.

For the next CAP iteration, the tight timing and institutional context will make it even more difficult to present a Commission vision on the next CAP strategy prior to the publication of the MFF proposal. Thus, the amount allocated to the CAP in the next MFF proposal may be subject to even more political negotiation before any decision is taken on its content. The key debates on the shape of the next CAP legislation will

most likely take place after the allocation of the CAP budget in the same way that has been decided since the European Parliament co-decision on the CAP has been introduced.

The CAP has always had to strike a balance between accommodating asymmetries in its design while preserving the single market. Examples include differing price levels during the period of monetary compensatory amounts, differing unit values for direct payments (Section 3.4.1), differing interpretations and implementation of cross-compliance and greening requirements (as outlined in Chapter 4), and differing access to Pillar 2 funds. The risk is that the new delivery model could further exacerbate these differences, leading to fragmentation and renationalisation as Member States take advantage of the flexibility to design their own agricultural policies (European Parliament, 2018[143]). A particular source for concern is the potential for differences in environmental standards, given the greater importance given to higher environmental and climate ambitions in the CAP 2023-27.

The post-2027 CAP design will also be influenced by the continuity – or not – of the structure of the European Commission introduced in 2019-24, with an Executive Vice-President responsible for co-ordinating the implementation of the EGD across several directorates-general. This structure encourages a broader perspective on agricultural policy making than might occur through a more horizontal assignment of competences across directorates-general (Table 3.4) and could also be important in determining the balance of priorities in the next CAP.[13]

The specific policy context in which the post-2027 CAP will be formulated cannot be known with certainty. Nonetheless, it seems likely that the consequences of Russia's war of aggression against Ukraine – the dependence of European agriculture on imported energy, fertiliser and animal feedstuffs – will continue to be salient in the coming period. Consequently, the need to strike a balance between productivity and sustainability (sustainable productivity), as well as to strengthen resilience to greater global market volatility may remain prominent in the future agenda. Furthermore, the growing ambition of EU climate policy may be reflected in the European Union's update of its Nationally Determined Contribution in the 2025 Global Stocktake under the Paris Agreement. This will put an additional focus on the future role of livestock, which by far makes the largest contribution to EU agricultural emissions, and its role in diets and in the sustainable productivity balance.

The need to address the climate and biodiversity crises debate will also be influenced by the impact of the legislative initiatives announced by the Commission to reduce the use of chemical pesticides, protect nature and reduce agricultural emissions (Chapter 4). The debate on the sustainability of the European Union's agricultural production is likely to also be shaped around the need to ensure greater coherence between sustainability demands on European farmers and trade policy, to avoid domestic production from simply being offshored, thus displacing environmental damage to third countries (Fuchs, Brown and Rounsevell, 2020[144]). The external dimension of the EGD is likely to pose challenges, both inside the European Union and with its trading partners.

Finally, as outlined in Chapter 2, an important piece of legislation will be the Sustainable Food Systems Framework initiative announced in the F2F Strategy. This horizontal framework law aims to establish new foundations for future food policies by introducing sustainability objectives and principles on the basis of an integrated food system approach (EC, 2021[145]). The Commission's view is that (environmental) sustainability is already established as a guiding principle in sectoral policies such as the CAP or the Common Fisheries Policy, but this is not the case for the food system as a whole, where the General Food Law focuses principally on protecting human health and consumers' interests in relation to food. The proposed legislation, subject to the EU decision making process, would create harmonised rules applicable in Member States to ensure the sustainability of food and food systems. Inevitably, additional sustainability demands and objectives for the food system and food consumption will feed back into the demand for farm produce. Even in the absence of direct legislative interventions affecting primary agriculture, these demands transmitted through the food chain will have an impact on future food production. The post-2027 CAP will be designed within the context of this framework.

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Notes

[1] Market price support is defined as the "annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, arising from policy measures that create a gap between domestic market prices and border prices of a specific agricultural commodity, measured at the farm gate level" (OECD, 2016[146]). It is calculated for individual commodities, as the gap between the domestic price paid to producers and the equivalent price at the border (market price differential), multiplied by the quantity produced, and aggregated to the national level.

[2] GSP utilisation rates are calculated as the share of GSP-received imports in GSP-covered imports.

[3] In the policy debate these instances are commonly described with the term "mirror clauses".

[4] Regulation (EU) No. 2019/6 of the European Parliament and of the Council of 11 December 2018.

[5] See also discussions in Gruère et al. (2023[38]).

[6] The current OECD Producer Support Estimate database calculates support for the whole European Union, not at Member State level.

[7] Green harvesting refers to the complete collection of non-marketable products carried out prior to the beginning of the normal harvesting date.

[8] Non-harvesting refers to the non-harvest or collection of the product on a particular date throughout the normal production cycle.

[9] The discussion in this section refers to the traditional way of looking at economic productivity and does not consider the environmental dimension associated to the broader concept of sustainable productivity growth (Bureau and Antón, 2022[147]).

[10] Measure 4 of the RDP 2014-20 provides support for investment in physical assets and comprises four sub-measures. Sub-measure 4.1 aims at supporting the overall performance and sustainability of an agricultural holding.

[11] Member States' IACS oversee the standardised administration of all income support schemes for farmers and certain rural development schemes as long as support is granted based on number of hectares or animals held. The IACS draws on a number of interconnected databases in order to, among others, manage irregularities and support farmers in their applications to programmes.

[12] The process of gold-plating describes the national implementation of obligations derived from EU laws that exceeds the requirements imposed by the European Union.

[13] A potentially important piece of legislation influencing the post-2027 CAP will be the Sustainable Food Systems Framework initiative (Chapter 2, Section 2.3.6).

4 Environmental sustainability

This chapter examines the broad range of EU environmental regulations and directives affecting the farming sector, as well as all the CAP instruments falling in the agri-environmental domain. The assessment of the main EU legislation and policy implemented until 2022 highlights the presence of a gap between the ambition of policy objectives and the results of their implementation. The new CAP 2023-27 embodies changes that address some of the shortcomings observed in past cycles. Similarly, important pieces of legislation that have been recently proposed have a stronger focus on objectives and reporting results and could be an opportunity to improve the effectiveness of policies and to simplify administrative requirements around programme delivery.

Key messages

- The European Union (EU) has applied a broad set of regulations and incentives to improve the environmental sustainability of agriculture in the European Union, with different ambitions and mixed results.
- The Effort Sharing Regulation (ESR) governs non-CO_2 emissions linked to agricultural activities. Agriculture is the third-largest source of emissions in ESR sectors but contributed only 1% of the emissions reduction effort; EU Member States are not projecting significant emissions reductions in the agricultural sector by 2030.
- The 2000 Water Framework Directive has not achieved its original objective of restoring all surface and water bodies to good status by 2015; doing so by 2027 remains challenging.
- The Nitrate Directive has been in place for over 30 years, but nitrogen surpluses from agriculture are still a problem affecting surface and groundwater quality.
- The 2009 Sustainable Use of Pesticides Directive (SUD) provides Member States with many tools for reducing the risks of pesticide use. However, imprecise targets and poor monitoring have made it difficult to assess its benefits. The new proposed Sustainable Use of Plant Protection Products Regulation addresses some of the shortcomings of the SUD and provides a stronger connection to the European Green Deal's (EGD) targets on pesticide use.
- The Birds and Habitats Directives have played a major role in nature and biodiversity protection in the European Union, but the targets are not strongly enforced. The proposed Nature Restoration Law brings the objectives of these directives into the modern era, with more quantified targets, stronger obligations on Member States, and a more integrated connection with EU environmental policy and the EGD.
- Environmental objectives have been progressively included in the Common Agricultural Policy (CAP) since the 1992 MacSharry Reform, including both voluntary and compulsory environmental compliance for farmers.
- Cross-compliance can potentially have a positive impact on the environment by encouraging the development of more sustainable agricultural practices, but evaluation of the measure is incomplete and the inspection rate and penalties are low.
- Agri-environmental schemes (AES) are targeted measures to encourage environmental practices that provide significant beneficial outcomes, but their effectiveness depends on voluntary participation, suitable monitoring and sufficient funding. Result-based and collective AES hold promise but are not yet widely diffused.
- The new CAP 2023-27 embodies many changes that address the shortcomings observed in past CAP cycles. A stronger focus on objectives and reporting results can be an opportunity to simplify administrative requirements around programme delivery.

This chapter looks at EU policy that has been in place to date with respect to the sustainability of production, conservation of resources and production of ecosystem services. The major arms of EU policy in this agri-environmental domain are the many directives aimed at or strongly affecting the sector, cross-compliance, the greening elements of Pillar 1 of the CAP and AES in Pillar 2. Section 4.1 provides a short overview of the recent development of EU regulations and policies. Section 4.2 deals with environmental regulations and directives, beginning with climate change policies and covering the Water Framework Directive, Nitrates Directive, Sustainable use of Pesticides Directive, and Birds and Habitats Directives. Section 4.3 covers those CAP measures having to do with environmental sustainability, in particular cross-compliance, green direct payments, AES and eco-schemes.

4.1. The EU legislative and policy landscape is evolving

Recognising persistent environmental and climate challenges at European and global scales, European environmental and climate policy making is increasingly driven by long-term sustainability goals (EEA, 2019[1]). While progress has been made in many respects, much remains to be done to achieve the European Union's long-term vision to 2050 of living well, within planetary boundaries.

Farmers have a vital role in preserving, managing and enhancing biodiversity in the 39% of the EU area in agricultural land use. At the same time, certain agricultural practices are a key driver of biodiversity decline. Nature regulates the climate, and nature-based solutions, such as protecting and restoring wetlands, peatlands, and coastal ecosystems or sustainably managing forests, grasslands and soils, will be essential for reducing emissions and adapting to climate change.

Agricultural activities are important factors in achieving policy objectives across a range of areas. These include the objectives of the EU nature legislation and the EU and global Biodiversity Strategies for 2030. The United Nations Biodiversity Conference (COP15), on 19 December 2022, ended with the agreement called "Kunming-Montreal Global Biodiversity Framework" (CBD, 2022[2]).[1] Additional environmental objectives relevant for agricultural activities are related to air pollution (National Emission Ceilings Directive), greenhouse gas (GHG) emissions (Effort Sharing Regulation and the LULUCF Regulation on Land Use, Land-use Change and Forestry) and water quality (Water Framework Directive and Nitrates Directive). Agriculture also has a key role to play in achieving the Sustainable Development Goals (SDGs), particularly SDG 2 – Zero Hunger, and for Europe, SDG 12 – Responsible Production and Consumption (EEA, 2019[1]). The Farm to Fork (F2F) Strategy, part of the EGD, has sustainable production and consumption of food as part of its six targets. See Chapter 2 (Section 2.3.6) for a discussion of the main food system initiatives where legislation is foreseen.

Over the last two decades, EU agriculture continued its evolution towards fewer and larger, more intensive production units (Chapter 2) and achieving environmental targets has been a challenge, particularly concerning improving biodiversity on agricultural land (Chapter 1). Early gains in water, soil and air emissions have been followed by relatively slow progress, which has pushed the attainment of objectives, such as expressed in the main EU environmental regulations. A substantial body of existing legislation governs how the agricultural sector interacts with its environment. Progress under the objectives set by each has been mixed, with substantial progress in some areas but generally less than the initial targets. Biodiversity, in particular, has been challenging, while objectives for water quality improvements are also taking longer than expected. In response, a number of new initiatives have been put in place.

The "implementation gap" between ambition and action is one reason progress has been slow. Flexibility mechanisms designed to help bring about agreement in the sometimes-challenging negotiations process and to reflect the different situations in Member States have weakened efforts as farmers and Member States choose approaches that are less costly and easier to implement but offer limited improvements to sustainability. Better reporting on progress has become an effective tool to balance flexibility with achieving

ambitious targets, as it provides an incentive to take meaningful action. This is expected to take on a more important role as objectives are made more specific so that progress can be better evaluated.

This implementation gap has many causes, and systematically assessing and addressing these can improve the effectiveness of EU policy. Action is being taken on a number of fronts to improve the design and application of programmes, use objectives and targets to drive progress, and make better use of data and analysis to increase transparency and refine policy design. Many of these actions are described in this chapter.

The European Union has recently established its 8th Environmental Action Programme (EAP), which reiterates the long-term vision to 2050 of living well within planetary boundaries. It sets priority objectives for 2030 and the conditions needed to achieve these. Building on the EGD, the action programme aims to speed up the transition to a climate-neutral, resource-efficient economy, recognising that human well-being and prosperity depend on healthy ecosystems. The EAP identifies the enabling conditions needed to achieve the priority objectives. Among these is the need for full implementation of existing legislation.

In July 2021, the European Union adopted a Climate Law that increases the ambition for GHG emissions reductions in 2030 from 40% to net 55% compared to 1990 levels. Legislative proposals for a revised Effort Sharing Directive and a revised LULUCF Directive are under negotiation.

As highlighted in Chapter 1, the EU Biodiversity Strategy for 2030 is also part of the EGD. It aims to put Europe's biodiversity on the path to recovery by 2030 by addressing the main drivers of biodiversity loss, putting in place an enhanced governance framework, and filling any policy gaps while at the same time consolidating existing efforts and ensuring the full implementation of existing EU legislation. It proposes setting legally binding EU restoration targets and restoring significant areas of degraded and carbon-rich ecosystems by 2030 (Box 4.1).

To support the long-term sustainability of both nature and farming and to operationalise the objectives of the F2F and Biodiversity Strategies, the CAP 2023-27 includes a new "green architecture" with higher environmental requirements in cross-compliance ("enhanced conditionality") and the introduction of eco-schemes in the first pillar. Eco-schemes aimed at climate, environment and animal welfare reward farmers who manage land in a nature- and climate-friendly way. The CAP Regulation requires each eco-scheme to cover at least two areas of action for the climate (mitigation and adaptation), the environment (protection or improvement of water quality, reduction of pressures on water resources, prevention of soil degradation, soil restoration, improvement of soil fertility and nutrition management, protection of biodiversity, conservation, restoration of habitats or species, reduced or sustainable use of pesticides), animal welfare and anti-microbial resistance. As discussed in Chapter 3, the new CAP also includes a new delivery model, granting more flexibility to Member States, requiring them to develop CAP strategic plans (CSPs) and delineating how they will set and implement targets.

For the new funding period, ring-fencing rules on spending have also been introduced: 40% of the CAP budget should be climate-relevant, with at least 25% of the budget in the Pillar 1 allocated to eco-schemes and at least 35% of funds in the Pillar 2 allocated to measures supporting climate, biodiversity, environment and animal welfare.

Sections 4.2 and 4.3, together with the assessment of the main EU legislation and policy implemented until 2022, also provide an overview of the most important pieces of legislation that have been proposed recently (e.g. the proposal for a revision of the Sustainable Use of Pesticides Directive, the proposal for EU Nature Restoration Law), as well as an overview of the new policy measures introduced with the new "green architecture" of the CAP 2023-27.

Box 4.1. The EU Biodiversity Strategy for 2030: Bringing nature back into our lives

The Biodiversity Strategy lays out targets and plans for Member States' protected areas under the Nature Directives. These include:

- legally protect at least 30% of the European Union's land area, of this, at least a third is strictly protected, and effectively manage all protected areas
- create a coherent ecological network between protected sites to prevent genetic isolation, allow for species migration and climate adaptation, and maintain and enhance healthy ecosystems
- ensure that there is no further deterioration in conservation trends and status of all EU protected habitats and species by 2030 and that at least 30% of species and habitats not currently in a favourable status reach that category or show a strong positive trend by 2030
- increase the number of forests and improve their health and resilience
- create a new European biodiversity governance framework
- unlock at least EUR 20 billion a year for nature.

Source: EC (2020[3]).

4.2. Environmental regulations and directives

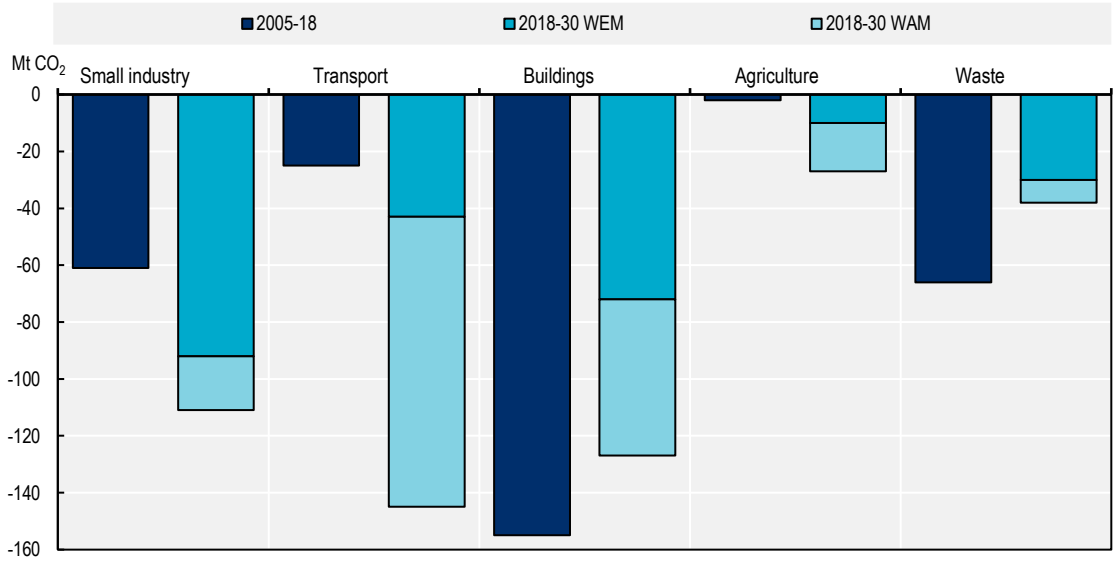
EU policy with respect to agriculture and environment comprises a package including directives that set rules, practices and objectives influencing the way agriculture production is carried out, combined with the budgetary support and additional regulatory requirements contained in the CAP regulation. The elements of this package must be taken together to understand the full picture of agri-environmental policy in the EU context. As shown below, many of these elements have synergies or interact with each other. For example, some part of CAP spending is used to help farmers comply with the requirements of certain directives. Cross-compliance, in particular, where statutory management requirements (SMR) are connected with the specific requirements of certain directives, is an example of how the different elements of the whole policy package can reinforce each other. This section covers those EU Directives that are most relevant to agriculture operations.

4.2.1. Effort Sharing Regulation (2018/842) and LULUCF Regulation (2018/841)

Formerly the Effort Sharing Decision, the Effort Sharing Regulation 2018/842 sets legally binding GHG emissions targets for 2030 for emissions from sectors not included in the EU Emissions Trading System (ETS), including transport, buildings, small industry outside the ETS, waste and agriculture sectors. The combined emissions of these sectors represent 57% of the European Union's total emissions (EEA, 2021[4]). For the agricultural sector, the ESR governs non-CO2 emissions linked to agricultural activities (methane and nitrous oxide), which account for ~98% of the sector's emissions. Under the Fit for 55 proposal, the overall ESR reduction target for 2030 was increased from 29% to 40% compared to 2005.

Member States choose where and how to achieve their ESR reductions and may focus on specific sectors. This results in differences between the sectors covered under the ESR. Emissions governed under the ESR declined by ~11% between 2005 and 2018 (EEA, 2021[4]). However, agriculture (the third largest source of emissions in ESR sectors) contributed only 1% of the emissions reduction effort, despite contributing more than 17% of ESR sectors' GHG emissions. Furthermore, EU Member State governments are not projecting significant emissions reductions in the agricultural sector by 2030, choosing instead to focus on other ESR sectors (Figure 4.1).

Figure 4.1. Past and projected Effort Sharing Regulation sectors' greenhouse gas emissions reductions, 2005-18 and 2018-30



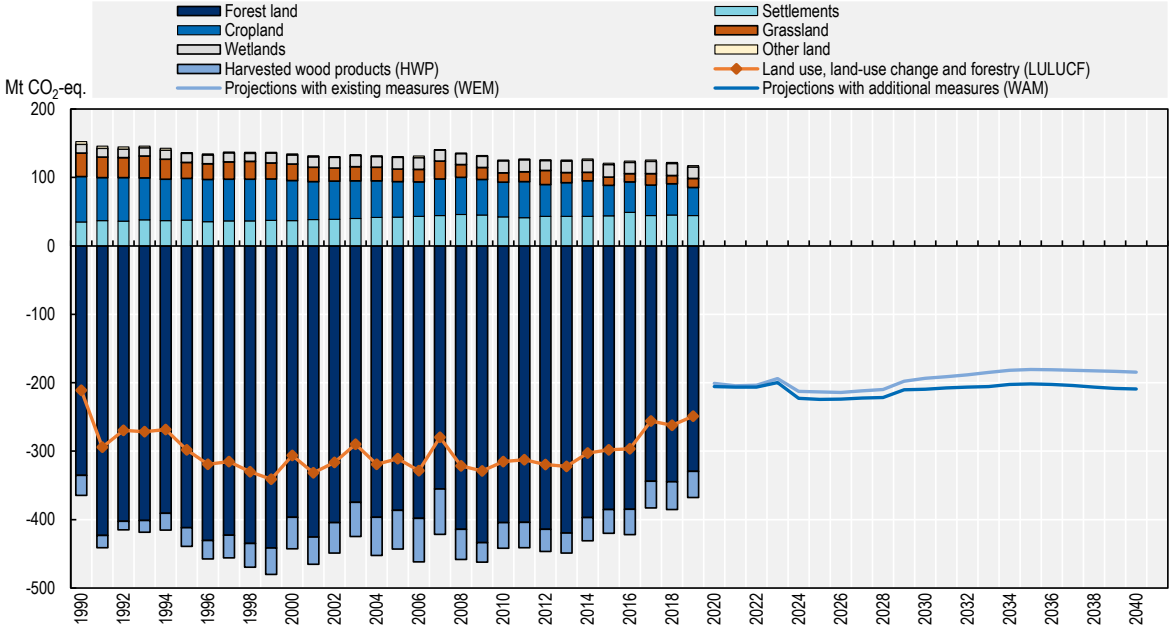
Notes: MT CO_2: million tonnes carbon dioxide. EU28. The bars represent changes in emissions between 2005 and 2018 and 2018 and 2030 based on inventories, approximated estimates for 2018 (proxy) and projections "with existing measures" (WEM) and "with additional measures" (WAM).
Source: EEA (2021[4]).

Under the ESR, Member States report on their annual emissions, projected progress towards meeting their emission limits, and information on planned additional national policies and measures to meet commitments. Member States not meeting their annual targets (after flexibilities are included) face an automatic penalty and must submit a corrective action plan. Flexibilities allowed under the ESR were designed to allow targets to be more cost-effective and include banking, borrowing and transferring emissions allocations and the use of ETS allowances and LULUCF credits to cover ESR obligations (under certain conditions).

The European Union's LULUCF Regulation (2018/841) establishes a legislative framework for accounting emissions and removals from the land-use sectors between 2021 and 2030. Under the current framework, Member States must ensure that accounted CO_2-eq emissions from the LULUCF sector are entirely compensated by an equivalent removal of CO_2-eq from the atmosphere through action in the LULUCF sector. This is calculated as the sum of total emissions and total removals in all of the land accounting categories defined in the LULUCF Regulation. This is referred to as the "no-debit" rule". The regulation includes six categories of land in its accounting: 1) afforested land; 2) deforested land; 3) managed cropland; 4) managed grassland; 5) managed forest land; and 6) managed wetland. However, it does not include non-CO_2 emissions from the agricultural sector in its accounting as they are covered in the ESR.

The main source of GHG emissions in the LULUCF sector is cropland, of which approximately 50% are caused by organic soils, which is 1.2% of the total cropland area (Böttcher and Hennenberg, 2021[5]) (Figure 4.2). Emissions from organic soils come from the drainage of peatlands for agricultural or forestry use. Approximately 35 million hectares of EU27+UK peatland area is drained (Joosten, Tanneberger and Moen, 2017[6]), at least 6 million hectares of which is agricultural land under grassland or cropland (Schils et al., 2008[7]). Besides emissions from drained organic soils, there are also significant emissions from the loss of soil organic carbon in mineral soils.

Figure 4.2. LULUCF sector emissions and removals in the European Union, and predicted net sink level, 1990-2040



Note: Mt CO_2-eq: million tonnes carbon dioxide equivalent.
Source: EEA (2022[8]).

There is potential for the agricultural sector to play an important role in meeting the 2030 sink target. While increasing carbon stocks in forests provide the largest absolute potential for strengthening the European Union's carbon sink, there are promising options in agroforestry, restoring wetlands and the conservation of organic soils, as well as for maintaining and enhancing carbon in mineral soils.

Carbon sinks in the LULUCF sector will play an important role in meeting climate neutrality objectives. The current LULUCF Regulation includes flexibilities to help Member States account for uncertainties, natural disturbances and reduce the risk of non-compliance. This includes the ability to exchange units between Member States and for individual Member States to exchange remaining units of LULUCF credits to the ESR. The flexibility is capped at 280 Mt CO_2-eq for all Member States and national maximum amounts.

The European Commission has proposed revisions to the LULUCF Regulation that establish a net carbon sink target for the LULUCF sector of 310 Mt CO_2-eq by 2030.[2] Other proposed changes to the LULUCF Regulation would merge the LULUCF sector with non-CO_2 emissions from agriculture within the regulation's accounting system by 2031, which will become the agriculture, forestry and other land-use (AFOLU) sector. This parallels the UN Intergovernmental Panel on Climate Change (IPCC) special report on *Climate Change and Land*, which merges agriculture, forestry and other land use together. Further, the European Commission proposes a GHG neutrality target for the combined AFOLU sector by 2035.[3] While the EU-level target of climate neutrality for the land sector by 2035 is non-binding, derived Member State targets will be binding and enforceable. From 2036 onwards, the combined sector will need to generate further carbon removals to balance remaining emissions in other sectors based on a robust carbon removal certification system. While the proposed updates have yet to be adopted, trilogues for the LULUCF Regulation have been completed and the Council and Parliament confirmed the overall EU-level net sink target for 2030. Under the provisional agreement, the current "no-debit" rule will continue to apply until 2025. The agreement maintains flexibilities for Member States encountering difficulties in achieving their targets caused by natural disturbances up to a fixed limit.

LULUCF sector GHG emissions total 136 Mt CO2-eq and removals were -410 Mt CO2-eq. Agricultural GHG emissions total 435 Mt CO2-eq. If the LULUCF sink is still at the proposed 2030 target of -310 Mt CO2-eq in 2035, agricultural non-CO2 emissions would need to be mitigated by nearly 20% (Böttcher and Hennenberg, 2021[5]). However, according to data submitted by Member States to the European Environment Agency, the combined emissions from cropland and wetlands are only expected to decrease from 77 Mt CO2-eq in 2020 to 65 Mt CO2-eq in 2040, with existing measures. Emissions from grasslands are predicted to increase from 11.9 Mt CO2-eq in 2020 to 15.2 Mt CO2-eq in 2040.

4.2.2. Water Framework Directive (2000/60)

The Water Framework Directive (WFD) is at the centre of EU water policy.[4] It updates and brings together past directives related to water and provides a legislative framework for a consolidated approach to water policy. The WFD aims to:

- prevent further deterioration of, protect and enhance the status[5] of water resources
- promote sustainable water use based on the long-term protection of water resources
- enhance the protection of and improve the aquatic environment by reducing the presence of priority substances
- ensure the progressive reduction of pollution of groundwater and prevent its further pollution
- contribute to mitigating the effects of floods and droughts.

The WFD improves upon past legislation in many ways, but two major innovations over past approaches are worth highlighting. The first is to align water governance with the physical dimensions of water basins by establishing river basin management districts (Article 3). Each district produces a river basin management plan (RBMP), covering a period of six years. The second innovation was taking a Driver-Pressure-State-Impact-Response approach that emphasised identifying anthropogenic pressures on water systems and asking river basin management districts to produce a programme of measures (PoM) to address these directly. This approach brings together consideration of sources of pollution or abstraction of hydro-morphological pressures and the resulting quality of the aquatic environment, which had previously been treated as separate domains. The WFD's governance mechanism is designed to enable Member States to bring together all the relevant actors to set up management plans based on river basins and to collaborate across borders.

The objectives of the WFD are ambitious and outcome-oriented, calling for a return to good status for all surface and groundwater bodies by 2015 (Article 4). Good status follows a strict "one out, all out" definition that requires all indicators of status to be good for the overall status of the water body to be considered good. This includes good status for water quality and quantity considering both surface and groundwater. Less than half of water bodies achieved good status by 2015, but provisions allow for two further planning cycles (2015-21 and 2021-27) that extend the deadline to 2027 under certain conditions.

Monitoring and reporting under the WFD have significantly increased knowledge of the European Union's aquatic ecosystems, with beneficial spillovers in other policy domains. Monitoring trends of certain pollutants has, for the first time, provided Member States with the necessary information to manage the presence in the water environment of pollutants which are not or no longer authorised, e.g. from illegal use or run-off (EC, 2019[9]).

The WFD has a broad focus on the ecosystem and chemical status of surface water and the quantitative and chemical status of groundwater. While it lists a set of priority substances requiring special attention, it is up to river basin management districts to identify and address all anthropogenic pressures affecting the status of water bodies.[6] The WFD also requires Member States to establish a register of areas that require special protection under other legislation, such as Natura 2000 sites (Article 6).

The WFD provides for three separate but related activities: 1) a framework for planning and governance (Article 5); 2) a system for monitoring and reporting of water quality (Article 8); and 3) a PoM based on an analysis of pressures on the water body to achieve the good status objective (Article 11). In addition, Article 9 requires the use of cost-based pricing for the delivery of water services.

The PoM consists of a common set of basic measures, along with additional supplementary measures if needed to achieve the objectives of Article 4. Basic measures encompass controls of water abstraction or potential pollution sources that may be detrimental to the status of a water body and mainly reflect the source control requirements of prior water legislation (such as the Nitrates Directive, covered below). The supplementary measures reflect the outcome-based objectives of the WFD. If the analysis shows that the basic measures are insufficient to achieve good status for a water body, supplementary measures are designed to bridge the gap. This combined approach of basic and supplementary measures brings together traditional source controls with outcome-based management.

The WFD was a larger institutional challenge than expected

The WFD was a breakthrough in water policy in Europe and resulted in improvements in many areas (Gruère, Ashley and Cadilhon, 2018[10]). In particular, ecological assessment, monitoring and reporting on water quality have been greatly improved (Carvalho et al., 2019[11]; EEA, 2018[12]). The river basin-based governance structure and integrated approach to addressing pressures were initially very challenging for the existing water management system to adapt to, but great progress was made after an initial slow start and the value of this structure is becoming clear (Voulvoulis, Arpon and Giakoumis, 2017[13]; Jacobsen, Anker and Baaner, 2017[14]; EC, 2019[9]).

WFD implementation is complex due to the need for measures that reflect the specific circumstances of each water body. This complicates the transparency and accountability of Member States and may have allowed lowered ambitions in their water policy. The extensive requirements for the river basin management plans and public consultation are designed to counteract this policy discretion via public transparency about water policy and actions (EC, 2019[9]).

The WFD has not achieved its original objective of restoring all surface and water bodies to good status by 2015 and doing so by 2027 remains challenging in many cases. Problems with implementation are a significant factor. The challenge in the first WFD cycle was to adapt existing governance structures to the new spatial scale of the river basin district and establish PoMs (Borowski et al., 2008[15]). The second cycle of the WFD improved the quality of monitoring and established a systematic approach to identifying all relevant pressures and designing and implementing appropriate measures as a main challenge (EC, 2015[16]; EC, 2019[17]).[7] In the latest cycle, sector co-ordination and aligning sector policies with WFD objectives – “mainstreaming” water policy – and the appropriate level of financing for measures are the main gaps (EC, 2021[18]).

Agriculture is a major pressure on water quality

Agricultural activity is a major driver of pressure on water quality and quantity and a factor behind many water bodies’ failure to achieve good status (EC, 2015[16]). In general, RBMPs do not show determined action to address agriculture pressures nor satisfactory association of farmers to the WFD process, and WFD PoMs rarely intervene directly in the emission of nutrients or pesticides (EC, 2012[19]; Wiering, Boezeman and Crabbé, 2020[20]). Additionally, EU funds have been underused in funding supplementary measures under RBMPs (EC, 2015[16]).

PoMs rarely include agriculture directly, nor does the CAP fully integrate the European Union’s water policy objectives. Better integration of water objectives in agriculture policy is needed, but it has not yet happened at the scale necessary (EC, 2019[9]; Zingraff-Hamed et al., 2020[21]). Past delays in establishing RBMPs and PoMs are likely affecting the pace of integration of the WFD and the CAP. The European Commission

anticipated that the basic measures in RBMPs would be part of cross compliance once these are fully implemented in all Member States and the obligations directly applicable to farmers identified (ECA, 2014[22]), but it took until the CAP 2023 27 to achieve this. The new CAP requires Member States' CSPs to contribute to and be consistent with legislative acts concerning the climate and environment. It also provides for payments for area-specific disadvantages arising from farmers' obligations under RBMPs (Article 72).

Financing availability, efficiency and effectiveness are limiting factors

Financing constraints are a major limitation in achieving WFD goals, while potentially related CAP expenditures on the environment are often inefficient and deliver limited results (ECA, 2017[23]). Both of these challenges can be addressed via closer integration of WFD objectives and agricultural policy (including the Nitrates Directive) (Ribaudo and Shortle, 2019[24]; EC, 2019[9]). Most Member States recognise the contribution of the Nitrates Directive implementation but only in qualitative terms, not assessing how much it will close the gap to good status or how much additional effort is needed (EC, 2015[16]).

Voluntary approaches such as agri-environmental and climate measures may not reach the polluters affecting a water body, and subsidy-based programmes can have a limited impact due to public budget constraints and a lack of environmental regulations on diffuse pollution (OECD, 2017[25]). At the same time, direct measures in nutrient action plans (NAPs) as part of the Nitrates Directive have not been sufficient to address nutrient pollution that prevents water bodies from reaching good status (Wiering, Boezeman and Crabbé, 2020[20]). The third WFD implementation report on the first cycle of RBMPs called for a better balance between voluntary actions and mandatory measures in agriculture to provide a solid baseline for rural development programmes and cross-compliance water-related requirements (EC, 2012[19]).

The principle in the WFD of using supplementary measures when basic measures are insufficient to reach the objectives of the WFD is highly relevant for agricultural policies related to water pollution by nutrients. While some Member States have quantitatively assessed the pollution loads from agriculture, few have estimated the reduction needed to achieve good status according to the WFD (EC, 2015[16]). NAPs under the Nitrates Directive specify actions and restrictions that farmers must follow that are considered appropriate practices, and greening and agri-environmental and climate measures as part of the CAP are designed around beneficial actions that farmers can take for a number of environmental issues, but there is no adjustment mechanism in place if results fall short of targets beyond the multiannual planning cycle.

Monitoring and reporting are important drivers of progress

The regular reporting requirements of directives are a strength. The WFD has stimulated an enormous portfolio of new ecological assessment methods, which have greatly improved the monitoring and assessment of the ecological status of water bodies. These assessment and monitoring methods have also greatly improved the knowledge of the status of European waters (Giakoumis and Voulvoulis, 2018[26]; EC, 2019[9]).

However, the reporting time frames do not always allow for the most up-to-date information to be used in the policy development cycle.[8] For example, the sixth implementation report of the WFD was released at the end of 2021, near the end of the second (2015-21) cycle of the WFD, but uses data from the 2018 mid-term evaluation (EC, 2021[18]). At the same time, by the end of 2021, the RBMPs for the third cycle (2021-27) were largely complete and likely did not benefit from the sixth implementation report. More frequent stocktaking of progress could help ensure that any needed adjustments can be made in a timely manner to ensure a successful outcome. At this stage, a three-year reporting lag represents more than half the remaining period up to 2027.

Economic measures are under used

Article 9 of the WFD requires Member States to take account of the principle of cost recovery for water services, including environmental and resource costs, in accordance with the polluter-pays principle. This article emphasises not only sharing costs between water users, but also using water pricing to ensure that the right incentives for water use and conservation are in place. Member States may decide to not apply cost recovery or water pricing but must ensure that this does not compromise the objectives of the WFD. The decision must be explained in the RBMP.

Relatively less progress has been made in implementing the cost recovery and pricing requirements of the WFD. In some Member States, in some sectors, such as agriculture or households, metering of water consumption is not fully implemented. Cost recovery is implemented, to a greater or lesser extent, in households and industry. Cost recovery is not sufficiently applied to water users in agriculture; in many areas, water is charged only to a limited extent (EC, 2012[19]) This situation has not progressed much in recent years in some Member States (as is the case for some non-EU OECD countries) (Gruère, Shigemitsu and Crawford, 2020[27]).

Early in the WFD process, the European Commission had started infringement procedures against some Member States for a narrow interpretation of the cost recovery provisions of Article 9 (EC, 2012[19]). Since then, a few Member States have upgraded their water pricing policies, but significant gaps remain in translating these into concrete measures and achieving more harmonised approaches to estimating and integrating environmental and resource costs (EC, 2019[17]). In the case of agriculture, there is generally a low level of cost recovery of irrigation water pricing. The price paid by irrigators is generally lower than the price required to achieve cost recovery (EEA, 2013[28]).

4.2.3. Nitrates Directive (91/676)

The Nitrates Directive (ND) is the main tool for protecting water threatened by nitrate contamination from agricultural activity.[9] Article 1 aims to reduce and prevent water pollution caused or induced by nitrates from agricultural sources.[10] The directive refers to both ground and surface waters (including coastal and transitional waters). While many nature-related directives concern agriculture, the ND primarily concerns agriculture emissions.

Member States designate nitrate vulnerable zones pursuant to Article 3, which include areas in which groundwater contains or could contain more than 50 mg/L nitrate without measures or where surface water is eutrophic or could become eutrophic without measures or drains into vulnerable zones.[11] For these vulnerable zones, Member States draw up nitrate action programmes containing measures to achieve the objectives set out in Article 1. These action programmes concern good agricultural practice and other specific measures as set out in the annexes of the ND. These action programmes are assessed every four years based on monitoring of ground and surface water quality.

The Nitrates Directive contributes to achieving WFD targets by reducing nutrient loads on ground and surface water by agriculture. The ND uses the Emission Limit Values approach, restricting pollutant loads discharged into the aquatic environment via management controls. However, this approach lacks an equivalent of the WFD's supplementary measures to ensure results are achieved, and so it is less effective in achieving its aims (Giakoumis and Voulvoulis, 2018[26]).

The directive's objective is to "reduce pollution", but there are no exact thresholds to be achieved for surface water resources and no specific target dates. The ND establishes planning and measurement processes in Member States and requires them to identify a set of practices to reduce the amount of nitrogen entering the environment, especially in nitrate-vulnerable zones. While the ND identifies a set of good agricultural practices (Annex II) and a list of measures for Member States to implement (Annex III), these annexes identify subject areas only, leaving the specific parameters to Member States.[12] One of the few specific requirements is the limit of 170 kg N/ha from manure (though derogations are possible).

Despite the ND having been in place for over 30 years and many Member States now implementing their seventh nitrate action programmes, N surpluses from agriculture are still a problem affecting surface and groundwater quality, with negative effects on Member States' ability to achieve WFD objectives of good chemical and ecological status of water bodies and increasing problems in drinking water production. Between 2012-15 and 2016-19, the total area of nitrate-vulnerable zones increased by 14.4% and eutrophication remains a problem for inland, transitional, coastal and marine waters. Many Member States still have a large share of eutrophic waters (EC, 2021[29]).[13]

A lack of binding targets slows progress

The ND is an older directive and lacks the clear timelines and objectives of newer legislation. That said, when put in place, it was a significant advancement in co-ordinated environmental policy at the EU level (Gruère, Ashley and Cadilhon, 2018[10]). It has established a reporting framework that has increased the amount of information available on the status and effects of nitrogen on ground and surface water. Moreover, new projects like NAPINFO bring this information together from all Member States in a coherent way. This, combined with WFD reporting, has provided a much clearer picture of nutrient pollution and water quality than would otherwise have been possible.

The situation has improved since the directive was adopted, but improvement has been slow since 2012. The low-hanging fruit have been collected and now more challenging measures are needed (EC, 2021[29]). Continual problems with water pollution from agriculture point to the inadequacy of current efforts as part of the nitrate action programmes to address sources of nutrients. In many cases, eutrophication and phosphate pollution are not sufficiently taken into account when identifying and designating polluted areas. While the ND requires that Member States take action when water quality does not improve, not all apply additional measures with sufficient ambition. Between 2016 and 2019, the European Commission opened ten infringement cases against Member States with respect to the designation of NVAs, their action plans or derogations. Most of these have been resolved (EC, 2021[29]).

There also appears to be an implementation gap where farmers are not correctly and completely implementing requirements. Ten per cent of observed infringements of CAP cross compliance requirements have to do with the statutory management requirements stemming from the ND, the third most common infringement overall and the most frequent among those cross compliance requirements related to the environment (ECA, 2016[30]).

The Biodiversity and F2F Strategies set a common objective of reducing nutrient losses in the environment by at least 50% by 2030, while preserving soil fertility. The ND is considered a key piece of legislation to achieve this target and other objectives of the EGD. To reinforce implementation and enforcement to match the objectives of the ND, an Integrated Nutrient Management Action Plan is planned to help co-ordinate efforts and identify the nutrient load reductions needed to achieve the EGD targets on nutrients (EC, 2021[29]).

Water quality results should provide feedback to nitrate action programmes

The ND has become a basic measure under the WFD. Member States may elect to implement their nitrate action programmes in an integrated framework that jointly implements the ND and the WFD. In this case, the additional measures provided for in the WFD contribute to achieving the ND's objectives (Gault et al., 2015[31]).

River basin management plans and PoMs are designed to achieve WFD objectives, and nitrate action programmes may be included in this process, but this is not always the case. There is no automatic process to adapt NAP measures in response to observed outcomes, only a requirement for Member States to amend actions when they are insufficient. This process is generally not integrated with the WFD and RBMPs. Aligning the nitrate action programmes and RBMPs is challenging – they operate at different

spatial scales and on different time frames (NAPs are renewed every four years; RBMPs every six) and are developed by different administrative bodies. Moreover, neither nitrate action programmes nor RBMPs align with the CAP planning cycle.

There are many ways to adjust nitrate action programmes when objectives are not being met. The European Commission may request changes via consultation with Member States or through infringement procedures, domestic courts may rule current approaches insufficient to meet legal obligations, or the responsible administration may institute changes based on observed lack of progress. The European Commission can request additional measures as part of a derogation agreement, such as the cap at 2002 levels on total N and P in the Netherlands (Gault et al., 2015[31]). For most Member States, NAPs have been strengthened over time and the area designated as vulnerable has increased. However, this process has not resulted in a sufficient reduction of water pollution from agricultural sources.

4.2.4. Sustainable Use of Pesticides Directive (2009/128/EC)

The authorisation and marketing of pesticides have been regulated at the EU level since 1991. In 2009, the Sustainable Use of Pesticides Directive (SUD) replaced the EU Thematic Strategy on the sustainable use of pesticides, which started in 2006. The directive's aim is to achieve a sustainable use of pesticides by reducing the risks and impacts of pesticide use on human health and the environment and promoting the use of integrated pest management (IPM) and alternative approaches or techniques, such as non-chemical alternatives to pesticides.

In principle, the Sustainable Use of Pesticides Directive provides Member States with many tools to reduce the risks of pesticide use

The SUD asks all professional users of pesticides to implement IPM, including the use of non-chemical alternatives, and to use practices and products with the lowest risk to human health and the environment. It defines IPM and the general principles it should include. The SUD requires Member States to identify trends in the use of certain active substances; identify priorities, such as active substances, crops, regions or practices that require particular attention, or good practices; communicate the results of these evaluations to the Commission and other Member States; and make this information available to the public (Article 15).

Member States are required to produce national action plans setting out how they will achieve the sustainable use of pesticides (NAPs), including quantitative objectives, targets, measures and timetables to reduce the risks and impacts of pesticide use on the environment. This should include indicators to monitor the use of pesticides containing active ingredients of particular concern. The NAP should reflect objectives, targets and measures set in other environmental planning tools, such as RBMPs, national biodiversity strategies or plans, or pollinator strategies. The first NAPs were published between 2012 and 2014, and the second between 2017 and 2021.

The SUD gives authorities the power to minimise or prohibit pesticide use in public spaces, Natura 2000 sites and water protection sites; to minimise or eliminate risks to the health of vulnerable groups; or to reduce pressures on biodiversity in protected areas (Article 12). There is a general ban on aerial spraying of pesticides (including from drones), with a procedure for Member States to grant derogations (Article 9). Article 10 requires specific measures to protect the aquatic environment and drinking water, including a preference for pesticides that do not damage the aquatic environment, buffer zones and safeguard zones, and measures to mitigate drift and flow, such as mandatory use of certain equipment. Member States should reduce the risk to water by decreasing or eliminating applications on or along roads, railway lines, very permeable surfaces, etc.

The SUD requires a system of regular checks of pesticide use equipment and regular training and certification of professional users and pesticide distributors and salespersons. It sets rules for handling,

packaging, storing and disposing of pesticides. It requires a system of surveillance of pesticide poisonings of humans and wildlife. Member States shall inform and raise the awareness of the general public with accurate and balanced information relating to pesticides about the risks and the potential acute and chronic effects for human health, biodiversity and the environment arising from their use, and the use of non-chemical alternatives.

But imprecise targets and poor monitoring reduce effectiveness

According to two Commission assessments, there is a lack of precise and measurable targets in the NAPs, along with a lack of ambition and a need to upgrade NAPs regarding biodiversity biodiversity objectives (EC, 2017[32]). These assessments were informed by a series of fact-finding missions, followed by audits to check compliance in 2018 and 2019. Only four NAPs set an overall quantified pesticide risk reduction target,[14] and only Denmark and Germany link this to a measure of environmental risk. Despite these measurement problems, some evidence suggests that the SUD has failed to reduce pesticide use and risk and has not led to a common approach in NAPs to systematically treat problems, propose measures, or define timetables for implementation and indicators (Helepciuc and Todor, 2021[33]).

Limited monitoring of the impact of pesticides on the environment and human health makes it difficult to assess the impact of NAPs (Remáč et al., 2018[34]). Member States are required to ensure that professional users keep records of their pesticide use, but there is no legal requirement for the government to collect these records from users. A parliamentary resolution in February 2019 noted that very little progress had been made in promoting and incentivising the innovation, development and uptake of low-risk and non-chemical alternatives to conventional pesticides. Moreover, approximately 80% of Member States' NAPs do not contain any specific information on how to quantify the achievement of many of the objectives and targets, particularly as regards targets for IPM and aquatic protection measures.[15]

The European Commission responded to the observed weaknesses in the SUD implementation with a combined evaluation roadmap and inception impact assessment of the SUD. The evaluation that followed included a support study submitted in October 2021 (Ramboll and Arcadia International, 2021[35]), stakeholder consultations during 2020 and 2021, and a public consultation between January and April 2021. In May 2020, the F2F Strategy established an EU-wide objective to reduce the use and risk of pesticides by 50% by 2030. The target was accepted by the European Parliament and Council. In June 2022, the Commission published its proposal for a new Sustainable Use of Pesticides Regulation to replace the SUD.

Measuring and reporting on reductions in the risk and use of pesticides is set to improve

The first EU-wide Harmonised Risk Indicators were published in May 2019, setting a baseline of pesticide use in the period 2011-13, and trends from 2011 to 2019 based on sales data. Member States also produce Harmonised Risk Indicators at the national level. The indicators put greater weight on the use of pesticides that are candidates for substitution and the use of unauthorised pesticides and less weight on the use of low-risk and biopesticides. The risk indicators show a decreasing trend since 2011, but the volume of pesticides used in the European Union is not decreasing (Eurostat, 2022[36]). This reduction in risks has come mainly from banning or withdrawing active substances at the EU level that are then replaced with other pesticides with a lower risk weighting (Chapter 1).

Eurostat publishes annual pesticide sales figures for the major groups, categories of products and chemical classes. The significant differences in the range of products reported by different countries limit comparability and data on individual active substances are unavailable.[16] Member States are not required to report these data to Eurostat, and currently, only 16 do. The revised Statistics on Agricultural Input and Output (SAIO) Regulation 2022/2379 places stronger reporting requirements on Member States starting in 2025. It implements farm-based collection of pesticide use statistics across the European Union and requires Member States to collect annual data on pesticide use from 2026 and publish annual reports from

2028 based on “a common list of representative crops” to be determined over a transition period from 2025. It will result in a register held by competent national authorities on the use of plant protection products in agriculture and ensure the availability in electronic format of the records to be kept by professional users of plant protection products. An implementing regulation is being developed that proposes that professional users of pesticides transmit their records in electronic format to competent national authorities.

Harmonised risk values focus on the most dangerous pesticides; large agricultural countries are the biggest users

The indicators are designed to reflect reductions in the use of candidates for substitution (CfS), pesticides whose use is considered most problematic because of their health or environmental hazards. The number of CfS in the EU market has decreased slowly in the six years since the system was introduced (Robin and Marchand, 2021[37]). CfS currently in use in the European Union must periodically have their approval renewed. Twenty-one of the 56 approved CfS were due to have their approval reviewed in 2022 and an additional 15 in 2023.[17] If all these active substances were removed from the market, this would have a very noticeable effect on the indicator HR1.

Member States can improve their indicators by decreasing or eliminating the use of pesticides classified as CfS, with herbicides and fungicides having more impact due to their higher weight per application. For example, in France, CfS made up 22% of the weight of sales in 2018 (BASIC, 2021[38]). Governments may ban or severely restrict the use of CfS, make them more expensive than alternatives through differential taxation, or promote alternative methods.

Pesticide use is dominated by the largest agricultural producers: France, Germany, Italy, Poland, and Spain, which account for half of the pesticide sales by weight in the European Union. Reductions in pesticide use in these countries would have a large effect overall, while changes in smaller users would be less likely to be reflected in overall values.

Proposed new Regulation on Sustainable Use of Plant Protection Products

The European Commission published a proposal for a Sustainable Use of Plant Protection Products Regulation in June 2022. The proposal was designed to address four problems: 1) alignment with pesticide-related targets in the F2F Strategy; 2) strengthening current SUD provisions; 3) improving data availability and monitoring; and 4) addressing new technologies. The regulation contains many of the provisions of the directive but also sets legally binding reduction targets for Member States, tightens the provision for pesticide-free areas, and more clearly defines what an IPM is and how it can be assessed.

Since the proposal was drafted in 2022, some have called for additional impact assessments of the Sustainable Use of Plant Protection Products Regulation. In December 2022, the European Council requested an additional analysis under Article 241 of the Treaty on the Functioning of the European Union.[18] The Commission must deliver the requested assessment by June 2023.

Production costs per unit may increase subsequent to the Sustainable Use of Plant Protection Products Regulation due to:

- stricter and more detailed reporting requirements
- the expected reduction of yields due to lower pesticide use
- the inclusion of an additional cost layer for those professional users not currently using advisers.

The Sustainable Use of Plant Protection Products Regulation evaluation support study (Ramboll and Arcadia International, 2021[35]) found a large uncertainty in the predicted economic impacts of the reduction targets. Estimates of yield loss from 2030 pesticide reduction targets range from 7% to 30% for permanent crops to 0-15% in annual field crops, based on expert opinions (Bremmer et al., 2021[39]). The impacts of the pesticide target on crop production depend on the alternatives that will be available to farmers in the

future. The potential for innovation in this respect is hard to estimate but could be substantial, as shown by the reductions achieved by leading farms in France while maintaining overall profitability (Lechenet et al., 2017[40]). Member States may provide support under the CAP to cover the costs to farmers of complying with all the legal requirements imposed by the regulation for a period of five years (EC, 2022[41]).

The CAP's role in achieving Sustainable Use of Pesticides objectives

The 2009 SUD foresaw the possibility of the IPM becoming part of the conditionality rules of the CAP. However, the CAP legislation for the 2014-22 period did not include the SUD in the statutory management requirements for farmers. The European Commission's report of October 2017 concluded that Member States had not developed clear criteria to assess the implementation of IPM principles in controls at the farm level and have not taken appropriate measures to deal with non-compliance in this regard. The second report reached the same conclusion. The European Court of Auditors (ECA, 2020[42]) concluded that Member States undertake only very limited control of farmers to verify that IPM principles are implemented, and as that IPM implementation is not a condition for receiving CAP payments, there is little development of non-chemical alternatives and little incentive for farmers to take them up. Several Member States request that farmers fill out a form with information on how they have applied for IPM. However, the forms are currently not checked by inspectors to determine compliance with the principles of IPM.

The CAP 2023-27 requires compliance with the SUD as part of conditionality; however, it does not reference the SUD Article 14 requiring farmers to apply IPM.[19] There is, therefore, no mandatory requirement in the CAP that specifies that farmers have to make plans to reduce pesticide use and prove that they are applying IPM in order to receive direct payments. If the Sustainable Use of Pesticides Regulation is adopted, this will replace the directive in the CAP regulation.

The CAP framework includes the scope for Member States to set a strong mandatory baseline of requirements that make up the basis for IPM in the Good Agricultural and Environmental Conditions (GAEC) for crop rotation, buffer strips along water courses, cover crops, and at least 4% of area under landscape features and fallow or nitrogen-fixing crops in which pesticides are not used. Eco-schemes, agri-environmental schemes and investments can then be used to provide incentives for farmers to apply IPM or to carry out practices that support IPM. However, the ambition of the new CSPs appears to be low – target values for the results indicator on the share of utilised agricultural area under-supported specific commitments which lead to sustainable use of pesticides are below 10% in an assessment of nine plans (EEB and Birdlife, 2022[43]).

The CAP is an important source of funding for innovation and learning, which are crucial components of the transition to less use of chemical pesticides, and in particular the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) approach has a good potential to tackle practical problems through a co-creation process involving farmers (Chapter 5, Section 5.6). Almost 450 of the 2 500 EIP-AGRI Operational Groups focus on topics related to the sustainable use of pesticides (EC, 2022[44]). The new CAP plans have considerable scope to support the transition and innovation and increase farmers' capacities and knowledge to manage crops with lower pesticide use.

4.2.5. The Habitats Directive and the Birds Directive (2009/147/EC)

Known collectively as the Nature Directives, the Birds and Habitats Directives are the two main pieces of EU nature legislation which, for more than 30 years, have helped conserve natural habitats and wild fauna and flora in the European Union. Adopted unanimously by the Council in 1979, the Birds Directive aims to protect all wild bird species and their habitats across the European Union. The Habitats Directive, adopted unanimously by the Council 13 years later (1992), introduces very similar measures but extends protection to more than 1 200 other rare, threatened or endemic species of wild animals and plants, collectively referred to as species of Community interest and, for the first time, protects 231 habitat types in their own

right. Both directives are similarly designed and structured, requiring the conservation of species and their habitats through a combination of protection measures, monitoring and research.

The Nature Directives require Member States to establish, protect and manage the Natura 2000 network, protect landscape features of importance for the coherence of the Natura 2000 network, protect species, and carry out supporting measures (e.g. funding, research and public awareness-raising). These actions form a coherent framework that can address the many problems facing habitats and species. The Natura 2000 network of areas of high nature value across the European Union is the most visible element of this framework, but the effect of the directives goes beyond the sites that make up Natura 2000 (Milieu, IEEP and ICF, 2016[45]).

Annex I of the Habitats Directive lists the natural habitat types of Community interest whose conservation requires the designation of special areas of conservation (Natura 2000 sites). There are 63 habitat types whose conservation depends on appropriate agricultural management (Halada et al., 2011[46]). These can occur in three broad types of agricultural land, which differ in the degree to which they support habitats and the species of community interest (EC, 2014[47]).

- *Semi-natural agricultural habitats* (177 442 km^2). Habitats Directive Annex I and similar habitats of high nature value are dominated by native species, dependent on extensive agricultural management of the vegetation and associated native species that have not been planted.[20] These habitats are the result of centuries of human activities. They include permanent grassland and shrubland pastures that depend on livestock grazing, meadows dependent on mowing or grazing, and some long-established agroforestry habitats. Some areas of extensively managed cropland and fallow (pseudo-steppes) are also important habitats for species of European conservation concern.
- *Agriculturally improved grasslands and croplands* (1.9 million km^2). These include grasslands that are managed to increase their productivity through ploughing and reseeding with productive strains of agricultural grasses and the use of drainage and mineral fertilisers. Cultivated improved croplands are also included; these are arable or permanent crops intensively managed with the use of fertilisers, herbicides, pesticides and, in some cases, irrigation. Such intensively used farming landscapes do not host habitats of high nature value or sensitive species but do contain many widespread but declining farmland bird species, small mammals, etc., and may contain remnants of Annex I habitat types in small, fragmented patches.
- *Agroforestry,* which integrates trees or shrubs with crops or livestock, is estimated to cover at least 106 000 km², representing about 6.5% of the utilised agricultural area in Europe (den Herder et al., 2016[48]). The proportion of utilised agricultural land involving agroforestry is reported as varying from about 50% in Greece and Portugal to low values in central and northern Europe. High-value agroforestry includes orchards of full-sized fruit or nut trees and grazed or mown (Annex I) agroforestry is less intensively or traditionally managed and “new” agroforestry establishes trees or shrubs in existing arable fields and has less significance as a habitat for species of European conservation concern.

The implementation of EU Nature Directives is improving; closer integration with the CAP could accelerate progress

Implementing the Nature Directives habitats and species protection “on the ground” is largely the responsibility of Member States. LIFE is the only dedicated EU fund for implementing the Nature Directives, and provides project funding but not long-term support; however, national funds can be combined with other EU funds (Chapter 5). For example, protected agricultural and forest habitats and wild birds and protected species associated with agricultural land can benefit from CAP funding (largely from the EAFRD) for nature conservation management payments for land managers. Member States report to the European Union every six years on progress. These contribute to the *State of Nature* reports published by the

European Environment Agency, which provide the most up-to-date picture of the detailed performance of the Nature Directive.

The general objectives of the Nature Directives to conserve or restore habitats and species are translated into specific and operational objectives that lead to actions to identify and protect special protection areas and areas of conservation. The Natura 2000 network is made up of such areas. Financial, human and institutional resources are dedicated to support protection activities and achieve operational objectives. This includes site and species management, enforcement, research, information sharing, and education (Milieu, IEEP and ICF, 2016[45]).

Member States' compliance with the Nature Directives is enforced through the Court of Justice of the European Union. There are currently 77 active cases, involving 24 of the EU27 Member States, some dating back to 2014. The number of breaches of the directives reported to the European Commission has decreased over time, indicating that the implementation of the directives has evolved and improved substantially. This improvement comes from a combination of guidance and lessons learnt from experience, enforcement actions and interpretation of the legislation by the Court of Justice of the European Union (Milieu, IEEP and ICF, 2016[45]). Better coherence with other EU policies can help increase effectiveness. Integration with the CAP is of particular interest since agriculture and forestry exert the most influence on terrestrial biodiversity in the European Union.

The outcomes of the Nature Directives are underappreciated, leading to underinvestment and inattention

A comprehensive policy evaluation or "fitness check" in 2016 concluded that the Nature Directives are fit-for-purpose but achieving their objectives and realising their full potential will depend upon substantial improvements in their implementation. Key shortcomings in implementation include limited resources, weak enforcement, poor integration of nature objectives into other policy areas, insufficient knowledge and access to data, as well as poor communication and stakeholder involvement.

The Commission concluded from the fitness check that there has been important progress, such as establishing the terrestrial Natura 2000 network, but not all the necessary conservation measures have been put in place. The efficiency analysis shows a very low cost-to-benefit ratio, which means that investing in Natura 2000 makes good economic sense, but the biodiversity and ecosystem services within and outside the Natura 2000 network are undervalued (EC, 2016[49]).

The proposal for an EU Nature Restoration Law

The proposed Nature Restoration Regulation 2022 (also referred to as the Nature Restoration Law [NRL]) is an ambitious legal instrument to address the deficiencies in the implementation of the Nature Directives and achieve the ambition of the EU Biodiversity Strategy 2030 to reverse the decline of biodiversity in the European Union and build synergies between climate action and nature restoration. It is the most significant piece of EU biodiversity legislation proposed in the last 20 years and, if fully implemented, could be a substantial step forward in nature protection and a significant factor in meeting the ambitions of the Convention on Biological Diversity as expressed in the recent COP15 agreement.

Unlike the Nature Directives, it is an EU Regulation with quantified targets, indicators and milestones that the 27 Member States will be required to meet. The NRL will require:

- *Ambitious targets which strengthen and go beyond existing EU legislation* – the proposal sets an overarching, legally binding objective for ecosystem restoration as well as ecosystem-specific targets which strengthen and go beyond current EU nature restoration legislation. These targets are set for 2050, with binding milestones by 2030 and 2040.
- *Strong communication and understanding of the huge environmental, societal and economic benefits which these restoration targets will deliver*, highlighting the many benefits of nature

restoration, is key to ensuring the restoration targets are supported and embraced by all stakeholders and society at large. Through its co-benefits, the NRL will help Member States meet other existing and upcoming targets and obligations under the EGD and international commitments.

- *A strong implementation framework through carefully designed national restoration plans.* Member States are expected to submit a first draft of their national restoration plans within two years of the entry into force of the regulation and the plans will run until 2050. A key element of the plans will be to outline the financing needs for implementing the plan and to strengthen links and synergies with other EU environmental objectives, notably climate change action, and their corresponding planning tools. The European Commission will assess these plans to ensure they adequately meet the requirements of the law.
- *Effective monitoring and reporting.* Progress will be monitored and reported by Member States and EU-wide reports will be prepared based on this. The regulation will be reviewed in 2035 to determine whether the law is achieving its objectives.

The CAP's role in achieving the Nature Restoration Law's objectives

All farming and forestry systems in the European Union can potentially contribute to the proposed NRL targets, but the potential contribution, benefits and costs to the business differ between farming systems. The main benefits for farmers are resilience to the effects of climate change through improved soil functionality; crop pollination services; reduced impacts of floods, droughts and fire; and improved resistance of crops to pests and diseases.

There are costs to landowners and land managers in helping to achieve the NRL targets; many see this as "pay now, most of the benefits will come later". Nevertheless, certain measures, such as improvement in soil fertility, can show benefits already after a short period of time. Costs and benefits will vary between farms depending on:

- the agricultural intensity of the current management system
- the opportunity cost of meeting NRL targets with respect to other land uses (or, in the case of Annex I habitat and high nature value (HNV) farming systems, the cost of avoiding abandonment or intensification)
- the current (baseline) state of the habitats, species and agri-ecosystem indicators and, hence, the capital and ongoing maintenance costs of the NRL
- the transaction costs of making these changes and securing funding.

Capacity building is also required to give farmers and foresters the confidence, skills and knowledge to respond positively to new environmental challenges. Farm advisors and the agricultural education system also need upskilling to accompany farmers with the support they need. There is also a need for more long-term contractual arrangements and governance to ensure the maintenance of restored areas that need to go beyond the six-year EU Multiannual Financial Framework (MFF) funding cycle.

In principle, the flexibilities in the new CAP 2023-27 allow Member States to direct funds to support actions by farmers that aid NRL targets. In addition to the CAP, other sources of EU funding can deliver for agro-ecosystems and forests, including the other EU Regional Development and Cohesion Funds, and financing from supply chain and private funders. Earmarking spending for biodiversity across different EU funds in future MFF cycles could ensure the necessary stability for achieving the long-term investments needed.

4.3. CAP measures to promote environmental sustainability

This section looks at the environmental elements of the CAP, providing an overview of the current situation (as of 2022) and the evolution of policies to this point, together with an overview of the main changes of the new "green architecture" of the CAP 2023-27. It assesses the design and delivery of environmental elements with respect to their outcomes. As described in earlier chapters, the CAP is composed of two pillars. Pillar 1 has traditionally concerned itself with the common market organisation and direct payments to producers. Pillar 2 concerns rural development policy, including ensuring sustainable management of natural resources and climate action. This latter objective is mainly addressed through Agri-Environmental Schemes (AES), although not limited to such schemes. The CAP 2014-22 maintained the existence of two pillars but took a more integrated approach to agri-environmental policy support via the introduction of the green direct payments scheme in Pillar 1 (Greening). The CAP 2023-27 deepens this approach by providing increased funding flexibility between the two pillars, strengthening the cross-compliance and allocating 25% of the budget for direct payments to eco-schemes.

4.3.1. Cross-compliance

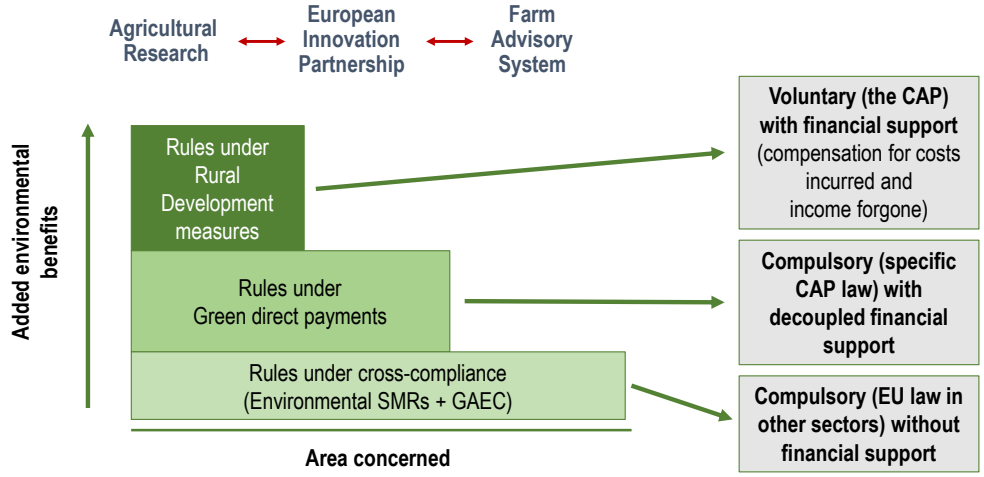
As discussed in Chapter 3, mandatory environmental cross-compliance was first introduced in 2000. It became a requirement in Pillar 1 as part of the Fischler 2003 CAP Reform and from 2005, all farmers receiving direct payments have been subject to compulsory cross-compliance provisions.[21] Cross-compliance aims to ensure that beneficiaries of the CAP implement mandatory basic standards and requirements and it is also designed to raise awareness on the part of beneficiaries regarding their obligations under statutory management requirements (SMRs). Since 2007, cross-compliance has also applied to area related EAFRD payments, and since 2008 to certain wine payments.

The intervention logic of the CAP with respect to the environment is based on a hierarchy of action and compensation based on distinguishing between minimum obligations and extra effort. Cross-compliance[22] is at the base of this hierarchy, tying direct payments to farmers to compliance with a series of rules relating to the environment, food safety, animal and plant health, and animal welfare and to maintaining agricultural land in GAEC (Figure 4.3).[23] These rules are set out (for the CAP 2014-22) in 13 SMRs and 7 GAEC standards. Non-compliance with these standards and requirements can lead to a reduction in CAP payments to the farmer.

SMRs are defined in the respective EU legislation on the environment, climate change, public, animal and plant health, and animal welfare and are obligatory on farmers regardless of whether they participate in the CAP. In 2019, 151 million hectares (84%) of all EU agricultural land were supported under the direct payment scheme and, therefore, subject to the cross-compliance requirements. Cross-compliance requirements have undergone revisions in each CAP cycle since their introduction, though these revisions are typically evolutionary in nature (Figure 4.4). SMRs consistently cover water quality, biodiversity and pesticide use. Initial GAEC requirements targeted soil quality and preservation of farmland area. After 2009, they were expanded to include additional conditions related to water and biodiversity, and after 2013 conditions preserving soil carbon stocks were added.

Member States have flexibility in the design of both SMRs and GAECs, so cross-compliance requirements do not result in the same requirements in all countries. For example, for the retention of landscape features (GAEC 7) in the CAP 2014-22, Member States selected mainly from the nine landscape features suggested in the legislation (hedges, ponds, ditches, trees in line, group of trees, isolated trees, field margins, terraces and traditional stonewalls), but could also choose elements that are not on the suggested list, such as protected trees and natural monuments (Table 4.1). Protection is most commonly applied to groups of trees, hedges and isolated trees, trees in a line, and terraces.

Figure 4.3. Environmental instruments of the CAP 2014-22



Note: SMR: statutory management requirements; GAEC: Good Agricultural and Environmental Conditions; CAP: Common Agricultural Policy.
Source: EC (2016[50]).

Figure 4.4. Evolution of cross-compliance requirements, 2003 to present

Statutory management requirements and GAECs in Common Agricultural Policy regulations

Notes: GAEC: Good Agricultural and Environmental Conditions; PPP: plant production products; SMR: statutory management requirements. All Water Framework Directive minimum obligations in terms of measures for agriculture are not covered by SMR 1 under Regulation 2021/2005. It includes Articles 11 (3)(e) and (h) to cover diffuse pollution of phosphates. Certain GAECs, such as buffer strips, are interpreted and implemented differently by Member States. Natura 2000 refers to environmentally sensitive permanent grassland in Natura 2000 areas. Landscape features in CR 2021/2115 include non-productive areas as well as hedges and trees.
Source: Compilation from CAP regulations as noted in the figure.

Table 4.1. Landscape feature types addressed by Member States in GAEC 7 (CAP 2014-22)

	Hedges	Isolated trees	Trees in line	Trees in group	Field margins	Ditches	Ponds	Stone walls	Terraces	Other[1]
Austria						X	X	X		
Belgium	X	X	X	X	X	X	X			
Bulgaria					X				X	
Croatia	X	X	X	X		X	X	X		
Cyprus	X	X	X	X		X	X		X	
Czech Republic		X	X	X		X	X		X	
Denmark							X			
Estonia	X		X	X		X		X		
Finland										
France	X			X			X			
Germany	X	X	X	X	X	X		X	X	
Greece	X		X			X	X		X	
Hungary		X		X			X		X	
Ireland	X		X			X				
Italy	X	X	X			X	X	X	X	
Latvia[2]	X	X								X
Lithuania										X
Luxembourg	X	X	X	X			X		X	
Malta		X	X	X	X					
Netherlands	X									
Poland		X				X	X			
Portugal	X	X		X		X			X	
Romania		X	X	X					X	
Slovak Republic	X	X	X	X	X				X	
Slovenia	X	X	X	X			X	X	X	
Spain	X	X	X	X	X		X	X	X	
Sweden		X				X	X	X		

1. In addition to the types predefined in the CAP legislation, it is also possible for the MS to nominate "other" landscape features for inclusion into GAEC 7.
2. Latvia nominates other landscape features in GAEC 7 including natural monuments such as protected trees and rock outcrops and requires removal of invasive species of the genus *Latana* on agricultural land. As for hedges some restrictions are applied on dates during which hedges may be cut or trimmed.
Source: Joint Research Centre GAEC database as reported in Czúcz et al. (2022[51]).

Inspection rates and penalties are less than optimal

CAP regulations require that 1% of farms applying for CAP support are selected for an annual check, 75% based on a risk assessment and 25% via a random sample. Penalties for non-compliance are percentages of Pillar 1 payments and so are poorly correlated to environmental damages (Dupraz and Guyomard, 2019[52]). Penalties generally are around 3% of the amount granted as a direct payment, though this varies between 1% and 5%. This level of penalty, combined with the low rate of inspections, has an insufficient deterrent effect and infringement rates for some requirements are high (ECA, 2016[30]; ECA, 2008[53]). On the other hand, the European Commission's own evaluation found that the compliance rate of farmers with GAECs 1 to 7 is estimated to be high, with only 1% to 4% of farmers non- compliant (EC, 2021[54]).

On-farm inspections are a valuable tool for raising awareness of legal requirements, understanding why farms fail to meet them and helping the inspected farm to come into compliance. OECD best practice on

regulatory enforcement and inspection emphasises the importance of proportionality: allocating resources according to the level of risk and taking enforcement actions appropriate to the seriousness of the violation (OECD, 2014[55]). A risk evaluation can help ensure that investments in monitoring and enforcement are sufficient (OECD, 2014[55]). In the case of SMRs, cross compliance is not itself the regulation; it is a supplementary incentive for compliance directed at beneficiaries of direct payments. For this reason, the proportionality of inspection rates and penalties with respect to risk should be evaluated as part of the overall enforcement mechanism of the related legal requirement.

Farm advisory services are in place to help farms meet their cross-compliance obligations, and cross-compliance can provide incentives that "guide the search" for new innovative ideas and methods. That is, cross-compliance and greening requirements could have a positive impact on innovation by favouring the development of agricultural practices and systems that are more sustainable (Détang-Dessendre et al., 2018[56]).

The effectiveness of cross-compliance is hard to measure

It is recognised that the trade-offs between the two CAP policy objectives – farm production and income on the one hand and good ecological health on the other – complicate implementation and contribute to the low environmental efficiency of CAP spending (ECA, 2014[22]; EC, 2021[54]). In this regard, Member States' ambitions are a key factor in effectiveness (EEA, 2019[1]; EC, 2017[57]).

Some positive effects of cross-compliance in promoting biodiversity on grassland and on arable land were observed in Switzerland, where the introduction of ecological compensation areas became conditional cross-compliance requirements in 1998 (Aviron et al., 2009[58]). As for the European Union, direct evidence of the effect of cross-compliance on environmental outcomes is lacking, but generally it is not perceived as an effective tool to improve sustainability. A public consultation of stakeholders, administrators, non-governmental organisations and the general public on the effectiveness of the CAP instruments that contribute to the sustainable management of biodiversity, habitats and landscapes found that GAEC were perceived as the least effective among all options. Forty six per cent of respondents reported GAECs as effective "to a very small extent" or "not at all". GAECs also ranked at the bottom for effectiveness with respect to sustainable management of water and near the bottom with respect to sustainable management of soil (EC, 2021[54]).

A few years after the implementation of compulsory cross-compliance, the European Court of Auditors recognised that cross-compliance had contributed to better respect of the relevant environmental, food safety, health and animal welfare directives and regulations (ECA, 2008[53]). At the same time, SMRs do not place additional requirements on beneficiaries, and cross-compliance with SMRs is an additional penalty for non-compliance. On the other hand, GAECs help to maintain landscape elements (such as buffer strips, grassed strips and terraces), reduce soil erosion and limit the loss of soil organic matter. However, opting for minimum GAEC requirements is unlikely to bring substantial improvements (EC, 2021[54]).

Integration with other agri-environmental policies can increase coherence

The European Court of Auditors has twice examined the effectiveness of cross- compliance (ECA, 2016[30]; ECA, 2008[53]). In its earlier audit, it found that the scope of cross-compliance was not well justified, and that Member States only partially implemented requirements and standards. It noted that the introduction of cross-compliance in 2005 had weakened prior standards for "usual good farming practice".

Closer integration of the policies and regulations related to environmental performance can benefit overall effectiveness and efficiency. In this regard, including elements of the Water Framework Directive (WFD) as an SMR in the new CAP is an important advance. Overall, cross-compliance can promote the external coherence of the CAP, as SMRs introduce mandatory conditionality based on non-CAP legislation. That

said, cross-compliance does not alter the linkages between CAP and other legislation at a programmatic level, i.e. it does not direct CAP funding towards other objectives.

The internal coherence of the CAP instruments and measures to support the sustainable management of biodiversity, soil and water has been assessed as high (EC, 2021[54]). The effectiveness of those instruments on the biodiversity, soil and water objectives depends, however, on Member States' choices and the related level of ambition. Cross-compliance and greening measures are also evaluated as highly coherent with respect to the objectives of biodiversity, soil and water (EC, 2021[54]). Significant synergies exist between SMR 1 (phosphates), SMR 2 (nitrates) and the cover crops' ecological focus area (EFA) choice. However, overlaps of the two can create redundancies.[24]

4.3.2. Greening

The 2013 CAP reform effectively repurposed agricultural subsidies to target more environmental objectives by requiring that 30% of each Member State's direct payments envelope be used for a greening payment for compulsory "agricultural practices beneficial for the climate and the environment". As of 2023, the requirements of the green direct payment scheme will be integrated into cross-compliance requirements and will no longer be associated with specific payments.

The practices required for this greening payment were designed to be simple, general, annual and non-contractual. The three practices identified included: 1) crop diversification (the cultivation of a minimum of two or three crops on arable land above a certain size limit primarily to improve soil quality); 2) the maintenance of permanent grassland (requiring the level of permanent grassland to be maintained at least at 95% of its area as a proportion of total agricultural area compared to a base year, which previously had been a cross-compliance standard, as well as a requirement to protect the most environmentally sensitive permanent grasslands from ploughing, as a measure to protect soil carbon stocks); and 3) a requirement to manage at least 5% of the arable land of farms with more than 15 hectares of arable land as EFAs, comprising a combination of management practices or landscape features as set out in the regulation and applied by Member States, in order to safeguard and improve biodiversity on farms (Box 4.2).

By design, green direct payments need not generate additional environmental benefits but can be for preserving practices already in place. This intervention logic makes sense when repurposing existing direct payments that previously had no environmental requirements beyond cross compliance. Greening is best understood as raising the environmental ambition of the direct payment system rather than a new programme (Kokot, 2021[59]; ECA, 2017[23]; EC, 2016[60]).

Box 4.2. Ecological focus areas

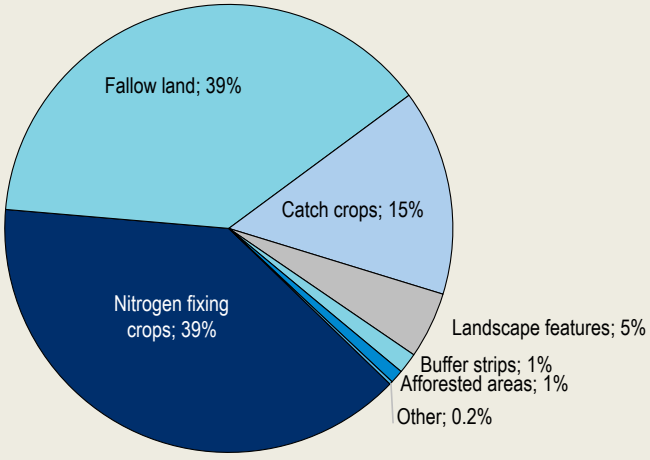
Ecological focus areas (EFAs) were intended to safeguard and improve biodiversity on arable farms in the European Union. Nineteen distinct EFA options were specified with which farmers can meet this obligation, including land lying fallow, catch crops, nitrogen-fixing crops and several types of landscape features, although Member States could decide to offer their farmers fewer EFA options. The contribution of each option to the minimum 5% requirement is weighted to reflect the value of its contribution to the safeguarding biodiversity objective.

In 2015, most EFA areas comprised nitrogen-fixing crops, fallow land or catch crops (Figure 4.5). Famers' choices regarding which EFA type were driven by three factors: 1) opting for the least costly and most productive EFA type; 2) policy-driven factors such as compliance risk and administrative burden; and 3) their perceptions and knowledge of the EFA obligation.

While landscape features make up only about 5% of the EFA area, this EFA type likely has the greatest impact on biodiversity. The most beneficial features are hedges, field margins and traditional stone

walls since they provide habitats for insects and arthropods, birds and plants. That said, certain management practices can enhance the environmental effects of other EFA types, such as the selection of species sown to fallow land or avoiding the use of pesticides.

Figure 4.5. Breakdown of declared ecological focus areas by type at the European Union level, 2015



Source: EC (2017[57]).

The additional benefits of the green direct payment scheme are uncertain

The green direct payment has been criticised because it led to very limited changes in farm practices (Louhichi et al., 2018[61]). This was partly due to exemptions introduced in the legislation and partly because what was asked of farmers was made less demanding in the legislative process (ECA, 2017[23]). The prevalence of productive EFA options (nitrogen-fixing crops, fallow, catch crops) over those options with more obvious biodiversity benefits is seen as a weakness in its implementation. The crop rotation requirements mostly confirm existing practices and are not strongly binding, and the grassland requirements are also mainly designed to maintain the status quo (ECA, 2017[23]). The formal evaluation of the greening payment commissioned by the European Commission concluded that far more could be done to improve the environmental and climate performance of the greening measures (Alliance Environnment and Thünen Institute, 2017[62]).

Although it is not possible to observe the counterfactual that would exist without the EFA, there is some evidence that the 5% EFA requirement does increase the use of the required practices. In 2015, land lying fallow declared as EFA accounted for 34% of the total fallow areas reported in Eurostat statistics for the Member States concerned. Still, the area used for leguminous crops, as reported by Eurostat, has increased by 20% since 2013. Of this, nitrogen-fixing crops declared as EFA represented 49% of the total (EC, 2017[57]). On the other hand, the percentage of EFA areas declared by farmers is almost twice as much as the required 5% at the farm level, indicating that the EFA area requirement may be binding only in certain places and conditions. It has been estimated that typical configurations such as existing buffer strips, field borders and inaccessible field sections that would qualify as EFA already represent 3% of farmland (Bureau, 2013[63]).

The EFA requirement's net impact on biodiversity could be much greater if farmers were to co-ordinate types and spatial arrangements to form larger habitat patches (as larger areas tend to be more resilient, hold more viable populations and have greater species richness) and/or mosaics of complementary habitats and/or Member States would have opted for non-productive elements instead. This might also be beneficial from a soil and water management perspective, depending on the location of the EFA elements (EC, 2021[54]).

Member States' flexibility complicates objective setting and transparency of results

Having so many productive and non-productive options available to farmers makes the share of area under EFA practices hard to interpret and of limited use for monitoring the results achieved (ECA, 2017[23]), which is reflected in the fact that as much as 14% of land was eventually registered as EFA.

In broad terms, the implementation choices that Member States have made suggest that their choices have primarily been driven by socio-economic, financial and administrative factors. This has limited the CAP's potential to address the sustainable management of natural resources despite increasing ambition at the EU level (EC, 2021[54]).[25] In particular, the predominance of productive EFAs, together with insufficient management requirements, reduces the potential benefits of greening for biodiversity (EC, 2021[54]; ECA, 2017[23]). As a response, some regulations were modified in 2018 to enhance the environmental delivery of greening, including via a ban on the use of pesticides and fertiliser on EFAs.[26]

New conditionality in the CAP 2023-27

Enhanced conditionality increases the mandatory layer of the CAP, revising and extending standards for GAECs in cross-compliance and including former greening commitments in a strengthened form. Member States have a degree of flexibility to further increase mandatory measures under conditionality. Previous GAECs have been carried forward and modified, while new conditionality rules related to climate have also been introduced (Section 4.3.1), notably GAEC 2 requiring the appropriate protection of wetland and peatland, with the possibility that the obligation to implement this standard can be postponed to 2024 or 2025 if Member States need additional time for management planning.

The GAEC standards are specified in the legislation in very general terms. It is up to Member States to set a national standard for each of the standards set at the EU level, taking account of the specific characteristics of the area concerned, including soil and climatic conditions, existing farming conditions, farming practices, farm size and farm structures, land use, and the specificities of outermost regions. While such discretion also existed for cross-compliance standards, the European Commission's guidance in prior CAPs had been more specific.

Conditionality sets the baseline for voluntary eco-schemes and AES. The more ambitious the GAEC standards are, the narrower the scope to remunerate farmers for practices that go beyond this baseline in voluntary measures. With respect to the main objectives of the GAEC standards, Member States are permitted to set additional standards to improve the environmental and climate delivery of the GAEC framework.

4.3.3. Agri-environmental schemes

Agri-environmental schemes are voluntary participation programmes that offer payments to provide agricultural public goods beyond the level defined by existing regulations and cross-compliance requirements (OECD, 2012[64]). In general, their objective is to reduce the negative environmental impacts of agricultural activities and incentivise the provision of public goods such as biodiversity, improvement of water quality and carbon sequestration, among others. Most schemes pay for the implementation of specific environmental practices; relatively few pay for the achievement of environmental results.

In the European Union, AES predate the introduction of cross-compliance, with their first appearance in the Agricultural Structures Regulation of 1985 (EU Regulation 797/85). They were initially conceived as a mechanism to compensate farmers for less intensive management of environmentally sensitive areas. They have become part of the CAP since 1987 and have expanded in importance since then, being compulsory for Member States after 1992.

AES, now sitting within Pillar 2 of the CAP alongside other land management measures (such as organic farming support and non-productive investments), are the oldest and the single most significant measures

for pursuing environmental objectives across the farmed landscape, both in terms of the spatial coverage and the resources allocated to them (Batáry et al., 2015[65]). Starting from small beginnings in a few countries where environmental issues were particularly sensitive, they have become a cornerstone of rural development policy applied throughout the European Union and support the management of landscape, biodiversity, natural resources, soil and genetic diversity.

AES are contract-based, with farmers enrolling their land in the scheme for a specified number of years. Farmers who participate in AES are compensated for any additional costs incurred or income foregone, in line with the criteria in the World Trade Organization's (WTO) Agreement on Agriculture to ensure that such expenditure falls into the green box category. The EU AES are not subject to the European Union's WTO ceiling on non-exempt support, although an incentive element (later changed to an element to cover transaction costs) has also been included. Overall, AES should not per se be classified as trade distorting, even if they lead to a positive production effect (Hasund and Johansson, 2016[66]; Glebe, 2007[67]).

Over time, the environmental priorities addressed by AES have expanded and the articulation of priorities at the EU level has strengthened. Maintaining and enhancing the character of cultural landscapes and protecting farmland biodiversity have been core priorities of the majority of AES operating in the European Union since the 1980s. Such measures have been increasingly used to encourage organic farming practices, but also objectives such as improving water quality and soil functionality or the maintenance of sustainable water resources have gradually become more widespread within these measures (OECD, 2011[68]).

Spending on AES has grown in importance, and these policy tools have become more flexible to be adapted to the needs of Member States. Furthermore, AES were referred to as agri-environment measures until 2008 and as agri-environment-climate measures after the 2008 CAP Health Check, which extended their thematic coverage by adding climate objectives. On average, in the period 2015-19, around 13% of EU agricultural area was managed under agri-environmental and climate measure contracts, although this proportion has been higher in the past.

In 2020, 15% of RDP expenditure was allocated to AES and, on average, farmers enrolled in such measures received a payment of EUR 162 per hectare (EC, 2022[69]). The main farm practices beneficial to natural resources supported by European AES relate to limiting livestock density (and pasturing), the conservation of grassland, no or reduced use of pesticides, crop diversification and crop rotation, grass-cutting restrictions, nutrient management, cover crops, and the conservation of landscape features (EC, 2021[54]).

AES often struggle to deliver value for money

AES are often seen as the prototype for payments to farmers for providing public goods. But although evaluations have pointed to some beneficial outcomes, their ecological effectiveness has been disappointing, despite many local and regional successes. The main inhibitors are limited budget, low uptake, and poor design and implementation (Pe'er et al., 2020[70]).

The voluntary nature of participation may lead to the problem of adverse selection, where the farmers that enrol are those that need to make minimum changes to their farming practices, leading to a high deadweight element and limited environmental additionality. In many cases, environmental issues surrounding intensive farms (such as the loss of nutrients and sediment to water and GHG emissions) are not being optimally addressed in scheme design and further development of such programmes is needed to reduce negative environmental impacts (Cullen et al., 2021[71]).

Evaluation studies commissioned by the European Commission on the impact of the CAP highlighted several limitations but also significant environmental achievement obtained through the AES. Biodiversity case studies revealed unnecessary administrative burden linked to designing options for AES (Alliance Environnement, 2019[72]). AES are the most demanding soil-relevant measure in terms of administrative

burden, but they also appear to be the most effective CAP instrument for soil protection, resulting in a favourable cost-effectiveness ratio (Alliance Environnement, 2020[73]). The study on water finds that targeting AES on relevant beneficiaries or geographical areas for water issues has improved their efficiency in some Member States (Alliance Environnement, 2019[74]). AES also supported the management of inputs on 14% of arable and permanent land in the European Union in 2018. However, an analysis of FADN data shows no significant change in fertiliser or plant protection product expenses for holdings entering an AES (EC, 2021[54]).

Inadequate assessment hinders evaluations

In the programming period 2014-20, most AES have been designed to address biodiversity and other environmental objectives rather than climate change. Relatively more measures are relevant or partially relevant to adaptation than mitigation (Alliance Environnement, 2018[75]). The literature on AES effectiveness is also dominated by biodiversity studies, despite the range of public goods that schemes typically seek to deliver, as well as the strategic importance of other policy objectives such as soil fertility, water quality, climate change mitigation and other ecosystem services. New empirical research and on-farm trials to evaluate the public goods arising from interventions for which evidence is weak would help to evaluate overall AES effectiveness (Reed et al., 2020[76]).

To fully assess the effectiveness of the AES, it would also be necessary to further explore the coherence of the CAP instruments and measures that support the sustainable management of biodiversity, soil, water and climate to look for synergies. When combined, support for AES, organic farming, Natura 2000 and investments in physical assets is more effective; and it can be even more effective if also combined with support to knowledge transfer, co-operation and the farm advisory system (EC, 2021[54]).

When assessing the effectiveness of the AES in the European Union, there are several shortcomings in the availability of evidence on the role of AES in the provision of environmental public goods, which are linked to several factors, including data availability and a lack of data comparability (Chapter 3). Moreover, certain outcomes, indicators, interventions, farming systems and countries are less studied than others, which leaves important evidence gaps (Reed et al., 2020[76]). The scientific literature highlights that the assessment of the environmental impacts of AES requires much more work, which is a limiting factor to being able to successfully evaluate their effectiveness. Moreover, evaluations of agri-environmental policy impacts rarely assess both environmental and economic aspects, making it more difficult to assess policy cost-effectiveness (DeBoe, 2020[77]).

Insufficient resources dedicated to AES

Overall, it is unclear whether the resources dedicated to AES are sufficient to achieve EU environmental objectives. The evolutionary process of AES development from one CAP to the next leads to improvement over time, but it does not ensure that AES are tailored to the specific needs of the moment. Moreover, the effectiveness of AES can also be offset by distortive policies such as market price support or output and input-based support (OECD, 2019[78]).

In many EU Member States, payment rates of AES designed for sustainable water management do not cover the opportunity cost for highly productive farms, while in others (e.g. Croatia, Finland Apulia in Italy), transaction costs are covered or limited (e.g. the Netherlands) (Alliance Environnement, 2019[74]). Similarly, as for AES targeted to soil protection, the payment levels provided under AES can sometimes hinder its attractiveness, notably for highly productive farms. In many cases though, the payment rate of Pillar 2 measures relevant for soil was high enough to offset opportunity costs but sometimes too low to cover the administrative costs further incurred by beneficiaries as part of transaction costs (Alliance Environnement, 2020[73]).

Result-based AES have the potential to perform better

AES often suffer from ineffective programme design and targeting (Pe'er et al., 2020[70]; Cullen et al., 2021[71]) increasing number of actors from the public and private sectors have experimented with new approaches that provide better incentives to farmers to increase their provision of ecosystem services (Bredemeier et al., 2022[79]).

The compensation principle used to determine payment levels of the majority of the current AES in the European Union has been criticised as failing to give adequate incentives for the provision of public goods and ecosystem services other than the provision of food and biomass. Results-based schemes have been identified as a way to overcome some of these problems (Burton and Schwarz, 2013[80]). The WTO Agreement on Agriculture does not restrict the use of results-based payments[27] (Hasund and Johansson, 2016[66]), and these have already been successfully used in a number of countries (Table 4.2). This approach offers several advantages that suggest the benefits of its wider use. However, it requires certain conditions to succeed and is not always a practical option. The European Commission has produced a Handbook on the use of results-based approaches that sets out these conditions and explains how to establish such approaches where appropriate (Keenleyside et al., 2014[81]).

Table 4.2. Examples of result-based agri-environmental schemes

Country	Name of scheme	Indicators	Payment basis
Austria	Humus-Program of the Ökoregion Kaindorf	Humus content in soil	Tonne of CO_2 sequestered in humus.
Germany	Harrier nest protection in arable fields (Weihenschutz) – Nordrhein-Westfalen	Number of nests of certain bird species	Forgone income from protecting nests/per nest.
	Co-ordinated grassland bird protection (Gemeinschaftlicher Wiesenvogelschutz) – Schleswig-Holstein	Presence of specific grassland-breeding birds species	Per hectare in those areas where birds have bred. The payment rate increases with the number of nests.
	Species-rich grassland (Artenreiches Dauergrünland) – Baden-Württemberg	Presence of minimum 4 or 6 flower species	Per hectare in those areas where species are found.
	Species-rich grassland (Artenreiches Grünland – Kennarten) – Rheinland-Pfalz	Presence of minimum 4 or 8 grassland plant species	Per hectare in those areas where species are found. The payment rate increases with the number of species.
Ireland	Sustainable agricultural plan for the Macgillycuddy reeks	Peatland scorecard	Based on habitat management costs and the peatland score.
	Managing the habitats of the Aran islands	Habitat condition based on presence and abundance of specific species and management practices	Based on management costs.
	Protecting farmland pollinators	Score obtained from the abundance and diversity of plants and pollinators, farm features, and physical structures	Based on the score and quality of habitat.
	The Burren Programme	Score obtained from management practices and landscape characteristics	Based on cost incurred and income forgone. The payment rate increases with the score.
Spain	Biodiversity in grasslands and improved hedges	Number of grassland species and hedges (characteristics and location)	Based on willingness to accept methods for participating in the programme.

Source: Result Based Payments Network as reported in OECD (2022[82]).

Result-based schemes are particularly well-suited to achieving and maintaining in the long term the EU nature restoration regulations of strictly protected habitats and species, provided they are well-designed and implemented (Box 4.3). Result-based schemes for biodiversity have been funded by the CAP in the past and interest is growing following a 2014-18 pilot (funded by the European Parliament and Directorate-

General for the Environment), which involved farmers in Ireland, Romania, Spain and the United Kingdom.[28] The pilot demonstrated that such schemes could improve the biodiversity status of Natura 2000 and high nature value habitats and support farm incomes while engaging farmers and rewarding their management skills (Byrne et al., 2018[83]; Chaplin, Mills and Chiswell, 2021[84]). Ireland has pioneered the use of CAP funding for result-based scheme support for Natura 2000 habitats and species in its 2014-22 RDP and as part of its new CSPs.[29]

Box 4.3. Result-based payment schemes for biodiversity

The concept is simple: by working with land managers and harnessing their skills, specific farmland habitats (or habitats used by identified species) can be restored to good condition and then maintained in that state for the long term. By defining habitat-specific biodiversity objectives and paying farmers for verifiable result indicators, farmers get higher payments for better results.

Typical indicators are certain characteristic plant species or structural features of the vegetation and ground cover of that habitat (e.g. varied height of grazed swards, areas left uncut, small wet areas). The parcel of land is "scored" by the number of these indicators and the agri-environment payment depends on the score achieved above a minimum performance threshold.

Selecting result indicators requires both ecological and agricultural expertise and must be done with care. A well-chosen results indicator will be representative of the target habitat or species. It should occur consistently in target farmland habitats in the area, be easily identified by farmers and paying agency representatives, easily measurable, sensitive to changes in agricultural management but otherwise stable, unlikely to be influenced by external factors beyond the control of the land manager, and not be achieved easily other than by agricultural management.

Payments to farmers are typically made annually per hectare based on the score band achieved by that field parcel and a pre-defined payment rate for each score band. CAP payments are calculated in exactly the same way as "action-based" environmental land management payments (based on the cost of management required to achieve each score band).

It takes some time to set up result-based payments for biodiversity (to select indicators and a measurement methodology, for facilitation and co-designing with target farmers, capacity building, etc.). Once operational, they have the potential to be cost-effective because farmers will self-select based on whether they can achieve the desired improvements in the indicators.

Farmers may be reluctant to sign up for results-based AES, as the payment depends on outcomes that cannot be perfectly predicted (though there are also many attractive aspects of this type of AES). To overcome this reluctance, hybrid approaches have emerged where results-based and management-based AES are combined to provide some payment certainty for farmers who adopt practices to improve biodiversity (OECD, 2022[82]). These, too, have some complications regarding the need to avoid double payment for the same practices, the different administrative requirements of the two types of AES, and the chance that the management-based component will displace the results-based one rather than complement it.

The OECD recently assessed the cost-effectiveness of different types of AES through a multi country choice experiment with farmers, with the objective of exploring their preferences for contracts based on the adoption of practices, the achievement of environmental results (based on either measured or modelled results) or hybrid mechanisms that offer a payment in exchange for adopting practices and achieving results (OECD, 2022[82]). Results indicate that schemes that pay farmers for achieving specific environmental outcomes (results-based payments) are the most cost-effective. Hybrid payments, in which

participating farmers are paid based on both practice adoption and achievement of environmental results, are the second most cost-effective payment type, while practice based payments, where payment is conditional on adopting specific practices, are the least cost-effective. Result-based AES have several advantages, but they can be rather complex and they may require more specialised knowledge and advisory (Cullen et al., 2018[85]). In many cases monitoring and transaction costs are also higher for both farmers and policy makers (Simoncini et al., 2019[86]), even though advances in digital tools may reduce these costs over time (OECD, 2019[87]).

Collective approaches to AES also hold promise

AES have been typically directed to individual farmers without the spatial co-ordination and collective action that could produce conservation synergies.[30] This is changing, and territorial co-operation and community-based approaches for the provision of environmental public goods are becoming increasingly common. An OECD report on the collective delivery of environmental services offers many interesting examples (OECD, 2013[88]). The majority of collective schemes are based on farmer-to-farmer collaboration to co-ordinate individually implemented practices; areas were managed collectively to reach a defined target, but the underlying contracts were individual (Bredemeier et al., 2022[79]).

Evidence suggests that AES are more effective when designed at the landscape level and implemented by groups of collaborating farmers (Burton and Schwarz, 2013[80]; Franks, 2011[89]). Co-ordinated action and community commitment improve the performance and efficiency of AES, encourage mutual learning and increase social capital (Mettepenningen et al., 2013[90]). The existence of a collective AES creates opportunities for increased spatial co-ordination to enhance conservation outcomes in agriculture (Nguyen et al., 2022[91]). They can also reduce transaction costs for farmers, improve social learning and help farmers engage in decision making beyond the farm scale (Barghusen et al., 2022[92]; Amblard, 2021[93]). Despite these potential benefits, farmers are often pessimistic about the possibility of collective action for environmental purposes (Villamayor-Tomas et al., 2021[94]).

While other EU Member States are still in the early phases of implementing collective AES, the Netherlands has had them as part of its national programme for some time already (Barghusen et al., 2022[92]). Dutch farm collectives are the beneficiaries of the subsidies and responsible for managing the implementation of measures in their area. Forty agricultural collectives were registered in 2020, receiving a total of EUR 71 million in 2019 to cover lost income and related costs (Berkhout, van der Meulen and Ramaekers, 2021[95]). This approach is seen as effective, flexible, cheaper and with less error than previous AES (Terwan et al., 2016[96]).

Another interesting example is the collective management in upland landscapes in southern France, where the funds provided by AES are directly invested to support collective management, such as for community pastures, and not distributed to single farmers for working together (Dodsworth et al., 2020[97]).

Given their potential advantages, their low uptake of collective AES seems surprising. Collective approaches are not mandatory in the CAP's national strategic plans and use thereof among EU Member States remains low. One reason is the start-up costs of establishing and managing the organisations serving as the intermediary between public authorities and individual farmers. Some initiatives are trying to address this by providing solutions to this and other barriers associated with collective engagement in agri-environmental schemes (Prager, 2015[98]).

Voluntary AES in the CAP 2023-27

Only limited changes were made to the provisions governing voluntary AES in the new legislation. The most important one, as for eco-schemes, is that Member States are no longer obliged to use average or representative costs as the basis for their compensation calculation but can set compensation at the level that will attract the desired level of participation in the scheme. There is no longer a specific measure

supporting organic farming; such support is now authorised under the general AES heading. The legislation also ring-fences 35% of a country's rural development budget for agri-environment-climate commitments (with 50% of expenditure for areas characterised by natural or other area-specific constraints included in the calculation of this percentage).

4.3.4. Characterising AES in EU Member States

Following the rules and legislation of the EU Rural Development Policy of the CAP, targeting and delivery of AES and the calculation of payment rates are made by Member States, reflecting their differing needs and environmental priorities and, indeed, their varying institutional capacity to apply to the measure. As a result, there is considerable diversity amongst the range of AES currently operating in the EU27.

This section provides an overview of the results of the AES questionnaire, which gathered information on key design features of the agri-environmental schemes applied by EU Member States (OECD, 2022[99]). The analysis is largely based on the taxonomy developed to characterise AES, where eight design features were identified as essential in determining the cost-effectiveness of AES: 1) targeting mechanisms; 2) use of baselines; 3) tailored payments; 4) contract flexibility; 5) technical assistance; 6) inspections; 7)penalties; and 8) policy evaluation tools (Guerrero, 2021[100]).

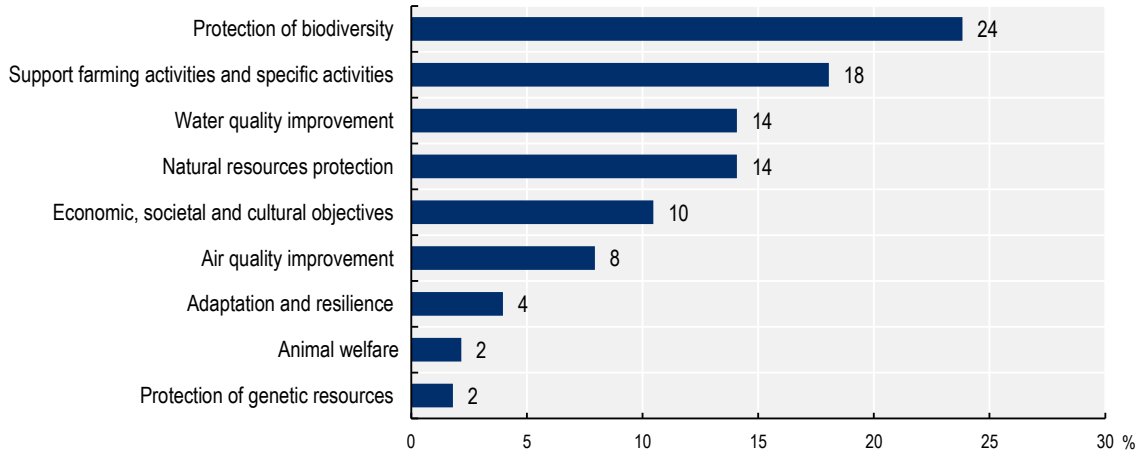
The questionnaire asked Member States to rank the three most important AES in terms of budget allocated in the 2014-20 programming period. Answers were then categorised in one of the 20 rural development measures defined by the European Commission in the context of rural development plans. A large majority of schemes (35 out of 59) is implemented as a sub-measure or operation of the agri-environment-climate measure (Measure 10); one-quarter of schemes (15 out of 59) are implemented in the context of the organic farming measure (Measure 11); a minority of schemes are implemented in the context of the investments in physical assets measure (Measure 4) (7 out of 59), animal welfare (Measure 14) and co-operation measures (Measure 16) (1 out of 59 each). Some of the answers reported below refer to the three selected schemes only, but since these concentrate about two-thirds of the overall budget allocated to AES in each Member State, such measures can be considered representative of the main features of the AES in each country.

The most commonly cited objectives for the selected measures were protecting biodiversity, which may entail a broad biodiversity goal or the protection of specific species (e.g. pollinators, crops, livestock); protecting ecosystems and landscapes; followed by support to farming activities and other specific activities, which include, for example, traditional practices, organic and sustainable farming, and pest management (Figure 4.6).

Results from the questionnaire also help to characterise key features of AES in Member States (Table 4.3). Overall, it was possible to identify the presence of several features that may be conducive to cost-effectiveness, such as the presence of baselines, enforcement mechanisms or contract adjustment clauses. However, targeting mechanisms should be improved adopting cost-effectiveness or environmental performance criteria in enrolment screens, by increasing bid-based mechanisms and result-based payments, and better integrating cost-effectiveness criteria into policy evaluation.

Figure 4.6. Main objectives of the selected agri-environmental schemes in EU Member States

Percentage of schemes in Measures 4, 10 and 11



Source: OECD (2022[99]).

Table 4.3. Presence of key design features in agri-environmental schemes of EU Member States

AES design features	Questionnaire results
Theme definition	(+) AES are generally designed as part of a broader policy package
Budget	(-) In around one-quarter of Member States, the budget is still based on past programme spending
Baselines	(+) Widespread presence of reference levels in eligibility criteria
Payments	(+/-) Differentiated payments in more than half of AES but scarce diffusion of bid-based and result-based payments
Flexibility	(+) AES can be revisited and modified
Engagement	(-) Stakeholders generally play only a consultative role
Eligibility criteria	(-) Only in a minority of Member States are eligibility criteria based on *ex ante* evaluations
Enrolment screens	(-) No enrolment screens in the majority of AES
Inspections	(+) Presence of both on-the-spot inspection controls and administrative data
Penalties	(+) Payment reduction to non-compliant widely diffused
Technical assistance	(+/-) Some form of technical assistance is provided but may be lower than ideal
Policy evaluation	(-) Cost-effectiveness not commonly evaluated

Notes: AES: agri-environmental scheme. Plus or minus symbols indicate whether the survey result is considered positive or negative with respect to cost-effectiveness.
Source: OECD (2022[99]).

AES theme definition. In almost all Member States participating in the survey (19 out of 20 respondents), AES are designed as part of a broader policy package. According to the respondents, the assessment of key environmental issues and national programmes/priorities play an equally important role in the definition of the priority themes for the AES (both are selected by 18 out of 20 respondents), but past programmes were also considered relevant in many Member States (14 out 20). Finland indicated that priority themes are chosen in direct co-operation with stakeholders, while Austria and Portugal also stressed the relevance of EU legislation and strategies when defining AES objectives.

Budget definition. In a large majority of Member States (70%), the budget for the AES is decided in advance based on the estimated cost of achieving a specific measurable objective. In around one-quarter of Member States, the budget is chosen based on past programme spending. It is extremely uncommon (5%) for the budget to depend on participation rates, regardless of whether a cap is applied or not, and the budget is never decided based on a negotiation with stakeholders.

Baselines. Establishing baselines, benchmarks or reference levels improves the effectiveness of policies, as payments will go to those beneficiaries who adopt practices or produce outcomes above those reference levels. More than 80% of schemes specify baselines or benchmarks in their eligibility criteria, and 56% of AES establish a minimum level of supported activity; land cover restrictions clauses are present in 36% of analysed schemes.

Payments. The payment rate has important implications for budgetary cost-effectiveness of the AES; tailoring payment rates is especially crucial to provide transfers no greater than necessary to obtain the desired outcomes (OECD, 2007[101]). The majority of AES use forgone revenue (92%), followed by estimated or actual participation costs (69%). None of the schemes uses a bid-based mechanism to calculate payments, whereas only a minority takes into account the estimated or actual environmental performance (8%). Almost half of the analysed schemes provide for uniform rather than differentiated payments. When payments are indeed differentiated, this occurs most often based on the following criteria: land use (approximately 20% of analysed schemes), extent of practices applied, farmland size or other criteria (all respectively applied by 12% of schemes). Individually differentiated payments are only implemented in 12% of analysed schemes. Payment rate characteristics are, therefore, only partially in line with the set of characteristics considered essential for AES effectiveness; these recommend the use of tailored payments (which are only used by half of the analysed schemes), based either on participation costs or on bid-based mechanisms (Guerrero, 2021[100]).

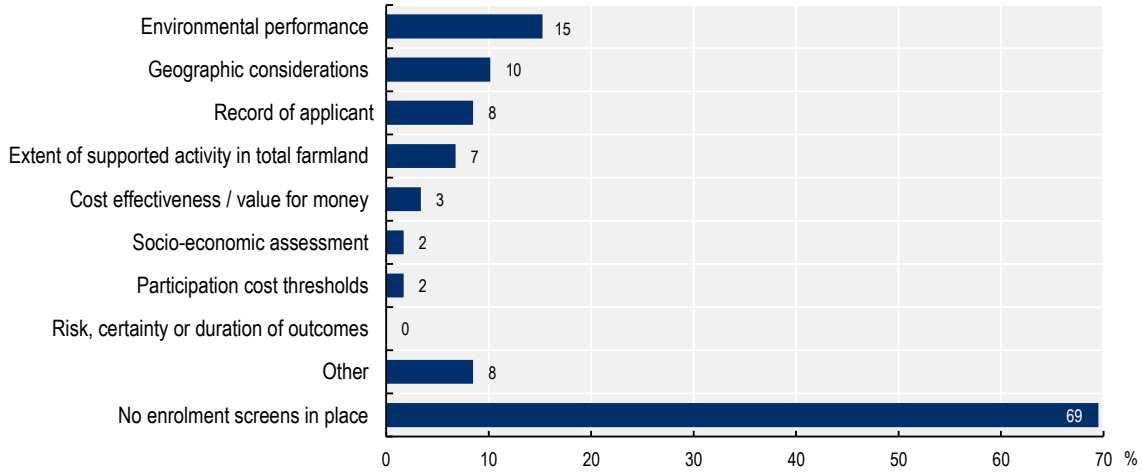
Engagement. Engagement with potential recipients of the agri-environmental schemes occurs at different stages of the policy cycle, but it is worth noting that in almost all Member States (17 out of 20 respondents), stakeholders are engaged in defining objectives, strategies and needs. In approximately three-quarters of Member States, stakeholders are also informed in advance of planned AES. In Spain, stakeholders are engaged throughout the entire policy process, as well as in public consultations, while Austria, France, Poland, and Portugal mentioned that stakeholders are more generally involved in the development of the intervention and/or its specifications and the design of the scheme. Overall results show that even if stakeholders are engaged in all Member States to different extents, they generally play a consultative role (providing comments and/or participating in discussions about the design of schemes). None of the responding countries reported that stakeholders co-manage or are equal partners in setting the agenda. As reported above in the examples of France and the Netherlands, in some countries, local organisations and co-operatives are in charge of the local implementation of AES schemes.

Eligibility criteria. The policy implementation phase has three main pillars: 1) distribution of benefits among beneficiaries; 2) monitoring and control instruments; and 3) technical assistance (Guerrero, 2021[100]). First, during the distribution phase, eligibility criteria and enrolment screens define scheme recipients and the actions they will implement. As for the Member States participating in the survey, eligibility criteria are most commonly decided on the basis of EU and/or national legislation (19 and 16 out of 20 respondents, respectively), but expert consultation and political considerations are also relevant (15 and 10 out of 20 respondents, respectively). Only in a minority of Member States (4 out of 19) are they based on *ex ante* evaluations.

Enrolment screens. Enrolment screens can be considered one of the essential features to ensure the cost-effectiveness of AES and should ideally be based on cost-effectiveness and/or environmental performance or directly support environmental performance or results. For a large majority of selected AES, enrolment screens are not used to select recipients from the pool of applicants that have already met the eligibility criteria (Figure 4.7). When enrolment screens are in place, these are most commonly based on environmental performance or geographical considerations.

Figure 4.7. Enrolment screens for selected agri-environmental schemes in EU Member States

Percentage of schemes in Measures 4, 10 and 11



Source: OECD (2022[99]).

Checks, inspections and penalties. The second pillar of scheme implementation refers to the monitoring and control phase, which requires monitoring compliance with scheme requirements and conditions and scheme enforcement actions: checks, inspections and penalties. Almost all analysed schemes (96%) use both on-the-spot inspection controls and administrative data to verify compliance with the contract. Self-reported data (such as beneficiaries' bills, records and/or receipts) and data from digital technologies are also widely used (almost 70% of schemes).

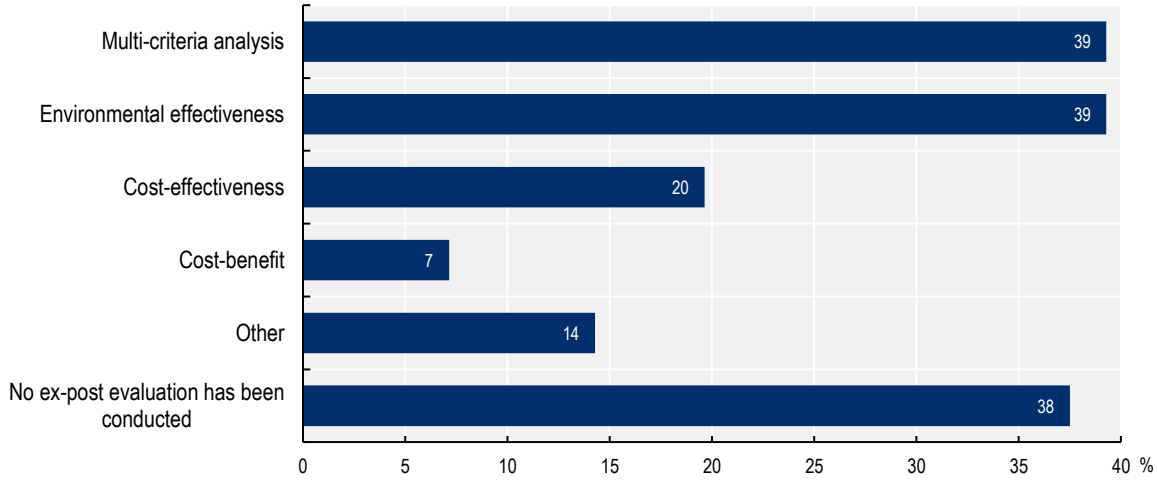
Technical assistance. The third pillar of the implementation phase is technical assistance, which involves training sessions, information dissemination and the use of tools such as software to simulate scheme interventions, monitoring devices and digital technologies (satellite images, sensors, apps, etc.) for monitoring outcomes. Almost all the analysed AES provide some form of technical assistance to recipients (93%). The most common forms of assistance are: the provision of training and the use of extension services (both provided by more than 60% of schemes); digital technologies are used by approximately one-third of schemes.

Policy evaluation. Regular evaluation of policies helps to detect flaws and strengths and points to areas for improvement. As such, policy evaluation tends to play an important role in improving the cost-efficiency of AES. Such evaluation can be undertaken before (*ex ante*) or after (*ex post*) a given policy is enacted. The survey included several questions to gather information on both *ex ante* and *ex post* policy evaluation. In the majority of respondent countries (13 out of 19), programme evaluations are carried out during their implementation rather than at their conclusion. Some countries stress that evaluations at different intervals of time, e.g. through a mid-term evaluation and *ex post* evaluation (Belgium, Flanders; Finland; France; Portugal) or annual reports (Slovak Republic); some receive feedback on the implementation on a continuous basis (Denmark). The evaluation tools and modalities are quite varied across Member States: survey of programme administrators, survey of recipients, and internal and external analyses are equally common evaluation methods used by 42-47% of Member States. *Ex ante* evaluations of potential impacts of the schemes can help to inform and decide policy features such as eligibility and enrolment criteria, payment mechanisms, and monitoring and compliance mechanisms. In all Member States, *ex ante* evaluations are mandatory and in almost all the investigated Member States (19 out of 20 respondents) are conducted at the design stage. Nevertheless, in a large majority of countries (14 out of 20), *ex ante* evaluations are consultative rather than determinant. In Lithuania, *ex ante* evaluations are consultative,

with the exception of the Strategic Environmental Assessment conducted by the State Service for Protected Areas, whose conclusions are binding. In the Czech Republic, they are formally consultative, but if no argument is found against the proposed amendments, these have to be integrated into the AES. In a large majority of countries (14 out of 20), *ex ante* evaluations are part of a Strategic Environmental Assessment. The majority of the selected schemes call for some form of *ex post* evaluation (62%). The most common criteria employed are environmental effectiveness or a multi-criteria analysis. Cost-effectiveness and cost-benefit criteria are used, respectively, by 20% and less than 10% of schemes (Figure 4.8).

Figure 4.8. *Ex post* evaluation in selected agri-environmental schemes in EU Member States

Percentage of schemes in Measures 4, 10 and 11



Source: OECD (2022[99]).

4.3.5. Eco-schemes: The new instrument introduced in the CAP 2023-27

Eco-schemes are voluntary for farmers and refocus some Pillar 1 funds on climate-friendly actions in agriculture. These schemes for the climate, environment and animal welfare aim to reward farmers who manage land in a nature- and climate-friendly way. The CAP Regulation requires each eco-scheme to cover at least two areas of action for the climate (mitigation and adaptation), the environment (protection or improvement of water quality, reduction of pressures on water resources, prevention of soil degradation, soil restoration, improvement of soil fertility and nutrition management, protection of biodiversity, conservation, restoration of habitats or species, reduced or sustainable use of pesticides), animal welfare and anti-microbial resistance.

Practices that could be funded under eco-schemes overlap with those that can be funded under voluntary AES in Pillar 2 of the CAP (DG AGRI, 2020[102]; EC, 2021[103]). A recital in the Strategic Plans Regulation notes that "It should be possible for Member States to establish eco-schemes as 'entry-level schemes' as a condition for farmers for taking up more ambitious environmental, climate-related and animal welfare commitments under rural development". Whether eco-schemes and AES are linked in this way or are programmed as stand-alone measures, the "no double-funding" obligation applies (commitments under the two measures must be different) and in both cases should go beyond the mandatory conditionality standards. However, Member States can design enhanced eco-scheme commitments to complement conditionality. A preliminary assessment conducted by Runge et al. (2022[104]) on eco-schemes in 15 Member States shows that the majority either build upon components from past greening obligations that did not become compulsory under conditionality or stem from AES.

The major differences between the eco-schemes and AES are that the eco-schemes are confined to farmers in receipt of direct payments, are annual and have greater flexibility in the way payments are set. Payments in eco-schemes can be determined either on the compensation principle for costs incurred and income foregone (as for AES) or set as a top-up to the basic payment when the practice covered by the eco-scheme is not linked to any form of production. The payment under the compensation principle can take account of the targets set for eco-schemes, implying a more flexible interpretation of the compensation principle than that used in the CAP 2014-22. The top-up option can enhance the attractiveness of enrolling in eco-schemes for more intensive farms. However, it may also allow schemes that are primarily intended to provide income support under the guise of being an environmental scheme. Thus, just as evaluations of the greening payment found, there is potential for considerable deadweight in the implementation of eco-schemes.

Eco-schemes suffer from several design weaknesses that could limit their effectiveness. One is that they are located within the annual payments structure of CAP Pillar 1. In principle, there is the option to extend eco-schemes several years where suitable, but as they are non-contractual, such commitments would not appear to be binding. In practice, farmers who opt into an eco-scheme in one year are likely to continue to opt-in in later years. Also, the benefits of some eco-scheme practices (e.g. tree or hedgerow planting) will continue in later years even if a farmer does not later enrol in a similar eco-scheme. An annual scheme may allow farmers who have not previously engaged with environmental and climate-friendly agricultural practices to gain experience in these practices without committing to a multi-year contract. This increases the likelihood that they may later enrol in an AES (Runge et al., 2022[104]). Nonetheless, the environmental and climate benefits of annual schemes are likely to be more limited than the benefits derived from similar multiannual AES, where collective efforts can be encouraged (ECA, 2018[105]).[31]

The European Commission reports 184 eco-schemes in 27 Member States based on the draft CSPs (EC, 2022[106]). Many different types of eco-schemes are available to farmers. Individual measures vary in their complexity: some focus on a single requirement regarding a particular management practice while in other countries, a single measure contains a bundle of requirements to be respected, so the number of measures alone does not give the full picture. The agricultural knowledge and innovation system (AKIS), a mandatory element of the CAP 2023-27 (Chapter 5), could play a key role in fostering training and advice on sustainability issues. This may also facilitate the uptake of eco-schemes (Runge et al., 2022[104]).

4.3.6. The role of climate change in the CAP

Attention to climate change accelerated in the CAP 2014-22

Attention to climate change accelerated in the CAP 2014-22, most notably through the greening requirements in Pillar 1 and the relabelling and reform of AES into agri-environmental and climate measures in Pillar 2. The 2013 reform incorporated climate priorities by making climate action one of the three new core CAP objectives, with climate action becoming an objective for both pillars for the first time. In Pillar 1, measures were subject to formal monitoring and evaluation requirements alongside Pillar 2 for the first time, with relevant climate indicators put in place (i.e. result indicator 17% of agricultural land under management contracts targeting the reduction of GHG and/or ammonia emissions).

In the second pillar, EU RDP Priority 5 focused on resource efficiency, and a low-carbon/climate-resilient economy. The focus areas for Priority 5 include: increasing efficiency in energy use in agriculture and food processing; facilitating the supply and use of renewable sources of energy; reducing GHG and ammonia emissions from agriculture; and fostering carbon conservation and sequestration in agriculture and forestry. Several measures under the EAFRD have an intervention logic involving the mitigation of GHG emissions (Table 4.4).

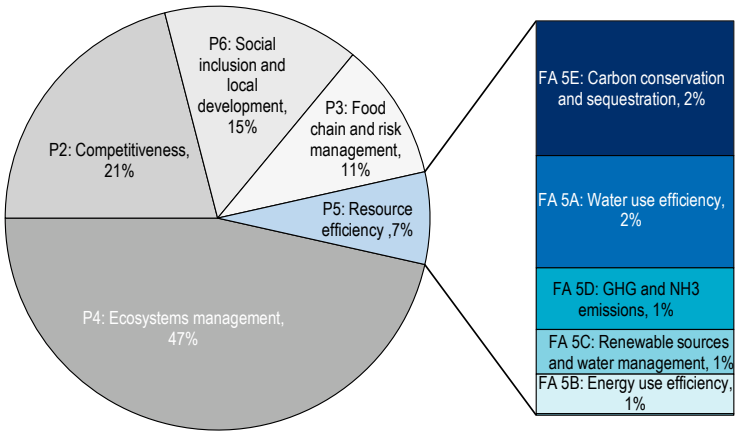
Table 4.4. Measures under Rural Development Programme 2014-22 and their theoretical impact on greenhouse gas mitigation

Measure	Purpose of measure	Theoretical impact on greenhouse gas mitigation
M2	Advisory farm management and relief services	Provision of knowledge on issues such as climate change
M4	Investments in physical assets	Support provision of physical infrastructure contributing to climate mitigation (i.e. animal housing and equipment)
M6	Farm and business development	Content of business plans must provide details of actions related to environmental sustainability and resource efficiency
M7	Basic services and village renewal	Refers to investments in renewable energy and energy saving (7.2)
M8	Forest investments	Extend and improve forest resources (including agroforestry) as climate-friendly land use
M10	Agri-environment climate measures	Support for farmers or groups of farmers to change or maintain their agricultural practices to contribute to climate change mitigation and adaptation that are compatible with protecting and improving the environment and landscape, natural resources, soil, and genetic resources
M11	Organic farming	Generally lower direct emissions per hectare farmed than conventional systems due to greater use of soil management and legumes
M12	Natura 2000	Compensate farmers disadvantaged from having to farm in Natura 2000 areas and meet requirements beyond those outside such areas
M15	Forest-environment-climate	Provides support for forested land and protects carbon stock in soil and above-ground biomass
M16	Co-operation	Supports a variety of forms of co-operation, including joint actions to secure greater climate benefits on a greater scale

The European Commission estimated that measures on climate-related expenditures under the 2014-20 funding period totalled EUR 14.7 billion per year, representing 26% of the CAP budget. The Court of Auditors reassessed this number to a more "prudent" estimate of 18%, because many of those measures primarily address biodiversity, water and air quality, and social and economic needs (ECA, 2021[107]). This compares to the EUR 20.4 billion per year that the European Union spent in 2019-21, on average, on market price support and on payments based on output and on the unconstrained use of variable inputs (OECD, 2022[108]), i.e. on the policy measures that are the potentially most environmentally harmful (Henderson and Lankoski, 2019[109]).

Funding for climate mitigation focus areas under Priority 5, as a proportion of total spending allocated to the programmes, may, in fact, have been quite limited, and measures supported during this period generally were not those with the highest potential to mitigate emissions (ECA, 2021[107]; ENRD, 2021[110]). A total of EUR 7.7 billion, approximately 5% of the total public expenditure under RDPs, was set out under Priority 5, with just 1.1% dedicated to GHG and ammonia emissions (FA 5D) and 2.4% dedicated to carbon conservation and sequestration (FA 5E) (Figure 4.9). The 118 RDPs, on average, allocated less than 5% of their budget to climate mitigation focus areas, with just 11 allocating more than 20% of their budget to climate change mitigation actions under Priority 5 (ENRD, 2021[110]). The aggregated targets that were set for the result indicators under Priority 5 are also an indication of the overall level of ambition of the related public expenditure: across all RDPs, 1% of livestock units (R.16) and 2% of agricultural land (R.17) was targeted for actions to reduce GHG and ammonia emissions, while 0.3% of agricultural and forest land was targeted to come under management contracts for carbon sequestration (R.20).

Figure 4.9. Share of planned total public expenditure per priority and selected focus areas in the European Union, end-2018



Notes: GHG: greenhouse gas; P: priority; FA: focus area. EU28.
Source: ENRD (2021[110]).

CAP 2023-27 support to climate change mitigation objectives

The 2023-27 CSPs combine a range of targeted interventions addressing the specific climate needs of each EU Member State and demonstrate how they will deliver tangible results in relation to EU-level objectives, specifically how they will contribute to the ambitions of the EGD.

CSPs must demonstrate result-based outcomes. Updated CAP legislation established a new set of indicators (result indicators, impact indicators, output indicators) as part of a performance, monitoring and evaluation framework. Climate-related indicators include: impact indicator I.10 (contributing to climate change mitigation); result indicator R.13 (share of livestock units under support to reduce GHG emissions; result indicator R.14 (share of land under supported commitments to reduce GHG emissions or to maintain or enhance carbon storage). These indicators will be monitored through annual performance reports and biannual reviews of the performance of the CSPs, which will assess Member States' progress. CSPs must also abide by the "no backsliding" rule, meaning they must demonstrate increased ambition in their climate-related measures over the previous funding period.

The new CAP can support the uptake of carbon farming (Box 4.4) in the European Union through payments as well as developing skills and funding for pilot schemes. The CSPs are intended to be a vehicle to support various interventions facilitating the uptake of carbon farming, either through Pillar 1 eco-schemes or Pillar 2 rural development environment-climate and investment interventions, investments, and co-operation measures, with support for advice and training. Besides the CAP, other sources of EU funding will come from the LIFE programme, Horizon Europe projects and Cohesion Funding.

Box 4.4. Carbon farming

The European Commission adopted a Communication on Sustainable Carbon Cycles (EC, 2021[111]) at the end of 2021, outlining an action plan to accelerate the upscaling of carbon farming practices through the integration of carbon farming activities into public support, as well as the development of a regulatory framework for the accounting and certification of carbon removals. In November 2022 the Commission proposed a Regulation (EC, 2022[112]) to establish an EU certification framework for carbon removals, where carbon farming is defined as a "a carbon removal activity related to land management that results in the increase of carbon storage in living biomass, dead organic matter and soils by enhancing carbon capture and/or reducing the release of carbon to the atmosphere".

The potential for increasing carbon removals in the agriculture sector is particularly relevant to the European Union's mandated targets under the LULUCF Regulation, which has set the objectives of increasing the European Union's carbon net removals to 310 Mt CO_2-eq by 2030 and the achievement of climate neutrality for the land-use sector by 2035. Examples of carbon farming practices with the most promising climate mitigation potential are the restoration of drained peatland, paludiculture, agroforestry, afforestation, the maintenance of permanent grasslands and the management of arable soils measures (such as minimum tillage and catch crops on arable lands). Such practices have the potential to mitigate 3-12% of current EU emissions (26% of EU agricultural sector emissions) (McDonald et al., 2021[113]). However, mitigation potential can vary widely, as it is dependent upon how, where and for how long the practices take place. In addition to the policy relevance for the LULUCF Regulation, certain practices have co-benefits for biodiversity objectives in the Nature Restoration Law as well as the Climate Adaptation Strategy. Co-benefits include reduced risks of soil erosion and floods, improved soil health and productivity, improved water filtration and availability, and improved microclimate adaptation (McDonald et al., 2021[113]).

The proposed certification mechanism is based on robust and transparent carbon accounting to monitor and verify the authenticity of carbon removals. However, monitoring, reporting and verification of carbon removals present many challenges in practice. Data monitoring of the impact of carbon farming is difficult, as EU countries are not legally required to monitor key soil attributes, and the European Union does not have common indicators or methods to monitor soil health. Certain carbon farming practices also present risks to biodiversity that will need to be mitigated. Most certification mechanisms issue credits following a baseline – a counterfactual against which future removals are compared, with the difference considered additional. Different baseline setting approaches have strengths and weaknesses, with simpler methods resulting in less accurate quantification and more complex methods resulting in higher transaction costs. Carbon leakage – when a carbon farming initiative increases emissions elsewhere due to land-use change – can also increase administrative costs due to complexity if the mechanism involves quantified estimates of either whole lifecycle analysis or whole farm analysis. There are not only difficulties in quantifying how much carbon is being stored but also for how long. Monitoring, reporting and verification approaches must account for the permanence of storage and manage the risks of reversals (either through natural disasters or intentionally) to avoid crediting carbon that does not remain stored in the long term. A robust monitoring, reporting and verification system that improves upon current monitoring systems for soils and land-use emissions can help address these challenges. Investments in developing cost-effective but accurate monitoring, reporting and verification, with better enforcement of data monitoring, seem a necessary first step.

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Notes

[1] The agreement includes concrete measures to halt and reverse nature loss, including putting 30% of the planet and 30% of degraded ecosystems under protection by 2030.

[2] The European Parliament proposed repealing the use of LULUCF credits and restricting the rules on borrowing, banking and trading. The European Parliament also recommended the European Commission produce a report assessing EU-wide non-CO_2 emissions reductions planned and implemented under relevant EU and Member State laws and policies. If needed, the European Commission should recommend additional mitigation measures, and where appropriate, potentially include sectoral targets or sector-specific measures, or both.

[3] This is not without controversy. The Rapporteur for the LULUCF Regulation in the European Parliament's Committee on Environment, Public Health and Food Safety argued against this merger, saying that there was "no benefit" of bringing non-CO_2 emissions of agriculture into LULUCF and instead sees a "risk of hiding emissions from the agricultural sector behind forest sink…without incentives for the agricultural sector to decrease emissions."

[4] Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.

[5] Ecological status and chemical status for surface waters (including environmental flows); quantitative and chemical status for groundwater bodies.

[6] The WFD list of priority substances was updated by the Directive on Environmental Quality Standards (Directive 2008/105/EC), also known as the Priority Substances Directive, which also set environmental quality standards for the substances in surface waters. The list was replaced again in 2013 by Annex I to Directive 2013/39/EU, which also included environmental quality standards and some other provisions on chemical pollutants.

[7] The second RBMPs show a marked reduction in water bodies with "unknown" status and improved confidence in assessment. For surface water bodies, the proportion in unknown ecological status and chemical status fell from 16% to 4% and from 39% to 16%, respectively, while, for groundwater bodies, the proportion in unknown chemical status and quantitative status decreased to only 1% (EEA, 2018[12]).

[8] The European Court of Auditors notes this same issue for monitoring information related to the CAP policy development cycle (ECA, 2018[105]). Some lag in reporting is inevitable for technical reasons. In water monitoring time is needed to have reliable data worthwhile for analyses. Data are also dependent on weather and many other fluctuating short-term conditions.

[9] Council Directive 91/676/EEC of 12 December 1991 Concerning the Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources.

[10] Fertiliser use can also result in emissions of ammonia (NH_3), nitrogen oxides (NO_x) and nitrous oxide (N_2O) to the atmosphere, contributing to poor air quality and climate change. These emissions are covered, *inter alia*, by the National Emissions Ceiling Directive and the WFD.

[11] Eutrophism in fresh waters in dominantly caused by phosphates, while in brackish or salty waters nitrates are the main cause.

[12] Annex III requires certain measures to be included in NAPs, such as minimum manure storage capacity, periods where the application of fertiliser is prohibited and limits to the total land application of fertiliser.

[13] Among these are Belgium, the Czech Republic, Denmark, Finland, Germany, Latvia, Luxembourg, and Poland (EC, 2021[29]).

[14] Denmark, France, Germany, and Luxembourg.

[15] European Parliament Resolution of 12 February 2019 on the Implementation of Directive 2009/128/EC on the Sustainable Use of Pesticides (2017/2284(INI), https://www.europarl.europa.eu/doceo/document/TA-8-2019-0082_EN.html.

[16] Eurostat Agri-environmental indicator – consumption of pesticides. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_consumption_of_pesticides.

[17] The 2022 reviews were delayed for technical reasons and will be carried out in 2023.

[18] Council of the European Union press release of 19 December 2022: https://www.consilium.europa.eu/en/press/press-releases/2022/12/19/council-calls-for-a-complementary-impact-assessment-on-the-sustainable-use-of-plant-protection-products-proposal.

[19] According to CAP Regulation (EU) 2021/2115. SMR 8 refers to SUD Article 5(2) (certification) and Article 8(1) to (5) (equipment checks); Article 12 with regard to restrictions on the use of pesticides in protected areas defined on the basis of Directive 2000/60/EC and Natura 2000 legislation; Article 13(1) and (3) on handling and storage of pesticides and disposal of remnants.

[20] This estimate excludes Romania (which does have a significant area of semi-natural habitats in pastoral use, but accurate estimates are not available); and including a relatively small area of natural habitats, mostly in remote or localised areas that are extensively grazed but not dependent on grazing by farm livestock for maintenance of their ecology and biodiversity

[21] The first cross-compliance requirements were put in place in 2000 for set-aside (Article 19.4 Regulation 2316/1999) and as part of Pillar 2 AES which were requirements for so-called ‘Good Farming Practice’ (GFP). In 2001, the Small Farmers’ Scheme (Regulation 1244/2001) required farmers receiving decoupled payments under this scheme to keep their entire holding in “Good Agricultural Condition” as defined by their Member States.

[22] In the new CAP, the term is “enhanced conditionality”.

[23] Cross-compliance also applies to seven rural development measures, which represented approximately 40% of planned EAFRD expenditure for the 2007-13 period.

[24] Member States can act to limit or avoid deadweight through additional restrictions, as in the Netherlands, where catch crops required under SMR 1 cannot be declared as EFAs.

[25] This conclusion is not restricted to greening and has been noted for cross-compliance and the WFD.

[26] Commission Delegated Regulation (EU) 2017/1155 of 15 February 2017.

[27] One green box criterion for environmental payments is that "the amount of payment shall be limited to the extra costs or loss of income involved in complying with the government program". Therefore results-based payments do not meet the criterion for exemption but are still permitted since the European Union has a very large margin (many billions of euros) below the ceiling on non-exempt support (the amber box).

[28] See https://ec.europa.eu/environment/nature/rbaps/index_en.htm (accessed on 10 November 2022).

[29] Using a combination of agri-environment, environmental investment and (especially) co-operation measures. Ireland's CAP Strategic Plan 2023-27 is available at: https://www.gov.ie/en/publication/76026-common-agricultural-policy-cap-post-2020 (accessed on 10 November 2022).

[30] Collective action mechanisms have been also identified as one of the three necessary pillars for sustainable management of groundwater resources in agriculture (OECD, 2015[114]).

[31] Member States may choose to target eco-schemes to specific areas (territories) if this is justified by the SWOT analysis and the needs assessment, but there is no mechanism in eco-schemes to encourage groups of farmers within an area to work together to achieve environmental change at the landscape level.

5 Innovation for sustainability

The European Union plays a major role as a research and innovation catalyst across European countries. Over the last decade it has implemented a broad range of research and innovation programmes to foster the transition towards more sustainable food systems. This chapter analyses the European Union's Agriculture Knowledge and Innovation System (AKIS), its actors, and the related policy incentives and organisational structures. While the European Innovation Partnership for Agricultural Productivity and Sustainability is an important initiative with high potential to make enhanced productivity and environmental sustainability mutually compatible, resources devoted to agricultural knowledge and innovation are relatively limited compared to the total support provided to the sector and the adoption of innovation remains challenging. The chapter also identifies skills imbalances and examines the role of farm advisory services in addressing them. Enhancing digitalisation and further strengthening data strategies are key to improving the monitoring of EU policies, create awareness, facilitate knowledge exchanges, and to finding innovative solutions.

Key messages

- Research and innovation (R&I) play a prominent role in the European Union as key levers to achieving the environmental, economic and social sustainability of the agricultural sector. Horizon Europe's far-reaching vision sets a strategic orientation for R&I, including in areas such as agriculture and food systems.
- Unlike other sectors, agricultural research and development are financed primarily from public sources. The resources devoted to agricultural knowledge and innovation are relatively limited compared to the total support provided to the sector (6.1% in 2019-21). They mainly come from the budgets of individual EU Member States (over 90%).
- The Horizon Europe programme and Pillar 2 of the Common Agricultural Policy (CAP) constitute the two main EU funding streams supporting knowledge and innovation in EU agriculture. While Horizon Europe offers funding to stimulate public and private investment in agricultural R&I and fosters multi-actor projects and partnerships across EU countries, the CAP provides targeted measures for relevant knowledge exchange, advice and co-operation (2.3% of CAP Pillar 2 in 2021).
- The European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) is the European Commission's main policy tool to channel CAP and Horizon Europe funding towards bottom-up multi-actor agricultural innovation projects that aim to tackle practical problems through a co-creation process involving farmers, researchers and other relevant actors.
- The European Union also provides a framework for national and regional agricultural knowledge and innovation systems (AKIS). To strengthen national AKIS, the CAP 2023-27 required EU Member States to develop their strategic approach to AKIS and to increase collaboration between advisors, researchers and CAP networks.
- While the sector experiences a high degree of skills shortages and mismatches, farmers' participation in adult training is still low compared to other sectors. There is a growing need for skilled agricultural advisors to help shift skillsets and practices towards new sustainability demands, but the share of expenditure on instruments targeting farm advice in the CAP budget remains limited.
- Some aspects of the overall regulation and policy environment in the European Union, such as the precautionary principle, may hamper innovation in certain areas, such as biopesticides, genetically modified organisms and new breeding techniques.

This chapter analyses the European Union's Agriculture Knowledge and Innovation System (AKIS), the policy incentives and organisational structures that support this system, as well as their role in building a sustainable agricultural sector and rural areas. Section 5.1 outlines the main long-term visions for research and innovation (R&I) and their role in the transition towards more sustainable farming in the European Union. Section 5.2 presents the main actors, institutions, networks and knowledge flows in the EU AKIS. Section 5.3 looks at investments in knowledge and innovation, and provides insights into the performance of agricultural R&D. It also addresses cross-country co-operation in the field of R&I. Section 5.4 identifies the main skills imbalances in the agricultural sector and discusses policy responses. It also indicates the role of farm advisory services. Section 5.5 sheds some light on the complex relationship between regulations and innovation as well as the protection of intellectual property rights (IPR) in the European Union. Section 5.6 focuses on co-creation of innovations by farmers and the adoption of innovation and digitalisation on farms, while the last section provides a high-level reflection on transformative approaches to policies.

5.1. Long-term strategies for research and innovation in the agro-food sector

The European Green Deal (EGD) laid down a roadmap for the transformation of the EU economy, particularly in the energy, mobility and food subsystems (EEA, 2018[1]). As discussed in previous chapters, the need for transforming the agricultural sector is expressed in several strategies, including the Farm to Fork (F2F) Strategy, the EU Biodiversity Strategy for 2030 and the "Fit for 55" package (EC, 2021[2]).

R&I policies are explicitly mentioned in the EGD strategy as key levers of the transformation, including initiatives that seek to combine societal pull and knowledge push. The CAP 2023-27 also recognises the central role of innovation in achieving the environmental, economic and social sustainability of the agricultural sector. It emphasises the role of fostering innovation, co-operation, knowledge exchange and digitalisation in agriculture as key policy levers for modernising agriculture and rural areas. As such, the CAP's cross-cutting objective, "Fostering knowledge and innovation", is expected to help fulfil all the other policy objectives (Chapter 1, Section 1.1).

5.1.1. The long-term strategy for EU agro-food innovation is directed towards sustainable agriculture, but not all EU Member States have reflected it in their national strategies

The EGD vision is echoed in the Horizon Europe vision and in its first strategic plan for the period 2021-24 (Section 5.3). The Horizon Europe Strategic Plan formalises intervention areas, including areas of agriculture and food systems. It sets 4 strategic orientations and 13 expected impact areas, which "define the wider effects on society, the economy and science to be targeted by research and innovation activities, but not the manner in which to achieve them. This is entirely up to the imagination and skill of the applicants" (EC, 2021[3]). The strategic orientations most relevant to agriculture and food systems are "Restoring Europe's ecosystems and biodiversity, and managing sustainably natural resources to ensure food security and a clean and healthy environment" and "Making Europe the first digitally enabled circular, climate-neutral and sustainable economy".

The European Union's long-term agricultural R&I strategy from 2016 has been a building block for the Horizon Europe Strategic Plan. The strategy defines five priority areas for R&I: 1) "sustainable resource management", notably soil, water, nutrients and genetic resources, to achieve a balance between productivity and environmental goals in agriculture through efficient resource use; 2) "healthier plants and animals" to boost resistance to pests and diseases, including by developing prevention, monitoring and control plants tools and a holistic "one health" approach; 3) "integrated ecological approaches from farm to landscape level" to enhance the understanding of the potential of using ecosystem services to

benefit sustainable agricultural production, including specific farming systems such as organic, mixed farming systems or agroforestry; 4) “new openings for rural growth” to stimulate the development of rural territories by exploring new avenues for business models, circular value chains, digital transformation, or economics of public goods; and 5) “enhancing the human and social capital in rural areas” through innovation networks, advisory services and demonstration sites in rural areas. Each of these five areas was further broken down into a set of targets (EC, 2016[4]).

The strategy also identified five cross-cutting issues related to the framework for R&I efforts in the European Union: 1) the need for system approaches, taking into account transdisciplinary and dynamic interactions; 2) societal engagement; 3) information and communication technologies (ICT) as an enabler; 4) enabling research and infrastructures; and 5) embedment of socio-economic research (EC, 2016[4]). Horizon Europe aims to structurally tackle these challenges through the transdisciplinary and cross-sectorial nature of the key strategic orientations for R&I and of their impact areas.

The European Commission has set ambitious transformation goals. Indeed, the European Commission’s far-reaching strategy for agro-food innovation is not fully reflected at Member State level and according to the OECD (2022[5]) survey for EU Member States, only 13 out of 19 countries reported having a long-term national strategy for agri-food innovation to guide their efforts.[1]

5.1.2. The transition to sustainable agriculture requires a system approach to innovation, embedded in the core of food systems

To respond to such high expectations of innovation for the transformation of the agro-food sector, innovation cannot be seen as business as usual and implies a specific reflection and tailored strategies. As stated in the F2F, “farmers, fishers and aquaculture producers need to transform their production methods more quickly, and make the best use of nature-based, technological, digital, and space-based solutions to deliver better climate and environmental results, increase climate resilience and reduce and optimise the use of inputs (e.g. pesticides, fertilisers)” (EC, 2020[6]). To undergo pathways of change towards these goals, farms should receive appropriate ecological, technological, market, policy and social stimuli and feedback, and transformation could imply removing system-related barriers to change. Such barriers include vertical (across levels of governance: European, national and regional) and horizontal (across policy areas: agriculture, environment, health, etc.) fragmentation of governance, which makes the co-ordination of actions around policy goals difficult, and implementation slow and conflicting.

Sustainable productivity growth in agriculture is likely to depend on improving the entire range of technologies and practices applied in the sector. In this context, innovations can contribute to achieving sustainability targets by improving and adapting existing technologies and practices to increase environmental performance (“changes in the system”), but also by creating new ways of producing and consuming, thus offering greater potential for transformation and reducing environmental pressures (“changes of the system”) (Weber and Rohracher, 2012[7]). Hence, “system innovation” (Box 5.1) could be broadly understood as a process where all types and components of innovation contribute to altering the resource base, knowledge base, critical skills, infrastructure and metarules that govern the system.

To generate system innovation, innovative processes and products should be widely adopted by users and enterprises. However, diffusion and uptake of innovations may encounter barriers (lock-in factors), such as the costs for disinvestment of incumbent processes and products, enabling infrastructures, learning new procedures, or social acceptance of new products (Section 5.6). Moreover, there is also a need to support the creation of innovative enterprises and the development of an innovation-conducive environment where enterprises can find the resources (skills, human resources, service) they need to innovate. Hence, the required interventions go well beyond agricultural policies (OECD, 2015[8]).

Box 5.1. "System innovation" for the transition of the agricultural sector

The Oslo Manual (OECD/Eurostat, 2018[9]) defines innovation as "a new or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)." However, innovation does not occur in a vacuum, but in a broad context as a change to the system that connects actors, artefacts and rules (Geels, 2004[10]). This implies that any change at the local level might trigger changes in other points of the system. In other words, transformative innovation occurs in the form of "bundles" "of mutually reinforcing technologies, policies, knowledge, social institutions and cultural norms" (Barrett et al., 2020[11]).

Innovations can be analysed by identifying their three components: technological, social and institutional. For instance, *high nutrient-density products* such as high-level Omega3 Italian Sheep Cheese or Selenium Potato (Selenella®) were obtained through genetic improvement and innovative agricultural practices (technological component). However, their success depends on consumers' increasing interest (social component) and on institutional attention to nutrition reflected, for instance, in dietary guidelines (institutional component). *Biological pest control* is another example of innovation and is considered one of the cornerstones of the Common Agricultural Policy's Good Agricultural Practices and of the proposed Regulation on the Sustainable Use of Plant Protection Products (see Chapter 4, Section 4.2). The technological component of this innovation is related to the selection of species for biological control and on agricultural practices, but the diffusion of this innovation also depends on its social aspect, i.e. the intensity of peer-to-peer learning processes between farmers, and on institutional support to these practices (e.g. Good Agricultural Practices). *Machinery rings*, which have been present in Europe since the 1960s, also display the interplay of different components of innovation. The principle of this scheme is to shift from individual to collective ownership of machinery (social component), thus helping farmers to match machinery and labour shortages on one farm with surpluses on another. Today, apps for machinery rings are being developed (technological component), allowing to balance demand and supply and substantially reducing the transaction cost. The wave of digitalisation of machinery (which makes it possible, for example, to localise machines and monitor their maintenance status) might substantially increase the uptake of this scheme. However, the successful establishment of machinery rings requires a set of legal and institutional conditions. The above examples show that policy makers can foster innovation by influencing each of the components of innovation.

Achieving the "sustainability transition" calls for placing the agricultural system within a broader system, i.e. the food system (den Boer et al., 2021[12]; Ingram and Zurek, 2018[13]). Applying the system approach to innovation implies here that farms and landscapes evolve in relation to changes in other parts of the food system, and at the same time their changes affect the other subsystems. In the transition envisaged by the F2F Strategy, agricultural systems are supposed to align their practices to social goals such as halting climate change, ensuring food security and nutrition, and restoring biodiversity. Given that each of these goals might generate trade-offs, the system approach is needed to find balanced and win-win innovation bundles. For instance, if at the level of the food system policies seek to steer demand towards highly nutritious and sustainable food products, and to shape Europeans' diets towards more plant-based meals, the agricultural sector may respond (or be proactive) by producing more nutritious and low-footprint products, thus altering the production mix.

5.2. Governance and organisation of EU agricultural knowledge and innovation systems

AKIS[2] are the most important drivers of agricultural innovation and, therefore, must play a key role in transforming the agricultural sector. The EU AKIS consists of a complex network of actors from regional, national and European levels, from both the public and private sectors, that generate, disseminate, and apply knowledge and innovation for agriculture and associated fields and promote and facilitate these processes.

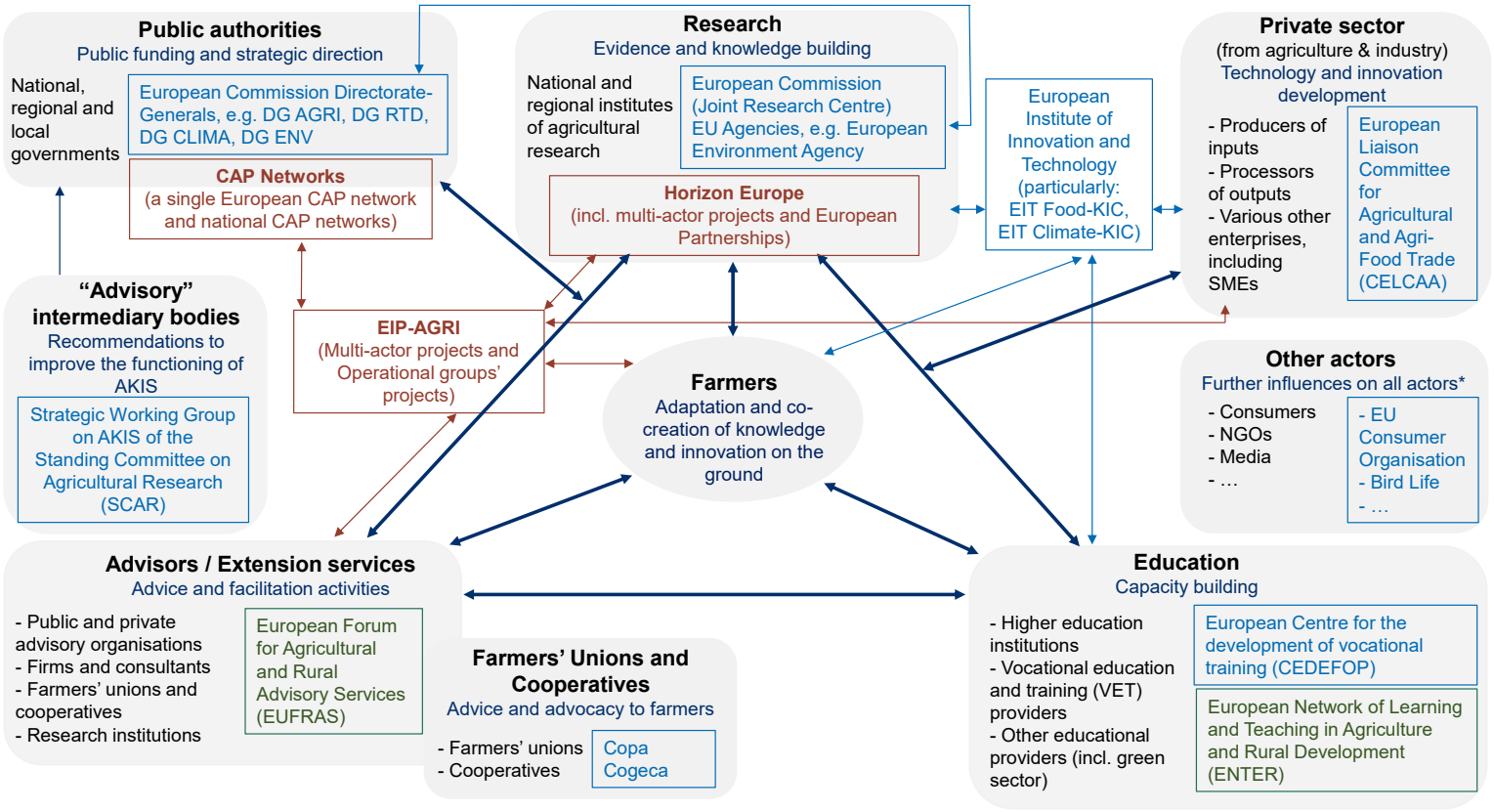
Under the new CAP 2023-27 (Chapter 3, Section 3.5), EU Member States are required to integrate their AKIS strategies into their CAP strategic plans. Strategic actions aim at, inter alia, better integrating agricultural advisory services with other AKIS actors; enhancing knowledge flows between all actors and, in particular, research and practice; as well as promoting interactive innovation and digitalisation in agriculture (EC, 2019[14]).[3] The decision on the selection of actions and the dedicated budget for knowledge and innovation lies with Member States. While a number of changes foreseen in the CAP 2023-27 have the potential to address some of the shortcomings of the previous CAP and strengthen the functioning of national AKIS, the analysis presented in this chapter only highlights the main expected changes without discussing them in detail.

Figure 5.1 provides a simplified illustration of the European Union's knowledge and innovation ecosystem for the agricultural sector, including the main actors at the EU level, their roles in the EU AKIS in terms of knowledge flows and their links to farmers (EU SCAR AKIS, 2019[15]; Kania, Vinohradnik and Knierim, 2014[16]). It encompasses the public decision-making authorities and six broad groups of actors: farmers, research, education, advisory and extension services, the private sector, and others. The triangle of knowledge – research, education and extension services – highlights the particularly intensified interaction between these actors, with farmers being in the centre (FAO and World Bank, 2000[17]; EU SCAR AKIS, 2019[15]). Additionally, other actors, such as consumers, the media, non-governmental organisations, financial institutions, etc., may directly or indirectly influence the demands posed to the innovation systems and the creation and uptake of innovative solutions (including sustainable practices). While national actors are essential to build and strengthen their AKIS, the focus of this analysis is on the overarching EU framework for national AKIS.[4]

5.2.1. The European Commission provides a framework for EU Member States' R&I policies

The public decision-making system sets the policy and institutional framework and provides funding to foster innovation for sustainable agriculture. It comprises multiple public authorities at the European, national, regional and local levels. At the national level, in many EU countries, governments, and in particular Ministries of Agriculture, play a crucial role in setting the strategic direction of innovation in the agro-food sector and are often considered the most decisive directional organ in this context[5] (OECD, 2022[5]). At the EU level, the European Commission, preparing legislation in agreement with the Council and the European Parliament, is the overarching body that aims to provide guidance and directionality to the AKIS across EU Member States. When implementing the legislation, the European Commission supports co-ordination between their actors on a transboundary scale. To foster a stimulating environment for innovation across the European Union, it lays out rules and provides funding. The European Commission also aims to steer research to respond to agricultural challenges and the resulting needs for novel practical solutions (EC, 2022[18]; EU SCAR AKIS, 2019[15]), as further discussed in Sections 5.3 and 5.6. In this context, the Strategic Working Group on AKIS of the Standing Committee on Agricultural Research (SCAR) plays a particularly important role in EU agricultural innovation as a respected source of evidence-based expertise for EU policy making (Box 5.2).

Figure 5.1. Actors and knowledge flows in the European Union's Agricultural Knowledge and Innovation System



Examples of: EU-level actors and networks of actors; EU policy instruments and initiatives; and categories of national actors. * selected arrows not shown for simplification

Notes: This is a stylised, not a fully comprehensive, diagram: only selected EU-level actors and initiatives are depicted to provide concrete examples. Additionally, selected categories of actors from the national level are presented. The arrows indicate the directionality of knowledge flows, where dark blue arrows indicate the flows between general categories of actors; red arrows indicate flows pertaining to EU initiatives, networks and instruments; and light blue arrows indicate those specific to individual EU actors and/or initiatives. The categories of actors are not always sharply distinguishable but may overlap depending on the circumstances. The indication of knowledge flows is not exhaustive, i.e. only the most important ones are depicted. It should be noted that the directions of knowledge flows are not static but may change.
KIC: knowledge and innovation community of the European Institute of Innovation and Technology (EIT) (Section 5.3); EIP-AGRI: European Innovation Partnership for Agricultural Productivity and Sustainability (Section 5.6).

The European Commission's Directorate-General for Agriculture and Rural Development (DG AGRI), is the most important actor responsible for agricultural research and innovation at the EU level. Given the cross-sectoral nature of agricultural research and innovation in the European Union, various other DGs may contribute to shaping AKIS. Although their work streams do not explicitly target agriculture, they may steer AKIS through their influences in areas such as education or digitalisation. DG AGRI is the responsible department for developing and carrying out the European Commission's policies in the field of agriculture and rural development, and deals with all aspects of the CAP. Under Pillar 2 of the CAP, it provides EU Member States with a portfolio of types of interventions (measures), some of which have the potential to foster the EU AKIS, under the cross-cutting CAP objective on knowledge and innovation. Additionally, together with the Directorate-General for Research and Innovation (DG RTD) and the Directorate-General for Environment (DG ENV), it co-chairs Horizon Europe's strategic Cluster 6, "Food, Bioeconomy, Natural Resources, Agriculture and Environment", with a view to fostering agricultural innovation at large (Section 5.3). The European Research Executive Agency (REA), under the responsibility of DG RTD and DG AGRI, is the main executive agency responsible for managing EU R&I framework programmes, including projects on agricultural research in Horizon Europe Cluster 6.

Box 5.2. Advising research policies: The Standing Committee on Agricultural Research

Research policies can contribute substantially to policy co-ordination, as research provides the knowledge base for policy making. Given that Member States have their own research policies and funds, one of the objectives of European research policies is to develop a European Research Area (ERA) that aligns national research policies and fosters joint programming. In the agricultural sector, a specific body has been created to support this process: the Standing Committee of Agricultural Research (SCAR).

SCAR provides a place for interaction between the ERA countries on research and innovation (R&I) strategies. It has supported the development of the successive European Framework Programmes for Research and Innovation, including the current Horizon Europe Framework Programme (referred to as "Horizon Europe"). Its strategic working group on AKIS, the SWG SCAR-AKIS, has the explicit mandate to elaborate recommendations for improving the functioning of knowledge and innovation systems for agriculture and any interrelated area (e.g. environment, biodiversity, rural areas, food and non-food systems up until the retailer, consumer and citizen).

The strength of SCAR is that it brings together knowledge from 37 countries – all EU Member States, candidate Member States and states associated to the European Union. It also provides a very strong link to European policy making. It was established in 1974 through a Regulation of the Council of the European Union on the co-ordination of agricultural research, and in 2005 its mandate was updated to advise the European Commission and the Member States on the co-ordination of agricultural research in Europe.

SCAR work is articulated into "working groups", composed of civil servants of the European Commission and Member States, as well as representatives from universities and research institutes. The "Foresight Group" develops ideas for foresight studies and, after approval, governs the execution of these studies. Foresight studies are the core of SCAR's activity, as they involve all other groups to develop a shared vision. Collaborative working groups carry out mapping activities in specific areas and develop common research agendas. SCAR's strategic working groups develop strategic insights on the themes of their competence, as, for instance, on AKIS by the SWG SCAR-AKIS.

Sources: SCAR (2022[19]); European Council (1974[20]).

5.2.2. Agricultural innovation involves a complex system, with numerous actors and knowledge flows connecting them

An innovation system is a network of knowledge flows that go in all directions (Figure 5.1). The innovation process is usually not a linear top-down process. All actors receive and transmit knowledge from and to other actors, and they all play a role in knowledge generation, transmission and adoption.

Farmers, as well as other end-users[6] of project results, are decisive actors for the actual and effective uptake of innovation for sustainability and modernisation in the agricultural sector. Farmers are not only expected to apply innovative solutions on the ground, but to also be leading actors in defining sustainability challenges and co-creating their solutions, by leveraging the combination of acquired knowledge and advice with their own practical experience (EU SCAR AKIS, 2019[15]). Their co-decision in the projects also creates co-ownership for the results, which is an important incentive to adopt them. This can also accelerate the impact of the funded projects on the ground and in the field. Operational groups' innovation projects and multi-actor research project and thematic networks under the EIP-AGRI are discussed in Section 5.6.

Researchers provide evidence and contribute to the creation of knowledge within the AKIS that is necessary for the generation of sustainable innovation in agriculture. There are multiple agricultural research institutions in the European Union, i.e. national and regional research institutes, as well as universities. They should also learn from training, education and advisory actors on the needs, challenges and practices on farms. In addition, research institutes may be co-responsible for the implementation of innovation initiatives promoted by the government.

The Joint Research Centre has an important role as the European Commission's science and knowledge service. It informs the European Commission on topics relevant to agricultural policies, ranging from challenges facing the sector to potential breakthroughs. It provides anticipation and foresight reports, including on new technological solutions relevant to thematic areas such as sustainable food production and consumption, or agricultural innovations. It also assists the implementation of the CAP and its instruments, including the Good Agricultural and Environmental Condition (GAEC) (JRC, 2022[21]).

The European Environment Agency is another example of an actor in the area of research. It focuses on providing sound and timely information on the environment to inform policy makers and the broader public on pressing environmental topics, including those related to agriculture. Through the European Environment Information and Observation Network (Eionet), the European Environment Agency gathers data on the environmental trends and pressures from Member States and makes them available together with research reports on possible solutions (EEA, 2022[22]).

The European Commission established the ERA with the ambition to create "a single, borderless market for research, innovation and technology across Europe". It is fundamental to the European Union's R&I ambitions as it fosters multi-scale connectivity and thus helps to leverage economies of scale and spillover effects among all agricultural research agents (EU SCAR AKIS, 2019[15]). Horizon Europe multi-actor projects, European Partnerships (e.g. "Agriculture of Data") and European Missions (e.g. "A soil deal for Europe") are examples of initiatives fostering collaborations in agricultural research and the establishment of relevant research infrastructures (more widely discussed in Sections 5.3 and 5.6).

Educators are key actors in ensuring that sustainable practices become better known and mainstream. Across EU Member States, there are various higher education institutions, vocational education and training (VET) facilities, and further educational providers in the agricultural and green sector that offer comprehensive and specialised education, supporting the build-up of capacities necessary to embrace innovation, e.g. in the fields of sustainability, bioeconomy and digitalisation, including agribusiness and entrepreneurship (Fields, 2022[23]). In this context, VET facilities are of particular importance to farmers

as they provide lifelong learning opportunities that are necessary to enable the continuous uptake of knowledge and innovation on the farm.

The European Centre for the Development of Vocational Training (CEDEFOP) aims to foster VET, among others in the area of agriculture. It collaborates with the European Commission, EU Member States' authorities and other partners to develop effective policies that foster and promote VET facilities, their capacities and their outreach (CEDEFOP, 2022[24]).

To enhance the transmission of relevant skills and foster collaboration between the European Union, Member States and key stakeholders, the European Commission established the European Education Area. Green education is one of the main themes through which the European Union aims to encourage educational institutions to support the green transition and strengthen competences for sustainable development across Europe.

Another example is the European Network of Learning and Teaching in Agriculture and Rural Development, an association of educational bodies specialised in the agricultural sector. It serves as an exchange platform for teaching and learning in agriculture that aims at developing and transmitting agricultural knowledge through improved and novel teaching processes (ENTER, 2022[25]). Additionally relevant to the sector is EUROPEA, an association comprising more than 1 000 vocational schools and institutions across Europe that are represented by 25 national EUROPEA networks. The organisation is dedicated to developing and promoting VET in Europe's green sectors by focusing on improved international co-operation and knowledge sharing. To do so, it fosters participation in EU-funded VET projects and the dissemination of its results, for example, in the area of digitalisation or circular economy (Europea, 2022[26]).

Agricultural extensionists/advisors, private and/or public, offer information and advice directly to farmers. They are expected to co-operate closely with representatives of science and education, both to remain abreast with new research and to raise research and educational needs identified through interactions with farmers.

The European Forum for Agricultural and Rural Advisory Services is a body assembling a number of agricultural advisory services at the European level. It aims to contribute to the development and interactions between advisory services within the European Union. To this end, it advocates their needs, provides information and has also participated in a few EU projects to foster and strengthen European farm advisory services, e.g. the i2connect project that aims at connecting advisors, increasing their competencies and facilitating interactive innovation processes (EUFRAS, 2022[27]). A further discussion on the role of advisory services within the EU AKIS and relevant actors follows in Section 5.4.

Farmers' unions and co-operatives act as a direct meeting point to obtain and exchange practical training and advice in the context of ever-changing markets or the application of more sustainable agricultural practices. In addition, they represent the voice of European farmers to public authorities and advocate their needs among all AKIS players. At the EU level, Copa Cogeca is the largest organisation, representing more than 22 million farmers, their unions and co-operatives across the European Union. It contributes to the ongoing EU policy discussion and the definition of priorities in the sector by defending farming interests (Copa Cogeca, 2022[28]).

Private sector actors from agriculture and industry, such as small and medium-sized enterprises, multinational enterprises, producers of inputs or processors of outputs also play a key role in the EU AKIS. While they often follow their own innovation agendas and activities, they may also engage in multi-actor collaborations in the field of agriculture, at the national and/or international level. The European Union, as well as national governments in many countries, aim to incentivise private investment in R&I for agriculture. Such incentives most often take the form of grants or loans, and slightly less frequently public-private partnerships (OECD, 2022[5]). Private sector participants, such as input suppliers, for promotion purposes, often maintain close ties with both research and educational

facilities, and farmers to whom they provide information on “best practices”. However, such advice is not disinterested and supports the marketing of their own products.

Growing interest in strategic networking may foster greater synergies and stimulate inclusive knowledge exchange

Several EU knowledge and practice networks (Figure 5.1) contribute to improving the design and implementation of policies and measures at the EU and Member State levels. The European Network for Rural Development and the EIP-AGRI network were “networks of networks” established by the European Commission under the rural development pillar of the CAP. Until 2022, they aimed to increase the involvement of relevant stakeholders (e.g. from research, public authorities, local action groups and advisories) and share good practices on the implementation and evaluation of rural development programmes, thus also contributing to knowledge exchange and innovation, but also to policy learning. The EIP-AGRI Network has been particularly important in linking knowledge and innovation projects and actors, such as farmers, advisors, researchers and operational groups (ENRD, 2016[29]; EU, 2019[30]).

Due to the increased need for stakeholder engagement, knowledge sharing and capacity building under the CAP 2023-27, the scope of networking has been extended to encompass the whole CAP. In this context, the European Network for Rural Development and the EIP Networks have been transformed into a single EU-wide CAP network, while national rural networks have been replaced by national CAP networks (Figure 5.1). This change aims to further stimulate stakeholders’ involvement in CAP strategic plans and support the implementation of the plans; foster peer-to-peer learning, interaction at all levels, inclusive knowledge exchange and innovation; capacity building, including related to monitoring and evaluation; and help disseminate the results of the CAP strategic plans and of the EIP-AGRI Operational Groups (Skakelja, 2018[31]).

5.3. Investment in knowledge and innovation, and R&D outcomes for the agro-food sector

Innovation and knowledge exchange are considered to be the primary drivers of productivity growth and greater environmental sustainability. Public and private research and development (R&D) investment is fundamental to foster long-term productivity growth (Heisey and Fuglie, 2018[32]). The global evidence clearly shows that economic returns on agricultural R&D investment remain high (Rao, Hurley and Pardey, 2019[33]).

5.3.1. Public and private investment

Agricultural knowledge and innovation are financed primarily from public sources, with relatively limited resources compared to the total support provided to the sector

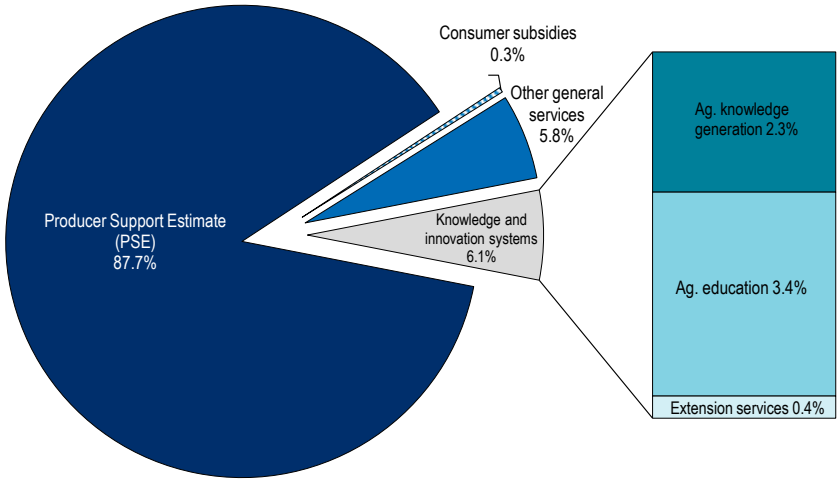
Public investment has always played a significant role in financing agricultural knowledge and innovation. This is largely justified by the public good[7] nature of most agricultural research. To incentivise private sector investments, governments provide direct support or exclusion mechanisms such as patents. In areas where these mechanisms are insufficient to spur private investment, government-financed research prevails (Heisey and Fuglie, 2018[32]).

Over 2019-21, the European Commission, EU Member States and EU consumers transferred, on average, more than EUR 100 billion per year to support the agricultural sector (Total Support Estimate). The vast majority was provided to individual producers (87.7%), and only 12.0% for general services to the sector (GSSE), which, through the provision of public goods and services, can create enabling

conditions for the development of the agricultural sector and improve its competitiveness (OECD, 2022[34]).

Transfers to agricultural knowledge generation, agricultural education and extension services (collectively referred to as "support to agricultural knowledge and innovation systems") totalled EUR 6 billion, which corresponds to around half of the GSSE (Figure 5.2). Although over the last 15 years, expenditures on knowledge and innovation systems relatively gained in importance in the support structure (an increase from 4.6% of total support in 2006-08 to 6.1% in 2019-21), it was mainly due to the decline in the support provided to other general services, such as development and maintenance of infrastructure. This positioned the EU27 above the OECD average (4.1%), but behind Australia (24.4%) and Canada (8.8%) (OECD, 2022[34]).

Figure 5.2. Composition of support to agriculture in the European Union, 2019-21



Note: European Union refers to EU28 for 2019; EU27 and the United Kingdom for 2020; and EU27 for 2021.
Source: OECD (2022[35]).

Well-targeted, strategic investments in agricultural knowledge and innovation are essential for the green transformation of the sector

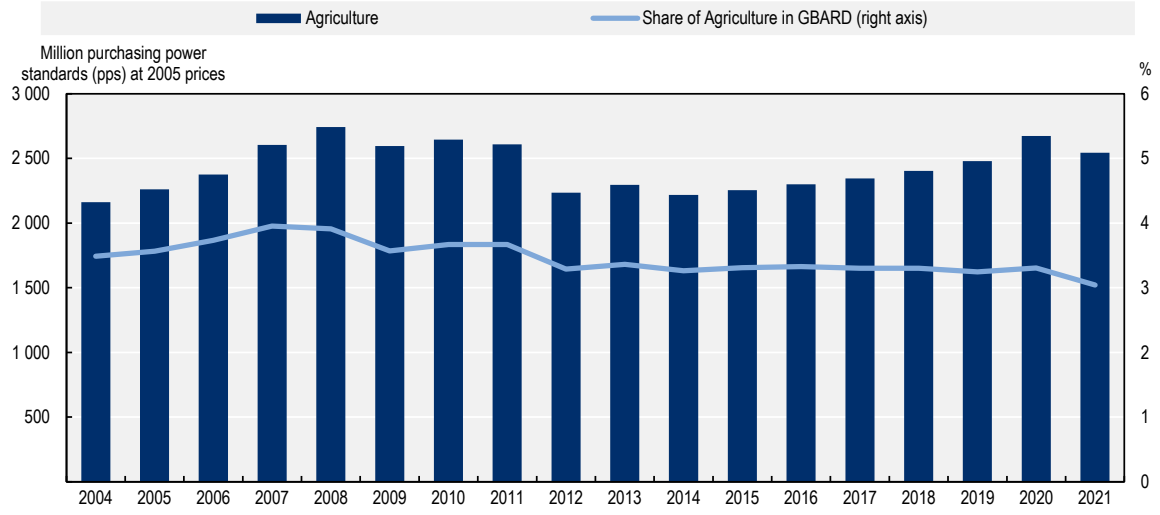
The European Union and EU Member State governments combine direct investment in R&D activities with other instruments to foster collaboration and facilitate knowledge exchange. Strategic investments in creating, sharing, and the uptake of knowledge and innovation have the greatest potential for improving the sector's capacity for sustainable growth and making it more resilient to shocks (OECD, 2022[34]). To effectively support the green transition of the sector, they have to be aligned with its global objectives: for instance, the EGD target of increasing the agricultural area under organic farming in the European Union to 25% by 2030 (Chapters 3 and 4) should be accompanied by appropriate investments specifically targeting organic farming actors and related knowledge, e.g. agroecology.

Knowledge and innovation are mostly financed by individual EU Member States, i.e. 91% of EU spending comes from national budgets; the rest is provided by the EU budget, either through selected measures under the rural development pillar of the CAP or through Horizon Europe Cluster 6 (OECD, 2022[35]). Overall, there is no direct evidence of a crowding-out effect of national public investments by supranational ones. Yet, co-ordination and alignment of different funding streams remain of the utmost importance. Moreover, the European Union should focus on topics and partnerships with high EU added value and essential to achieving strategic goals rather than focusing on specific national priorities and interests (LAB – FAB – APP, 2017[36]).

Public R&D expenditure in agriculture grew more slowly than the total national public R&D budget

In 2021, EU Member State governments allocated a total of EUR 3.26 billion (in current prices) to agricultural R&D activities carried out in both government establishments and higher education, business enterprises, private non-profit organisations, as well as abroad. Between 2006 and 2021, these allocations grew at a slower pace than the total national public R&D budget, and half of EU Member States even reduced their investment in agricultural R&D in real terms. Thus, the share of agriculture for the European Union fell from 3.7% to 3.0% (Figure 5.3), placing it behind Australia (8.6%), Canada (7.6%) and Korea (4.6%), but ahead of the United States (1.8%). The importance governments attach to agricultural R&D varied widely across EU Member States, with the highest shares in Bulgaria (17.4%) and Latvia (13.1%) and the lowest in Luxembourg (0.04%) in 2021 (Annex Table 5.A.1).

Figure 5.3. Government budget allocation for R&D in EU agriculture, 2004-21



Notes: EU27. More information on the EU Member States can be found in Annex Table 5.A.1. Government budget allocation for research and development (GBARD) is a funder-based approach for reporting R&D, which involves identifying all the budget items that may support R&D activities and measuring or estimating their R&D content. It allows linking these budget lines to policy considerations through classification by socio-economic objective. However, it only provides a partial indicator of investment in public agricultural research, since it refers to research funding instruments dedicated specifically to agriculture.
Source: Authors' calculations based on Eurostat/OECD (2022[37]).

Although agricultural R&D intensity has increased in the European Union, it remains lower than in Japan, Korea, and the United States

Both private and public resources invested in R&D provide some indication of a country's efforts to innovate. However, due to data limitations, it is often difficult to draw far-reaching conclusions. Box 5.3 discusses issues related to the availability of R&D data.

The "Europe 2020 Strategy" adopted in 2010 set the target of total gross domestic expenditure on R&D (GERD, which covers public and private expenditure on R&D carried out by all residents in a country) at the level of 3% of gross domestic product (GDP) for the whole EU innovation system by 2020 (EC, 2010[38]). Despite having also set country-specific national targets (Rakic, 2021[39]), the EU target was not met. The overall R&D intensity[8] for the European Union only increased by 0.5 percentage points between 2006 and 2020, to 2.20%, below the OECD average of 2.68% (Table 5.1; Annex Table 5.A.2

presents R&D intensities for individual EU Member States). Most of this growth can be explained by increased private sector activity.

Table 5.1. R&D expenditure intensities

Field of R&D	All		Agricultural science		All		Agriculture		All sectors		Agriculture		Food and beverages	
Sector of performance	All sectors		Public (government and higher education)		All sectors		All sectors		Business		Business		Business	
Source of funds	All sources		All sources		Government		Government		All sources		All sources		All sources	
Indicator	GERD[1] total as a % of GDP		Public GERD on agricultural science[2] as a % of sector's value added		GBARD[3] total as a % of GDP		GBARD on agriculture[4] as a % of sector's value added		BERD[5] total as a % of GDP		Agriculture BERD[6] as a % of sector's value added		Food and beverage BERD[7] as a % of sector's value added	
	2006	2020	2006	2019	2006	2020	2006	2020	2006	2020	2006	2019	2006	2019
EU27 (average)[8]	1.70	2.20	..	..	0.66	0.77	1.42	1.33	1.07	1.44	0.27	0.43	0.82	0.95
EU27 (median)[9]	1.11	1.53	1.69	1.58	0.51	0.67	1.24	1.11	0.53	0.92	0.17	0.11	0.52	0.72
OECD (average)	2.13	2.68	…	..	..	..	..	..	1.46	1.92	..	..	..	..
Australia	2.00	1.80	3.03	1.32	0.51	0.45	1.77	1.69	1.16	0.92	0.52	0.69	..	..
Canada	1.94	1.70	…	3.22	0.56	0.49	..	2.04	1.10	0.86	..	0.38	..	0.49
China	1.37	2.40	…	1.49	..	..	0.50	..	0.97	1.84	..	..	..	..
Japan	3.23	3.27	5.62	5.19	0.67	1.71	2.09	4.28	2.49	2.58	0.11	0.05	2.59	2.19
Korea	2.72	4.81	2.08	3.22	0.89	1.25	2.27	3.29	2.10	3.81	0.05	0.25	..	..
Russia	1.00	1.10	0.44	1.95	0.34	0.51	..	..	0.67	0.62	..	..	..	..
United Kingdom	1.57	1.71	3.48	2.65	0.61	0.58	3.22	2.77	0.97	1.25	0.31	0.10	1.09	1.06
United States	2.56	3.45	3.39	2.30	0.83	0.81	1.91	1.38	1.79	2.60	..	..	1.57	2.36

Notes: 2006, 2020 and 2019, or the nearest available year.

1. Gross domestic expenditure on research and development (GERD) is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad, but excludes domestic funds for R&D performed outside the domestic economy. 2. GERD for agricultural and veterinary. 3. Government budget allocation for R&D (GBARD) is a funder-based approach for reporting R&D, which involves identifying all the budget items that may support R&D activities and measuring or estimating their R&D content. It allows linking these budget lines to policy considerations through classification by socio-economic objectives. 4. GBARD on agriculture covers all R&D aimed at promoting agriculture, forestry, fisheries and foodstuff production, or furthering knowledge on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture, as well as concerning the impact of agricultural and forestry activities on the environment. This also covers R&D aimed at improving food productivity and technology. 5. Business expenditure on R&D (BERD) is the measure of intramural R&D expenditures within the business enterprise sector (regardless of the sources of R&D funds). 6. BERD on agriculture, forestry and fishing. 7. BERD on manufacture of food products, beverages and tobacco products. 8. The European Union (27 countries) aggregate was estimated for the BERD for the agriculture and food and beverage sectors. 9. The EU27 median only considers countries for which data are available. More information on the R&D intensities in the EU Member States can be found in Annex Table 5.A.2.

Source: Authors' calculations based on OECD (2022[40]), Eurostat (2021[41]) and USDA ERS (2017[42]) databases.

In the EU agricultural sector, as in many other economies, R&D expenditures are channelled primarily towards universities and research institutions. The median public gross domestic expenditure on R&D for agriculture represented 1.58% of the sector's value added in 2019, exceeding the intensity of investment from all sources in agricultural R&D in the business sector: BERD constituted 0.11% of agricultural value added.

In 2019, investment in private sector R&D relative to the sector size was lower for agriculture (0.43%) than for the food and beverages industry (0.95%) or the economy as a whole (1.44%). While in the period 2006-19, the intensity of business R&D in both the agricultural and food and beverages sectors increased in the European Union, it lagged behind the more advanced countries in this respect,

e.g. Australia (0.69%) for agriculture and the United States for the food processing sector (2.36%; Table 5.1).

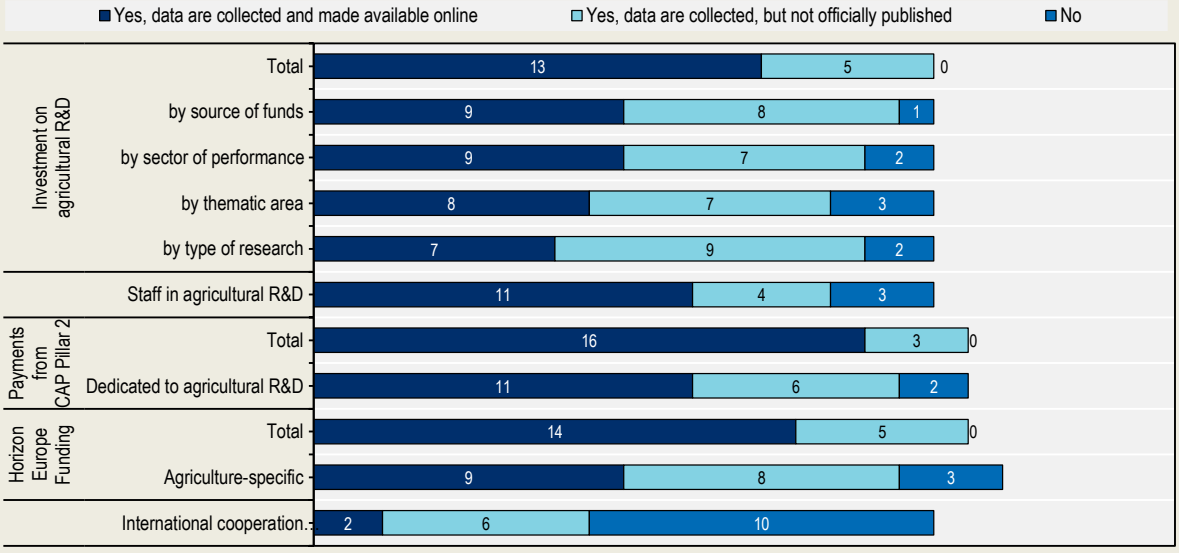
Box 5.3. Availability of data on research and development expenditure

Monitoring research and development (R&D) activities requires good-quality data on funding streams. However, despite the existence of international standards and efforts of the OECD and Eurostat, data on agricultural R&D expenditure are often incomplete. Government budget allocation for R&D (GBARD), government expenditure on R&D (GERD) and business expenditure on R&D (BERD) are the most popular indicators. While their data coverage is relatively good at the level of the economy as a whole, there are many gaps and discrepancies at the sectoral level.

GBARD in agriculture is the most timely and widely available indicator. Originating from budgetary sources, however, it includes only expenditure budgeted on agriculture and ignores other general financing mechanisms that may be used for this purpose. The GERD and BERD time series, for which data come from surveys, are often incomplete or have a time lag. GERD for agricultural science often is only available for activities performed by the public sector (government and higher education) and funded from both public and private sources (OECD, 2019[43]).

Results from an OECD survey (2022[5]) show that most participating EU countries collect data on agricultural R&D expenditures or activities (Figure 5.4). However, for more detailed crosscuts, such as investment in agricultural R&D by thematic area, data are often not publicly available. Also, private investment in agri-food R&D is difficult to track as such data are often missing or incomplete in official statistics.

Figure 5.4. Research and innovation data availability in EU Member States



Note: Numbers indicate the number of countries that selected the given answer for the question "Does your country collect the following agricultural/agri-food R&D&I data?".
Source: OECD (2019[43]; 2022[5]).

5.3.2. Main streams of EU funding

Funding streams and instruments available to support agricultural knowledge and innovation in the European Union are somewhat fragmented

The Multiannual Financial Framework (MFF) forms the backbone of the EU funding system that through various instruments and funds may contribute to the generation of knowledge and innovation in the agricultural sector. Figure 5.5 shows both funds specifically dedicated to agriculture[9] (marked in red on the left side), and funding that does not specifically target agriculture, yet may indirectly benefit the sector and promote innovation (depicted on the right side). Horizon Europe and the European Agricultural Fund for Rural Development (EAFRD) constitute two main EU funding sources for agricultural innovation. Further instruments such as LIFE or Erasmus+ can contribute to fostering the development of sustainable agriculture through innovative activities; however, they are discussed to a much lesser extent.

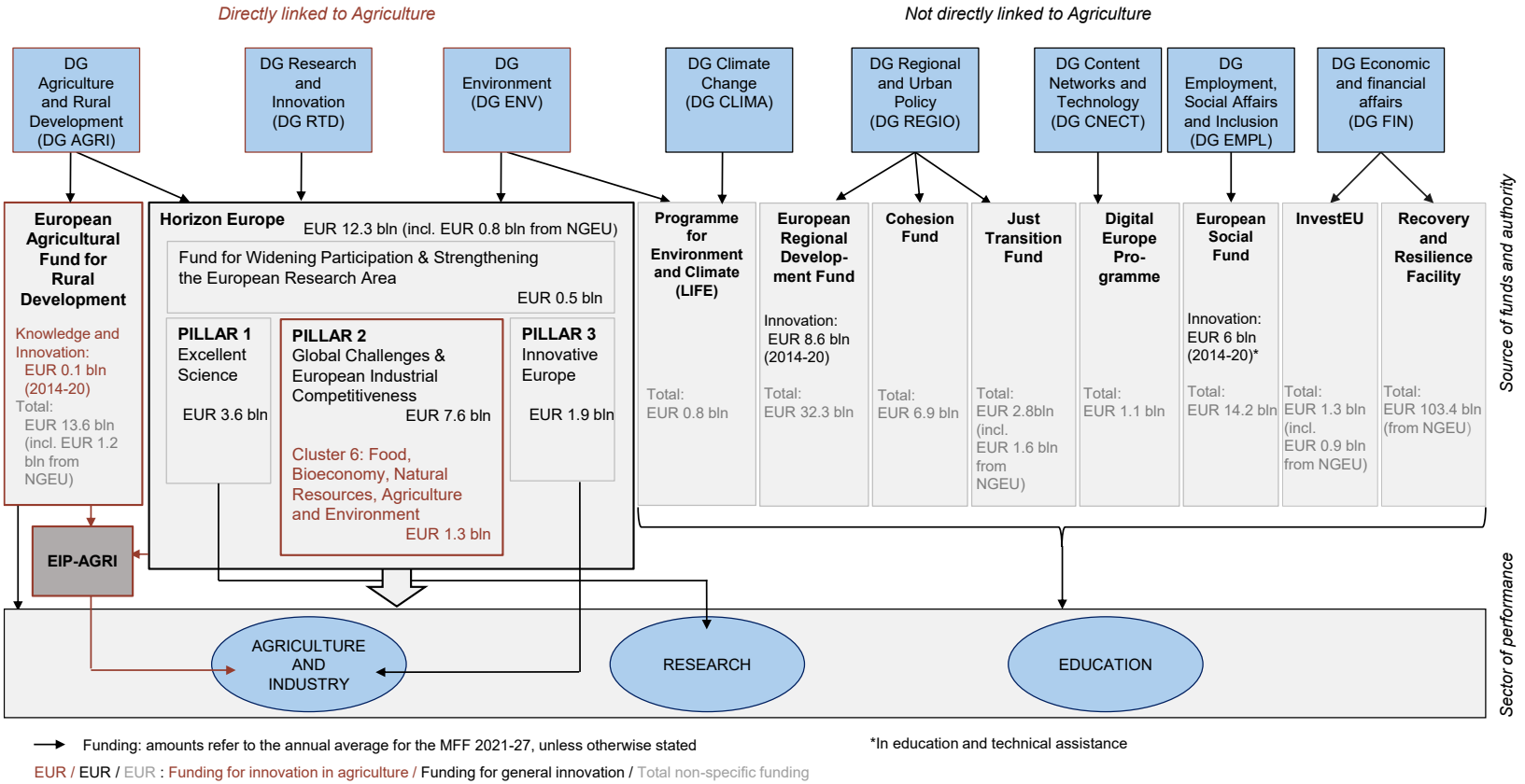
Horizon Europe, and in particular its Cluster 6, is the main EU fund with the potential to foster agricultural research and innovation

Horizon Europe, the European Commission's key Research and Innovation Framework Programme for 2021-27, is the main EU fund with the potential to foster R&I for sustainable agriculture. Its agriculture-relevant aspects are managed by DG AGRI in Cluster 6 on "Food, Bioeconomy, Natural Resources, Agriculture and Environment", which is jointly co-managed with the Directorate-General for Research and Innovation and DG ENV. Horizon Europe has a total budget of EUR 95.5 billion over a seven-year programming period (including Euratom and the contributions of Next Generation EU). The European Union decisively augmented its efforts to invest in knowledge and innovation activities, with a 30% higher budget (in real terms) compared to the previous programming, Horizon 2020 (2014-20).

Horizon Europe is based on three pillars. Under Pillar 1, "Excellent Science", the European Union aims to promote science across Europe by funding research activities with a budget of EUR 25 billion over the seven-year programming period. This includes measures to facilitate capacity building across researchers as well as the establishment of the European Research Council, a research funding and supporting body. It provides research grants, shares best practices and experiences with national and regional research funding bodies, and connects to other measures under Horizon Europe to leverage synergies in the area of research. It organises its work around different thematic groups (e.g. open science or innovation and relations with industry), adapted to the current needs and requirements of the European Research Area (ERC, 2022[44]). Pillar 2, "Global Challenges and European Industrial Competitiveness", establishes seven thematic clusters to foster increased R&I activities and innovative solutions in specialised areas with a budget of EUR 53.5 billion. Pillar 3, "Innovative Europe", with a budget of EUR 13.6 billion, implements activities to boost and better connect innovators in Europe and generally enhance the European innovation landscape. Horizon Europe entails an additional component, "Widening Participation and Strengthening the European Research Area", that facilitates the whole framework programme (EC, 2022[45]).

Cluster 6 of Pillar 2 "Food, Bioeconomy, Natural Resources, Agriculture and Environment", with an estimated budget of EUR 9 billion over the programming period, is of particular relevance for R&I in the agri-food sector, although its scope is much wider. One of the seven areas of intervention (area 3) supports activities that aim at fostering knowledge, building capacities and developing novel solutions to promote sustainable land use and a more sustainable, resilient and inclusive agricultural sector (EC, 2019[46]). The cluster also encompasses activities of partnerships, networks and initiatives, such as the "thematic networks", which aim to compile newly created scientific evidence and best practices and translate them into easily understandable materials for end-users.

Figure 5.5. The EU funding ecosystem to foster sustainable agricultural innovation



Notes: MFF: Multiannual Financial Framework; NGEU: Next Generation EU. This is a stylised, not a fully comprehensive diagram. Funds on the left side are directly dedicated to agriculture, while funds on the right side may have the potential to indirectly benefit agriculture. Additionally, red highlights the relevance for the agricultural sector. The European Space Programme is not included, yet it may benefit agricultural research and innovation through earth observation. The indicated funding amounts refer to the provided EU funding but do not incorporate co-funding from Member States, e.g. for the EARD and EIP-AGRI projects. The sector of performance "agriculture and industry" encompasses farmers, agri-food businesses and extension services.

Source: Authors' representation and calculations based on EC (2022[47]; 2023[48]).

The multi-actor approach under Horizon work programmes is increasingly becoming an eligibility condition for project proposals. Based on the interactive innovation model, in which end-users are directly involved over the whole course of projects ensuring co-creation and co-ownership of results, the approach aims at making R&I outcomes more demand-driven and relevant to society. While in the 2014-20 period, the multi-actor approach was only used in the agricultural part of the Horizon work programme, its application has been extended to the entire Cluster 6 under Horizon Europe. Already in the first work programme for 2021-22, it is an eligibility criterion for around half of the projects.

Under Pillar 3, the European Innovation Council (EIC) was established, and the European Institute of Innovation and Technology's (EIT) activities are promoted. The EIC's goal is to help researchers, innovative companies and start-ups scale up their innovative business capacities and bring their innovations to the market. Additionally, the EIC offers relevant expertise and fosters connections between businesses, corporates, investors and other ecosystem actors (EIC, 2022[49]). To date, the EIC has only initiated a few projects related to agriculture, e.g. the EIC pilot-funded company Infarm that creates sustainable vertical urban farms. The EIT provides funding that can benefit multiple actors in research, business/entrepreneurs and education. It offers, *inter alia*, opportunities related to education (e.g. an online course on innovation in arable farming), business creation (e.g. via grants, investment support) and innovation projects, offered within their "knowledge and innovation community". Among these, the most relevant for the agri-food sector is the EIT-Food, an innovation community centred around sustainable food systems of the future. Other EITs, such as Clima or Digital, may also support activities relevant to agriculture.

Horizon Europe's new mission approach to tackling societal challenges can foster greater synergies and innovation

In line with the recommendations of expert reports and impact assessment and case studies (Mazzucato, 2019[50]; Mazzucato, 2018[51]; LAB – FAB – APP, 2017[36]; Chicot et al., 2018[52]), the European Commission has geared towards a more mission-driven approach to tackling complex societal challenges that cannot be solved by any EU Member State alone and that require breaking disciplinary, sectorial and institutional silos. While this new approach permeates throughout the whole programme, Horizon Europe introduces the so-called EU missions (EC, 2021[3]), flagship initiatives with a strong focus on delivery. They intend to provide a clear direction that is societally relevant; set ambitious but realistically feasible objectives, as well as specific, measurable targets and a time frame for achieving them; spur activity across different scientific disciplines, sectors and actors; and be open to experimenting and exploring various types of bottom-up solutions that can lead to the expected outcomes of the mission (Mazzucato, 2018[51]). Horizon Europe identified five missions from different thematic areas, with the mission "A Soil Deal for Europe" benefiting the agricultural sector (Box 5.4) (EC, 2023[53]). Each mission is planned as a portfolio of actions, such as research projects, policy measures or even legislative initiatives, which should build on co-operation and synergies with other parts of Horizon Europe, including clusters and European Partnerships.

Box 5.4. EU Mission: "A Soil Deal for Europe"

The EU Mission "A Soil Deal for Europe", with a budget of EUR 320 million for 2021-23, aims to develop concrete solutions for restoring soil functions, and thus help the transition to healthy soils by 2030. The mission is firmly entrenched in the wider policy framework, contributing to the European Union's key objectives as defined, for example, in the European Green Deal, to assure the highest effectiveness and increase the uptake of soil-related measures. The mission follows the clearly defined target to significantly augment the share of healthy soils to levels that align with the European Green Deal commitments and 2030 targets, compared to the currently prevailing share of 30-40%. To this end, it has the objective to establish a network of 100 living labs and lighthouses[1] in rural and urban regions and aims to foster the development of a common European framework for monitoring soils to generate and disseminate knowledge and appropriate solutions for soil health. Living labs are collaborative research and innovation initiatives between multiple actors that experiment in laboratories on the ground (e.g. farms, forest sides or industrial settings) to find solutions to the problem of degrading soils, based on a jointly agreed-upon objective. The multi-actor topics of the Soil Mission are implemented in synergy with and building on the Common Agricultural Policy's Operational Group projects, many of which are already tackling soil issues. Accordingly, operational groups under the European Innovation Partnership for Agricultural Productivity and Sustainability may profit from the generated knowledge and practical solutions of the future living labs.

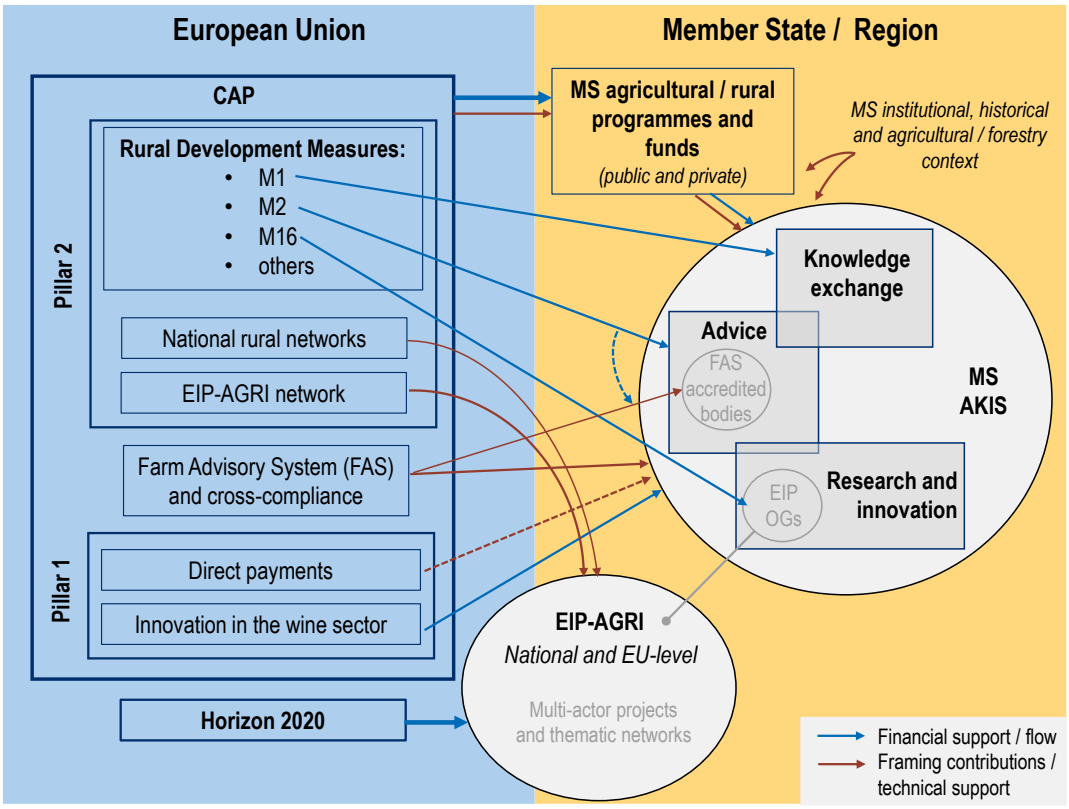
1."Living labs are collaborative initiatives to co-create knowledge and innovations while lighthouses are places for demonstration of solutions and of exemplary achievements" (EC, 2022[54]).
Sources: EU (2022[55]; 2022[54]).

European Agricultural Fund for Rural Development offers support to farmers on innovation-related measures, including knowledge transfer, advice and co-operation

The European Agricultural Fund for Rural Development (EAFRD) is another EU fund that supports knowledge exchange and innovation. It is financed under Pillar 2 of the CAP, with roughly a quarter of the total 2014-20 budget (EC, 2022[56]). Pillar 1 is less innovation-oriented, although some market measures under sectoral programmes may support investment in innovation, e.g. wine.

One of the European Union's rural development objectives is innovation for sustainable farming. National and regional rural development programmes under the EAFRD for 2014-20 target agricultural innovation with three main measures (Figure 5.6): 1) knowledge transfer (M1); 2) advice (M2) (Section 5.4); and 3) co-operation (M16), which, among others, supports the setting up and operation of the innovation projects of the EIP-AGRI (Figure 5.1, Figure 5.5, Figure 5.6). Additionally, some other CAP instruments may contribute to fostering knowledge and innovation. For instance, the requirement of a minimum level qualification or training to access some CAP aids, such as farm modernisation investment or support for young farmers, may encourage farmers to upgrade their skills (Chapters 3 and 4).

Figure 5.6. Architecture of CAP 2014-20 implementation with regard to knowledge exchange, innovation and advisory activities



Notes: AKIS: agricultural knowledge and innovation systems; CAP: Common Agricultural Policy; EIP-AGRI: European Innovation Partnership for Agricultural Productivity and Sustainability (Section 5.6); FAS: Farm Advisory System (Section 5.4); M: measure; MS: Member State; OG: operational group. For a discussion on networks, see Section 5.2.
Source: EC et al. (2021[57]).

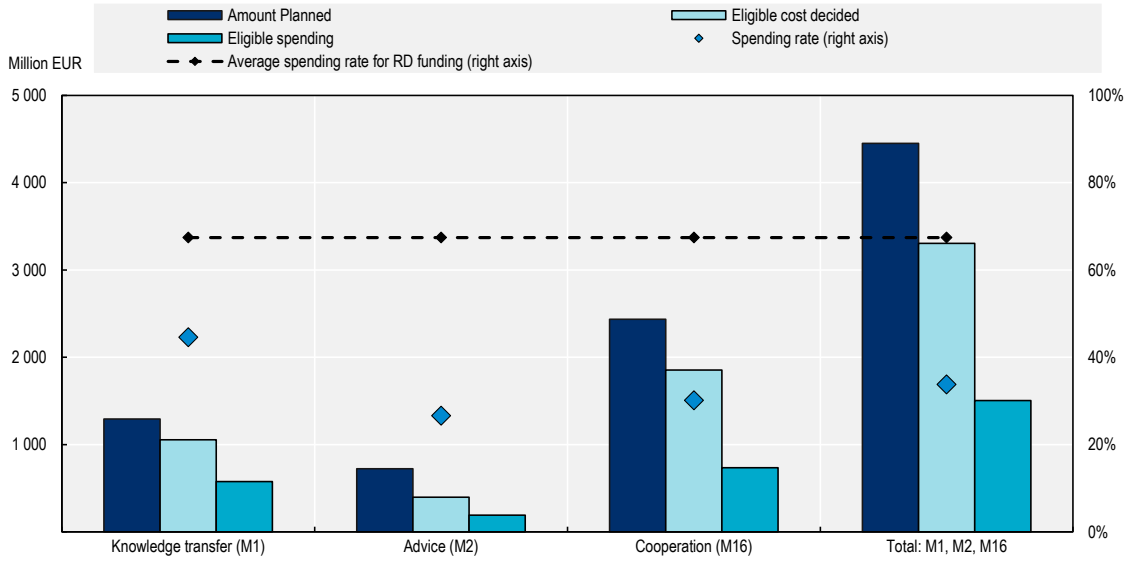
Agricultural knowledge and innovation activities remain a relatively minor expenditure in rural development funding and are relatively underused by EU Member States

Over the 2014-20 period, the European Union and EU Member States planned to spend jointly EUR 4.45 billion on knowledge and innovation-related measures: EUR 1.3 billion on knowledge transfer (measure M1), EUR 0.7 billion on advice (M2) and EUR 2.4 billion on co-operation (M16)[10] (EC, 2023[48]). As of this writing, the uptake of these measures by EU Member States was relatively slow and limited, respectively 45%, 27% and 30%, compared to 67% for the average spending rate for the entire rural development funding stream[11] (Figure 5.7).

The share of knowledge- and innovation-related spending in total public expenditure on agricultural support measures under Pillar 2, both EU and national contributions, grew slowly from 0.9% in 2016 to 2.3% in 2021 in the EU27 and was strongly driven by an increase in resources dedicated to co-operation (sevenfold increase for the measure M16). During this period, the average shares for individual Member States ranged from less than 0.5% (Luxembourg, Malta, Romania, Poland, Hungary, Greece, and Bulgaria) to more than 5% (8% for the Netherlands and 5% for Denmark).[12]

Figure 5.7. Resources planned, decided, and spent on knowledge and innovation measures in the European Union for 2014-20

Total expenditure (EU and national)



Notes: RD: Rural development funding of the CAP. Situation as of December 2020.
Source: Authors' calculations based on EC (2023[48]).

The EU provides funding streams not directly related to agriculture that AKIS may potentially benefit from, but the extent is difficult to quantify

Several additional EU funds, under the co-ordination of different directorates-general, also have the potential to benefit AKIS. Broadly, they are dedicated to general issues such as economic and social development, environmental and climate affairs, or digitalisation across sectors of the economy. The wide range of activities financed under these funding streams, including sustainable investments, green transition measures, skills transfer or improved digital infrastructures, intersect with AKIS. However, the extent to which they can benefit agricultural innovation is often difficult to quantify. Moreover, the agricultural sector is not one of the main beneficiaries of these programmes.

The European Regional Development Fund (ERDF), the EU Programme for Environment and Climate Action (LIFE), the Digital Europe Programme (DIGITAL), Erasmus+, and the Recovery and Resilience Facility are examples of such programmes. The ERDF invests in the social and economic development of regions across the European Union and can contribute to innovation for a sustainable agri-food sector through smart specialisation strategies. These strategies help to identify R&I priorities in strategic sectors of the country, such as agriculture, to channel knowledge-based investments and co-operation, including through partnerships such as the S3 Agri-food Partnership on High-tech Farming (EC, 2022[58]). The LIFE programme funds projects with an environmental and climate objective, many of them in or related to the agri-food sector. For instance, the Spanish LIFE Coop2020 project (2014-18) aimed to demonstrate a new sustainable business model for agricultural co-operatives based on the creation of "rural smart grids" and promoting the onsite generation of renewable energy (Coop2020, 2020[59]). DIGITAL funds European digital innovation hubs, initiatives that help companies to boost the development and the adoption of digital solutions. European digital innovation hubs offer services essential for innovation (e.g. financing advice, skills development and training), provide technical expertise and the possibility for experimentation ("test before invest") (EC, 2022[60]). They are also expected to create links with digital innovation hubs functioning

under EIP-AGRI and focused on agriculture (EC, 2021[61]). Erasmus+ is a specific programme to foster education and training across the European Education Area, with some interest in green education. It offers various exchange and co-operation opportunities in higher education, school education and vocational training that benefit the agricultural sector. Finally, the RRF is the European Union's temporary recovery instrument, put in place in response to the COVID-19 pandemic. Three of its six pillars (green transition, digital transformation, and social and territorial cohesion) entail relevant measures that can contribute to fostering a sustainable agricultural sector (EC, 2022[62]).

5.3.3. Cross-country collaboration on research and innovation

Fostering cross-country co-operation in the field of R&I is a strategic priority for the European Union and a unique role it can play to improve knowledge flows in a larger innovation space. The universal benefits of transnational R&I collaboration for national systems stem from enabling specialisation and from international spillovers. This allows countries with scarce resources and limited research capacity to better consider their local specificities and needs (OECD, 2020[63]). Partnerships are the European Commission's main mechanisms to stimulate cross-country collaboration.

Research and innovation programming is good at fostering cross-country collaboration

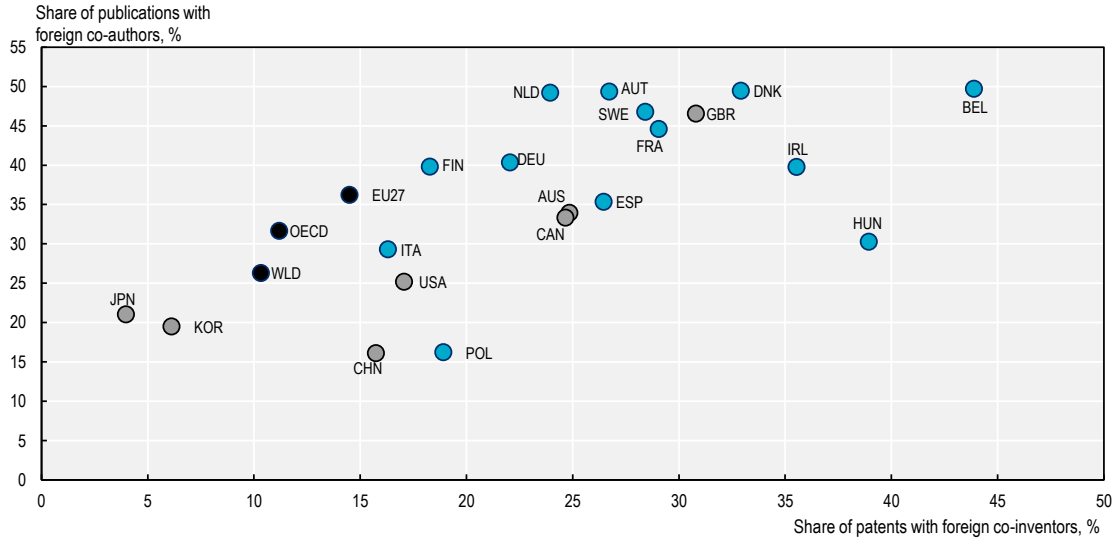
EU Member States are actively involved in international (extra-EU) and transnational (intra-EU) co-operation. According to the OECD survey (OECD, 2022[5]), all 21 surveyed EU countries[13] participate in bilateral or multilateral agri-food initiatives in the European Union, and more than three-quarters of them also with third countries. The three main priorities for such collaboration are: 1) sustainable natural resources management (15 countries); 2) animal health and welfare and plant health (11 countries); and 3) adaptation to climate change (11 countries).

EU Member States' engagement in international research co-operation in the agri-food field is also reflected in the share of scientific publications and patents with at least one foreign co-author or co-inventor. In the EU27, the share of research outputs co-created with authors from outside Europe grew from 30.1% to 38.9% for publications (between 2006-10 and 2016-20); and from 13.7% to 14.3% for patents (between 2004-08 and 2014-18). Thus, the European Union displayed a higher level of international collaboration than the OECD average (33.8% for publications and 10.7% for patents).

Figure 5.8 illustrates the performance of individual EU Member States in terms of cross-country co-operation in agri-food R&D, including with partners from both other EU Member States and non-EU countries. In most EU Member States, the share of publications with at least one foreign co-author is above the global and OECD averages (26% and 32%, respectively, for the years 2010-20). This share is highest in Luxembourg (73%), followed by Cyprus (56%), and Austria, Belgium, Denmark, and the Netherlands (all nearly 50%). The share of patents with foreign co-inventors is also relatively high among the EU Member States compared to countries such as China, Japan, Korea, or the United States, where less than 20% of inventions were the result of international co-operation in 2008-18. The leaders among the EU countries are Belgium and Hungary, with a share of around 40% or more.

Figure 5.8. Cross-country co-operation in agri-food R&D

Agri-food outputs with foreign partners as a share of total agri-food outputs



Notes: Values for EU27 exclude intra-EU collaboration, while for individual EU Member States they include co-operation with both other EU Member States and non-EU countries. For the world and OECD aggregates, the values refer to the averages of their members. Individual EU Member States are highlighted in blue, aggregates in black and selected comparison countries in grey. Shares for economies with fewer than 50 patents and/or publications are not shown. Patents data refer to the years 2008-18. Patents filed under the Patent Co-operation Treaty (PCT) by earliest filing date and location of inventors using fractional counts for specialisation and contribution, and using whole counts for collaboration. Agri-food includes patents from IPC classes: A01, A21, A22, A23, A24, B21H 7/00, B21K 19/00, B62C, B65B 25/02, B66C 23/44, C08b, C11, C12, C13, C09K 101/00, E02B 11/00, E04H 5/08, E04H 7/22 and G06Q 50/02. Publications in the field of agricultural and biological science refer to the SCOPUS 2-digit All Science Journals Classification and include the following categories: agronomy and crop science, animal science and zoology, aquatic science, ecology/evolution/behaviour and systematics, food science, forestry, horticulture, insect science, plant science, soil science, and miscellaneous agriculture/biological sciences. Data are based on fractional counts.
Source: Authors' calculations based on OECD (2022[64]; 2022[65]).

Horizon Europe attempts to rationalise the R&I partnership landscape, but it is too early to assess the results

Partnerships are the European Commission's main mechanism to foster cross-country collaboration on R&I, the alignment and integration of national R&I strategies, and more effectively channelling investments directed at meeting global challenges and European policy objectives. Partnership programmes bring together a wide range of actors from industry; universities; research organisations; bodies with a public service remit at local, regional, national or international level; or civil society organisations, including foundations and non-governmental organisations and farmers, if relevant. The first partnerships were launched in 2002 as part of the process of creating the European Research Area and were a response to the fragmentation and duplication of research efforts in the European Union. They also seek to ensure synergies across EU and national research agendas, to maximise the impact of public investment directed at meeting global challenges and European policy objectives, as well as to stimulate public and private investment in research activities by sharing risks and ensuring greater investment predictability for their partners. Resource pooling mechanisms from across Europe can help build economies of scale and critical mass that are more challenging for individual countries and thus ensure a strong global presence for European research. Over time, many types of partnerships have been developed to meet the changing needs of European R&I. The complexity of the partnership landscape peaked during Horizon 2020 (2014-20), when nearly 120 partnership initiatives and 8 forms of their implementation co-existed (EC, 2022[66]).

Under Horizon 2020, there have been three main types of mechanisms relevant to agricultural R&I: 1) joint programming initiatives (JPI); 2) European Joint Programme Cofund (EJP Cofund); and 3) European research networks (ERA-NET) (ERA LEARN, 2022[67]). JPIs are intergovernmental partnerships co-funded by the European Commission and Member States to tackle grand societal challenges that cannot be resolved solely at the national level. The main objective of JPI participation is aligning innovation strategies and developing joint calls for research proposals. The JPI on "Agriculture, Food Security and Climate Change" (FACCE-JPI) is of greatest relevance to agricultural research and has recently contributed to the development of new European Partnerships, mainly on agroecology and food systems. EJP Cofunds are designed to support co-ordinated national R&I programmes, co-funded by the European Commission and EU Member States. There are two EJP Cofunds in the area of agriculture: "One Health" (OHEJP) and "Towards climate-smart sustainable management of agricultural soils" (EJP SOIL). The ERA-NET Cofund is a funding instrument designed to support public-public partnerships such as JPIs in the preparation and establishment of networking structures, as well as in the design, implementation, and co-ordination of joint activities.

Horizon Europe aims to simplify the partnership architecture and introduce a more strategic approach with fewer and more impactful partnerships that are better aligned with overarching EU policy goals such as the EGD (EC, 2022[66]). Rationalisation is mostly achieved by merging or discontinuing numerous public-public partnerships, reforming existing partnerships (changing scope and/or partners involved) and launching some new partnerships, including on agroecology and on leveraging data technologies for the monitoring of sustainability performance and policy development (Chapter 2, Section 2.3), to better respond to new priorities. Under the "European Partnerships" umbrella, Horizon Europe establishes three possible forms of partnerships: co-programmed, co-financed and institutionalised.[14] The target number of partnerships has been reduced to 49, of which 8 are under Horizon Europe Pillar 2 Cluster 6. However, some partnerships funded under Horizon 2020, that have not yet completed their cycle, continue their activities and may still open calls for proposals.

Agriculture-relevant European Partnerships were brought together under the heading "Cluster 6: Food, bioeconomy, natural resources, agriculture and environment". Of almost EUR 9 billion of EU funds that go to this cluster, 23% is for partnerships. The EU contribution of EUR 2 billion is expected to be matched with EUR 1 billion committed by the private sector and EUR 0.96 billion by public partners. Four out of eight planned partnerships under Cluster 6 were launched by mid-2022 ("Rescuing Biodiversity to Safeguard Life on Earth"; "A Climate Neutral, Sustainable and Productive Blue Economy"; "A Circular Bio-based Europe"; and "Water Security for the Planet"), while, in line with the first Strategic Plan 2021-24, the remaining ones are expected at a later stage (EC, 2022[66]; EC, 2022[68]). These latter partnerships are of particular interest to the agricultural sector (Box 5.5).

Box 5.5. European Partnerships relevant for the agri-food sector

Horizon Europe proposed four European Partnerships of particular relevance to farming and food systems:

The "Accelerating Farming Systems Transition: Agroecology Living Labs and Research Infrastructures" partnership (EC, 2022[69]) aims to accelerate the transition towards sustainable, climate- and ecosystem-friendly farming practices. It will establish a network of living labs and research infrastructure that will provide space for real-life experimentation, help to better understand the agroecological processes and deliver ready-to-adopt practices.

The "Agriculture of Data" partnership (EC, 2022[70]) is to support the development of solutions for the sustainability of agricultural production and strengthen the capacity to monitor and evaluate policies.

The partnership will generate EU-wide data sets and information thanks to harnessing the potential of digital technologies combined with Earth observation and other environmental and agricultural data.

The "Animal Health and Welfare" partnership (EC, 2022[71]) aims to facilitate co-operation between relevant actors to develop new knowledge, monitoring and control tools that will strengthen preparedness and bring additional solutions to prevent, detect and respond to priority infectious animal diseases; fight against antimicrobial resistance; and improve animal welfare.

While the European Partnership "Sustainable Food Systems for People, Planet and Climate" (EC, 2022[72]) is less directly linked to primary agricultural production, it seeks to build synergies with the above European Partnerships to accelerate the transition towards healthy and safe diets that are sustainably produced and consumed in resilient food systems. It aims to establish a food system knowledge hub and a network of interdisciplinary and transdisciplinary food system living labs.

The European Union also promotes co-operation with countries from outside its borders

The EU framework programmes for R&I (Horizon Europe and its predecessor, Horizon 2020) are open to researchers and innovators from around the world who are encouraged to team up with EU partners in preparing proposals. Research framework programmes also include targeted initiatives with key partners from non-EU countries. For instance, the African-European R&I partnership on "Food and Nutrition Security and Sustainable Agriculture" was established in 2017 around the global challenge of food security. By June 2020, it channelled a joint investment of over EUR 390 million on priorities encompassing sustainable intensification of agriculture, agriculture and food systems for nutrition, and expansion and improvement of agricultural trade and markets. It financed projects mainly through the ERA-NET Cofund LEAP-Agri and DeSIRA. The EU-China "Food, Agriculture and Biotechnology" Flagship Initiative launched in 2013 is another example of EU collaboration with non-EU countries. By early 2019, the flagship had mobilised over EUR 120 million and organised more than 16 projects addressing priority themes of mutual interest, such as tackling food security, food safety, healthy diets, animal health and sustainable agriculture (EC, 2019[73]). Both initiatives are expected to continue under Horizon Europe (EC, 2019[46]).

The European Commission's partnership, "Development of Smart Innovation through Research in Agriculture" (DeSIRA), promotes the importance of R&I for accelerating the transition of agri-food systems in low- and middle-income countries. DeSIRA aims to support R&I projects in Africa, Asia, and Latin America; strengthen national research capacities and research governance; and enhance the use of evidence for better R&I policies. Its activities contribute to building science-based solutions of immediate application, including the adaptation of agricultural practices to climate change, the promotion of agroecology and the support of small farmers.

The European Commission also partners with the Global Research Alliance on Agricultural Greenhouse Gases. This initiative brings together over 60 countries from all regions of the world and nearly 30 partner organisations with a common goal of finding ways to grow more food without increasing greenhouse gas (GHG) emissions. The alliance provides a framework for voluntary action to stimulate co-operation and investment in relevant research activities.

5.3.4. Outputs of R&D investment in agri-food science

The performance of agricultural innovation systems can be monitored by proxy measures such as the number of patents or scientific publications. While these indicators only provide a partial picture of the overall innovation performance, they may shed some light on the profiles of countries in terms of their specialisation in agri-food R&D and their importance in the international arena.

The European Union's R&D system is relatively specialised in agri-food. In the period 2008-18, 5% of all patents in the European Union were in the agri-food field, well above that of Korea and Japan, but below

Australia, Canada, and the United States (Table 5.2). The most specialised in this respect among EU Member States were Denmark and Belgium (above 10%), while the least specialised were the Czech Republic, Sweden, Finland, Austria and Germany (below 4%; see Annex Table 5.A.3). Also, about 5% of scientific publications in the European Union in 2010-20 were related to agriculture and/or biology, a greater portion than in Korea, Japan, and the United States, but lower than in Australia (Table 5.2). Latvia (above 11%), and Romania and Cyprus (below 3%; see Annex Table 5.A.3) had the highest and the lowest shares in the European Union, respectively. The European Union gradually reduced its specialisation in the agri-food field due to the increased dynamics of other fields of science. The share of agri-food patents declined from 5.2% in the 1990s to 5.0% in 2004-08 and 4.9% in 2014-18, while the share of publications in the field of agricultural and biological science dropped from 5.8% to 5.0% between 2005-10 and 2015-20 (OECD, 2022[64]; 2022[65]).

Table 5.2. Agriculture and food science R&D outcomes

Agriculture and food science R&D outcomes, 2010-20 (publications) and 2008-18 (patents)

	Specialisation: Agri-food science outputs as a share of the country's total (%)		Contribution: Country's share of world agri-food science output (%)		Importance/visibility: Outstanding agricultural/biological science publications as a share of the country's total in this field (%)
	Patents[1]	Publications[2]	Patents[1]	Publications[2]	Publications[2] (top 10% most cited)[3]
EU27 [4]	5.0	5.1	30.0	24.0	12.3
OECD	3.9	4.8	89.8	62.0	12.2
Australia	7.1	6.9	1.1	3.3	14.0
Canada	5.8	5.4	2.5	2.9	12.5
China	2.6	4.1	5.5	15.8	10.6
Japan	2.1	4.1	15.0	3.7	6.3
Korea	2.0	3.8	4.8	2.1	7.7
United Kingdom	6.1	3.4	4.4	3.2	17.6
United States	5.4	4.2	27.3	16.4	14.0

1. Patents filed under the Patent Co-operation Treaty (PCT) by earliest filing date and location of inventors using fractional counts for specialisation and contribution, and whole counts for collaboration.
2. Publications in the field of agricultural and biological science.
3. Top 10% of the world's most cited publications in the field of the agricultural and biological science.
4. More information on the EU Member States can be found in Annex Table 5.A.3.
Source: Authors' calculations based on OECD (2022[64]; 2022[65]).

The European Union is a major contributor to global agri-food R&D outcomes. With around 2 500 patents filed per year over the period 2008-18, it accounted for 30% of the world's total, ahead of the United States and Japan (Table 5.2). The number of patents is not evenly distributed among EU Member States, with France and Germany jointly accounting for more than half of the EU's contribution (Annex Table 5.A.3). In line with the OECD trend, the EU27 also increased the number of agri-food patents between the 1990s and 2008-18 by over 50%. Nevertheless, due to increased R&D activity in the BRICS[15] countries (especially in China), and in Korea, the importance of the European Union on the international stage slightly decreased during this period. On average, over 28 000 agricultural and biological scientific publications were published in the European Union every year between 2010 and 2020, corresponding to almost a quarter of the global total. The United States and China were the next two economies with the highest publishing activity (Table 5.2). Within the European Union, four countries – Germany, Spain, Italy and France – together accounted for half of the EU contribution (Annex Table 5.A.3). Between 2005-10 and 2015-20, the number of publications in the European Union grew by nearly a third, growth comparable to

that of Australia and the United States, but lagging behind developing countries such as China, with more than a threefold increase (OECD, 2022[64]; 2022[65]).

The importance of the European Union's research results in the international area is further confirmed by the relatively high share of publications in the 10% of the most cited publications in the world. About 12% of all agricultural and biological science publications in the European Union were among the top 10% most cited publications in 2010-20. These shares were particularly high in the Netherlands (18.6%), Denmark (16.5%) and Ireland (16.1%; Annex Table 5.A.3).

5.4. Building the right balance of skills for innovation for sustainable agriculture

There has been a growing concern in many EU Member States and OECD countries over the last two decades of shortages of labour and the key skills needed to ensure the resilient growth, innovation and sustainable development of the agricultural sector. Given that the agricultural workforce generally presents a low skill level, agricultural VET and farm advisory services face several challenges, including providing opportunities for lifelong learning to upskill and reskill the current workforce, strengthening the responsiveness of the agricultural education systems to the sector's diverse need, and exploiting the roles of advisory services in AKIS as a service provider to farmers and a facilitator of formal and informal education and training programmes.

5.4.1. Skills and knowledge needs

The employment profile in European agriculture is shifting towards a greater demand for highly skilled workers…

According to the European Union Labour Force Survey,[16] around 8.4 million people were employed in the agriculture, forestry and fishing sector[17] in 2020 (CEDEFOP, 2022[74]). The sector comprises 71% of skilled farm workers, 14% of agricultural labourers, 4% of operators and assemblers, and 10% of other occupation groups.[18] The occupational composition of the sector varies greatly from one Member State to another.

Employment in the EU agriculture, forestry and fishing sector is projected to fall by 27% between 2020 and 2030, the highest decline among sectors, according to estimates of the European Centre for the Development of Vocational Training. This projected decline can be attributed to various reasons, including the ageing of the workforce, productivity improvements and expected greater automation, resulting in a reduction in the demand for manual labour (CEDEFOP, 2021[75]; Maucorps et al., 2019[76]). The employment profile in the sector is also expected to change, as the participation of low- and medium-skilled workers will decrease and the share of high-skilled ones will increase. Furthermore, it is estimated that there will be high turnover, with around 6.3 million skilled farm workers leaving the sector and being partially replaced by around 5.7 million new entrants (CEDEFOP, 2021[75]).

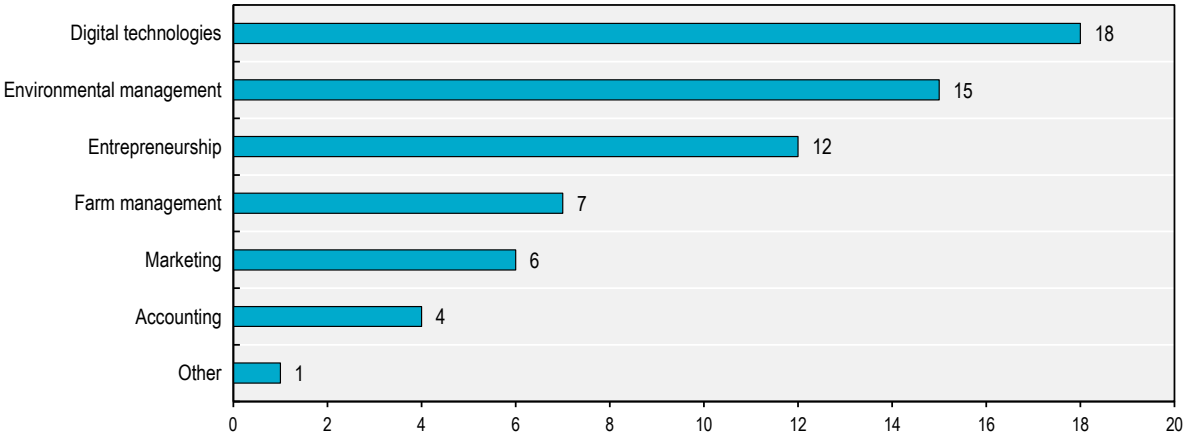
…which translates into a need for various new skills and capacities among agricultural workers, including digital skills, environmental management, and entrepreneurship…

The agricultural sector is changing, and with it the skills required. The effects of climate change, new environmental regulations, the availability of new digital technologies and analytical tools, or the emphasis on competitiveness are just a few examples of the challenges and opportunities the sector faces. Increasingly, farmers are being asked to consider environmental and social aspects of their farms alongside productivity and this may require more knowledge or advice that is specialised in these fields. Legal and regulatory knowledge related to both farming practices and working conditions is also required (Rose, 2021[77]). This translates into a change in the type and complexity of farming tasks, and different skills set that might be required of agricultural workers in the future.

…and consequently, for a robust long-term skills agenda for the EU agri-food sector

The broad range of needs outlined above clearly indicates a space for a more sectoral skills strategy that could respond to the social transition towards a green, digital, resilient economy. This is supported by the views on long-term skills needs and knowledge gaps for a sustainable agricultural sector expressed by EU Member States in the OECD survey (Figure 5.9). The majority of the participating countries are aware of the need to further develop skills and knowledge in the use of digital technologies in the sector (Section 5.6). Respondents overwhelmingly highlighted skills needs related to digital technology as a priority concern. Environmental management is the second top concern among Member States. The two needs may also be partially interlinked, as digital may facilitate information to better address environmental constraints, including for precision agriculture, which has the potential to reduce the excessive use of pesticides and reduce GHG emissions from the sector (OECD, 2019[78]). Furthermore, several Member States called for more investment in human capital to increase the number of entrepreneurs and skilled farm managers who could continue farming even in times of uncertainty.

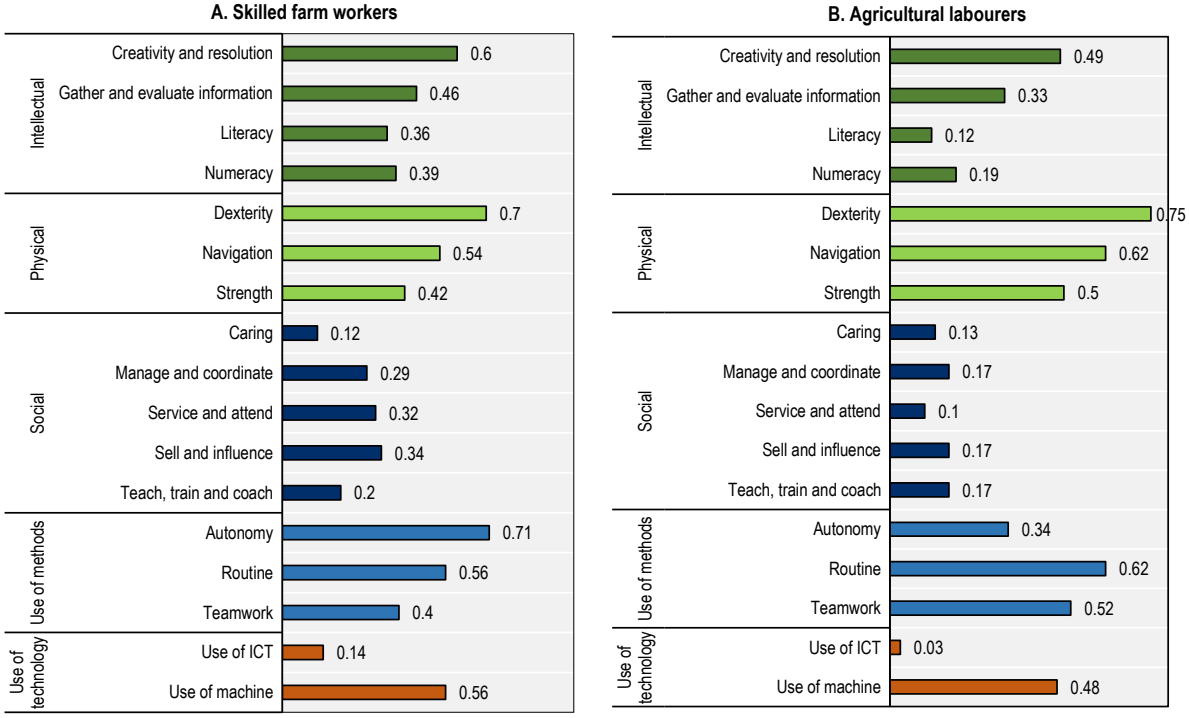
Figure 5.9. Long-term skills needs and knowledge gaps identified in EU Member States' food and agriculture sector



Notes: Twenty-one responding units provided an answer to this question. Values refer to the number of countries which indicated this option as one of the top 3 most important. See Annex 1.B for more information on the survey.
Source: OECD (2022[5]).

Various researchers and organisations have also been examining the question of what skills are needed to conduct agricultural business. For example, Eurofound (2016[79]) developed a set of task indices, with two main occupations of particular interest (Figure 5.10): skilled farm workers and agricultural labourers. The indices allow for measuring task content (what people do at work) and the methods and tools (how work is organised and done) across jobs in Europe. Autonomy, creativity and resolution, and the ability to gather and evaluate information were identified as the most important skills for skilled farm workers (Figure 5.10, Panel A). These skills are essential to planning, organising and performing farming operations and breeding animals (CEDEFOP, 2021[75]), but were of comparatively less importance for agricultural labourers (Figure 5.10, Panel B). The operation and maintenance of machinery was an important skill for both occupational categories, while the ability to use ICT ranked low. Social skills were relatively less important, especially for agricultural labourers.

Figure 5.10. Important tasks and skills in the agricultural sector



Notes: The importance of tasks and skills is measured on a scale of 0-1, where 0 means least important and 1 means most important. ICT: information and communications technology.
Source: CEDEFOP (2022[80]), based on Eurofound's European Working Conditions Survey, OECD Survey of Adult Skills PIAAC and the US Occupational Information Network ONET database.

Despite a low score for the importance of ICT use in the agricultural sector in the Eurofound's task indices, digital skills are now seen as a requirement according to many reports predicting the future of farming (Rose and Chilvers, 2018[81]; OECD, 2019[78]). Farmers will certainly need to understand how to gather and interpret data, and take decisions based on such evidence. Furthermore, to comply with the subsidy conditions, European farmers are requested to store digital evidence, such as information on agricultural practices at the parcel level, and present it to the national and EU agricultural regulators (OECD, 2019[78]; 2015[82]). Although some technologies may operate on a service model, and farm advisors may be available to help farmers interpret the data, basic digital skills are essential, as they help assess the potential benefits of new technologies and understand how to use them (Rose, 2021[77]).

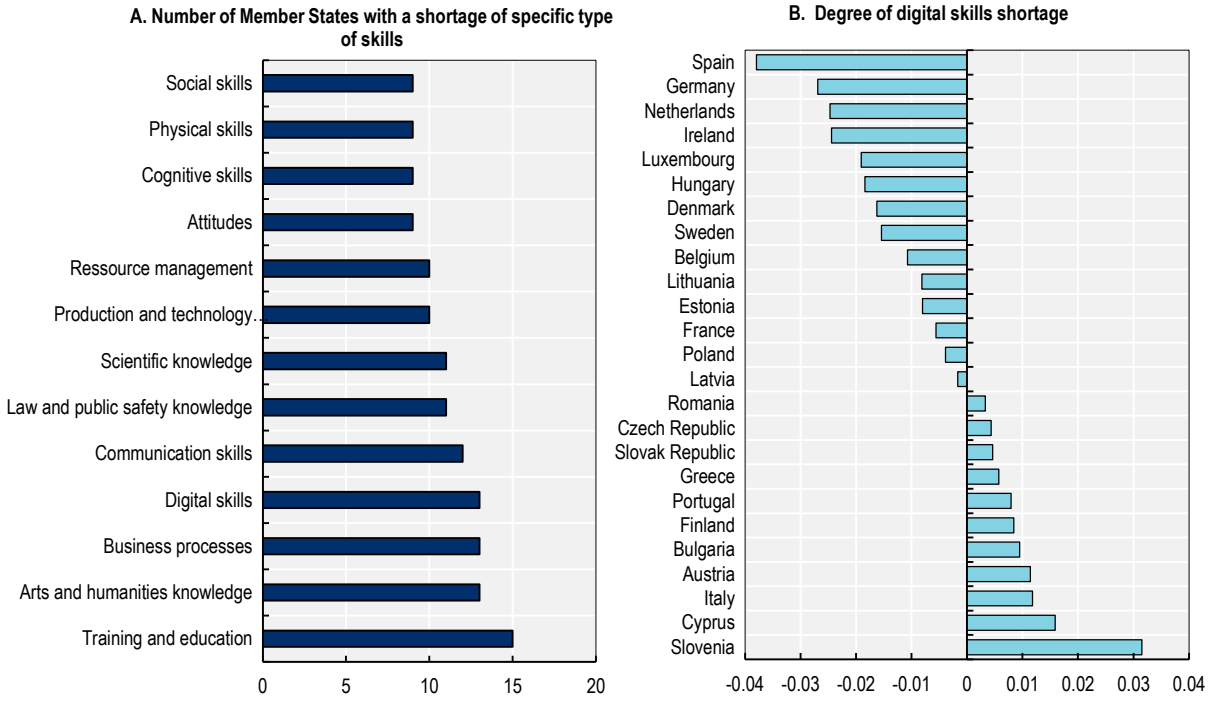
An EIP-AGRI seminar (EIP-AGRI, 2020[83]) on "New Skills for Digital Farming" highlighted the need for cross-cutting skills such as *open-mindedness*, c*omprehensive management*, *communication and collaboration*, *digital literacy*, and *advanced digital skills*. Communication and collaboration are particularly important in the digital transition of farmers as they do not take place in a vacuum and the ability to build networks with several actors (e.g. IT advisors) is of great importance for digital uptake as well as for the ability to learn and innovate. Moreover, an OECD report (2019[78]) pointed out the crucial role of "soft" skills, such as *problem-solving*, *creative thinking*, *management* and *communication skills*, in facilitating digital transition of farmers, and thus fully realising their benefits.

While the EU agricultural sector experiences skills imbalances…

Skills imbalances, such as skills mismatches and shortages,[19] in the sector can exert a negative impact on overall economic growth, firms and individuals. They can negatively affect economic growth through their effects on increased labour costs, lower labour productivity growth, slower adoption of new technologies and lost production associated with vacancies remaining unfilled (OECD, 2016[84]). Firms experiencing skills shortages may be constrained in their ability to innovate and adopt new technologies, and might face higher hiring costs, while workers with skills mismatches may experience a higher risk of unemployment, lower wages and lower job satisfaction (OECD, 2016[84]).

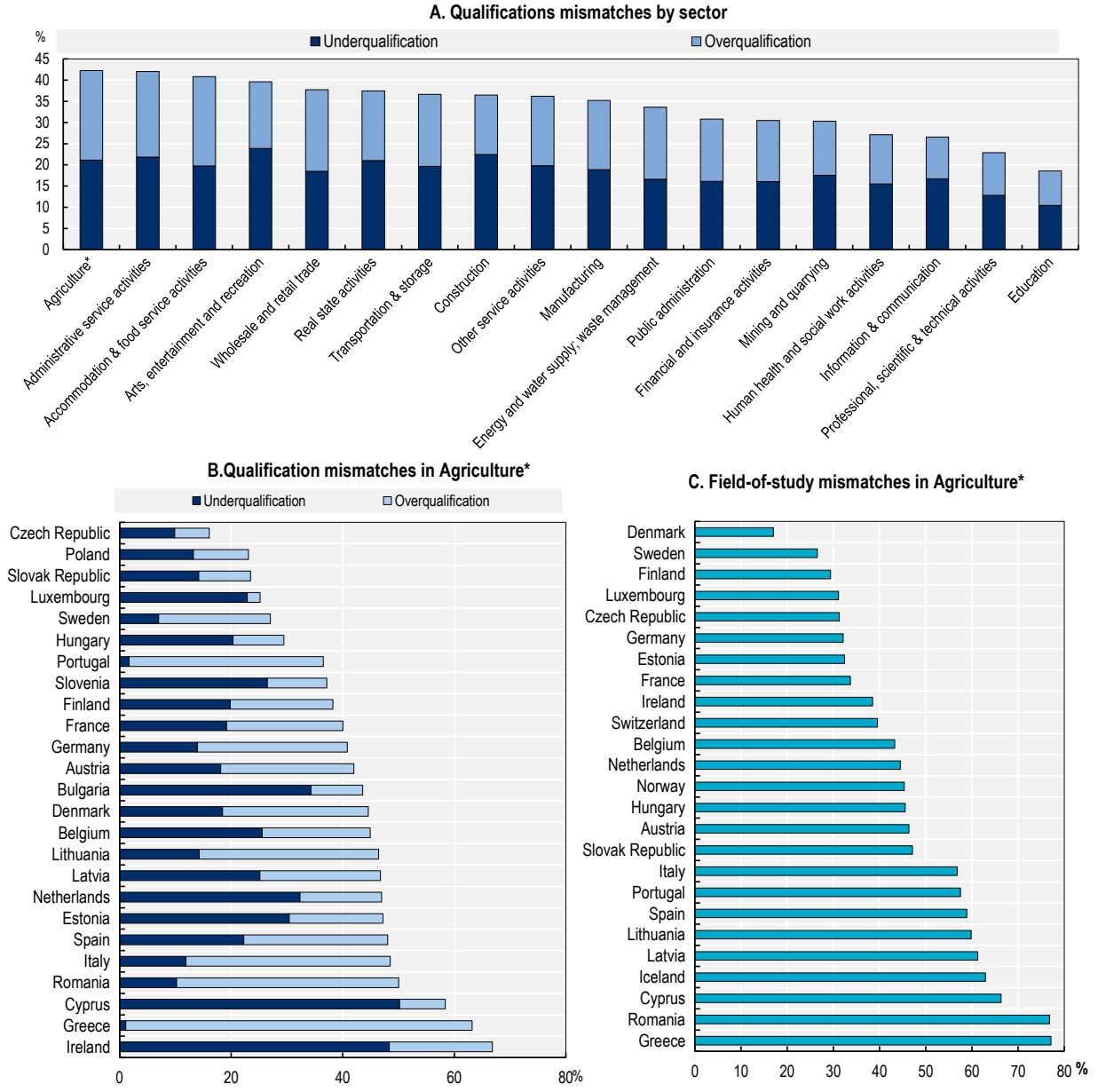
The *OECD Skills for Jobs Database* sheds light on whether the demand for a certain type of skills is adequately met, and whether skilled workers occupy positions where their abilities are fully utilised. It provides an overview of relative shortages and surpluses for skills, and measures skills mismatches using qualification mismatch and field-of-study mismatch indicators (OECD, 2017[85]). Figure 5.11, Panel A shows that more than half of EU Member States encounter shortages in *communication skills*, *digital skills*, *business processes*, and *training and education*[20] in the agriculture, forestry and fishing sector.[21]

Figure 5.11. Skills shortages in the EU agriculture, forestry and fishing sector, 2019



Notes: The skill shortage index for 14 skills types was calculated for the agriculture, forestry and fishing sector of 25 EU Member States. No data were available for Croatia or Malta. Skill types of *Medicine Knowledge* and *Arts and Humanities Knowledge* were excluded from the figure due to low consistency with the focal sector. The index is constructed in two steps. First, an occupational shortage index is calculated for each occupation based on five sub-components: 1) wage growth; 2) unemployment growth; 3) hours worked growth; 4) unemployment rate; and 5) change in underqualification. Second, the values of the occupational shortage indexes are used to weight the importance of the skill requirements associated with each occupational group. Information on skill requirements in each occupation is extracted from the Burning Glass Technologies (BGT) data. The scale ranges from -1 to +1, with negative values indicating skills surpluses, while positive values indicate shortages. For Panel A, the number of Member States with the shortages was counted.
Source: OECD (2022[86]).

Figure 5.12. Qualification and field-of-study mismatches in the European Union



* Agriculture sector refers to agriculture, forestry and fishing.

Notes: Qualification mismatch arises when workers have educational attainment that is higher or lower than that required by their job. If their education level is higher than that required by their job, workers are classified as overqualified; if the opposite is true, they are classified as underqualified. Field-of-study mismatch arises when workers are employed in a different field from what they have specialised in. For the field-of-study mismatch, no data are available for Bulgaria, Poland or Slovenia.

Source: OECD (2022[86]).

Digital skills can be understood as a broad concept and covers a wide spectrum of skills ranging from basic digital literacy, i.e. the ability to use office suite software (word processing, spreadsheet and presentation software) to advanced ones, such as skills in data analysis, digital design and marketing, and software and programming. The degree of shortage in *digital skills* varies among EU Member States, reflecting, *inter alia*, country-specific employment conditions and skills requirements (Figure 5.11, Panel B). For instance, a high surplus of digital skills in Spain may be partly linked with the high employment share of agricultural

labourers who are less likely to use digital technologies as also confirmed by Eurofound task indices (Figure 5.11, Panel B). Conversely, countries with a relatively higher employment share of high-tech occupations (e.g. science and engineering professionals, and ICT professionals) within the agricultural sector, such as the Czech Republic (14.1%) and Finland (9.4%), exhibit digital skills deficits. As highlighted above, farmers need different skills across the spectrum, from *digital literacy* to *soft skills* such as *communication*, to exploit the full benefits of digital technologies. This indicates more potential constraints on adopting new digital technologies in countries where both digital and communication skills are lacking.

The EU agriculture, forestry and fishing sector was also found to experience skills mismatch, i.e. workers have higher or lower skills proficiency than what is required by their job. As seen in Figure 5.12, Panel A, the sector displays the highest rate of overall qualification mismatch among all sectors of the economy, with 42% of workers' education levels mismatched to their current jobs. The levels of qualification mismatch, however, vary among EU Member States, ranging from 16% in the Czech Republic to 67% in Ireland[22] (Figure 5.12, Panel B). Nearly half of Irish workers in the sector are underqualified, with lower than required levels of education, while in Greece the majority of workers are overqualified. The level of overall field-of-study mismatch for the agriculture, forestry and fishing sector was also high. Forty-one per cent of workers in the sector are employed in a field other than in which they are specialised. This places the sector in the fourth position of field-of-study mismatch among all economic sectors. Greece and Romania had the highest rates of field-of-study mismatch (77%), while the majority of workers in Denmark benefit from their specialisations in their workplaces (Figure 5.12, Panel C).

…farmers' participation in adult training remains low despite the existence of relevant policy measures

"OECD Skills Strategy" country reports, covering several EU countries, highlight several opportunities to reduce skills imbalances.[23] They recommend improving information about current and future skills needs; providing opportunities to upskill and reskill the current workforce through VET; and attracting more young skilled workers to the sector. These are consistent with the approaches scoped by the European Skills Agenda and the Pact for Skills for the Agro-Food Ecosystem.

Effectively disseminating information on current and future labour market and skills needs is crucial to address shortages and skills mismatches (OECD, 2017[85]; 2019[87]). The Eurofound task indices can be a good reference for job seekers to get an overview of occupational profiles and skills requirements, even if ICT and social skills for the agricultural sector seem to be underestimated (Zagata and Sutherland, 2015[88]). The Erasmus+ projects of FIELDS (January 2020-December 2023) and I-Restart (September 2022-August 2026) are aiming to identify the current and future skills needs for sustainability, digitalisation and the bioeconomy in agriculture, and could support the prioritisation for training needs.

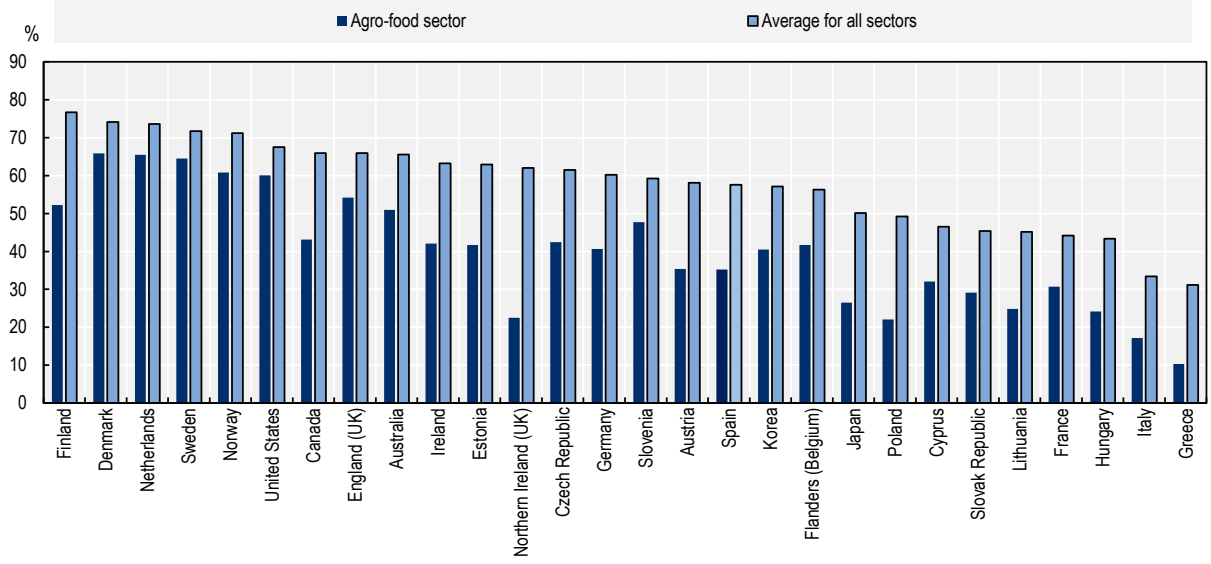
Lifelong learning and vocational training, ensuring that the existing agricultural workforce can upgrade their skills, is important to reduce skills imbalances. Much of the vocational education/training tends to focus on farm practices and management. This has been particularly important in helping farmers adapt in a rapidly changing sector and adopt more specialised agricultural technologies. Knowledge transfer measure (M1) of rural development programmes (RDP) for 2014-20 supports VET activities. The total public budget dedicated to the M1 in 2014-20 represents, on average, only 1.1% of the public expenditure planned under the RDP (Beck et al., 2020[89]). Out of 112 RDPs, 101 have programmed the knowledge transfer measure, resulting in 1.22 million farmers, or 31% of CAP beneficiaries, being trained in the period 2014-20.[24] Case studies used for their evaluation show that low uptake of training measures is due to lack of interest and opportunity costs of farmers, and demand conflicts among different types of farmers (e.g. demand of small, part-time or less-educated farmers, and demand among younger and more "professional" farmers).

International evidence confirms that adults' participation in education and training in the agro-food sector is quite low in comparison to other sectors. According to the OECD PIACC survey, only 30% of adult workers from the agro-food sector of OECD countries participated in some form of further education or

training over the previous 12 months, compared to over 50% for the entire economy (OECD, 2019[90]). Figure 5.13 shows that the participation ratio is variable among countries: more than 60% of adults participated in Denmark, the Netherlands and Sweden, while the rate was much lower in Greece and Italy. Furthermore, less than 30% of respondents who had not recently undertaken any actions to improve their qualifications expressed interest in participating in any form of further training or education in the future. Such a share was also quite low in the whole economy. This indicates that the agricultural workforce is skewed towards groups that face more barriers to training participation than workers in other sectors. Based on a narrative literature review, Rose (2021[77]) identified 11 barriers to farmers learning new skills, including cost, lack of time to complete/deliver staff training, geographic accessibility, gender inequality and fragmented learning.

Attracting younger highly qualified workers to the agricultural sector is crucial to reduce skills imbalances (Chapter 2, Figure 2.8), as more highly educated and skilled young farmers are more likely to adopt new technologies and innovative farming techniques (Zagata and Sutherland, 2015[88]; Staboulis et al., 2022[91]), hence contributing to making farms more competitive. In some cases, a policy instrument has been used to encourage farmers to gain formal education qualifications in return for support payments. For example, ten EU Member States had included additional qualification criteria for support payments to young farmers (under 40 years old). The Young Farmer Payment is a compulsory scheme for Member States to implement, but individual countries can add their own criteria to it (Chapter 3, Section 3.4). In Ireland, for example, to qualify for the payment, a farmer must have "successfully completed a recognised course of education in agriculture giving rise to an award at Further Education and Teaching Awards Council (FETAC) Level 6[25] or its equivalent" by a set date (Department of Agriculture, Food and the Marine, 2022[92]). This contributes to 44% of Irish farm managers under 35 years having completed full agricultural training, compared to 22% for the EU average (Table 5.3) (Eurostat, 2018[93]).

Figure 5.13. Participation in adult education and training in the agro-food sector and other industries across countries



Notes: Agro-Food industry includes agriculture, forestry and fishing, manufacturing of food, and manufacturing of beverages. Adult education and training refers to participation in formal or non-formal adult education and training in the 12 months preceding the survey.
Source: OECD (2022[94]).

Table 5.3. Training level of EU farm managers, 2010 to 2016

Training level of farmers	2010 All farmers	2013 All farmers	2016 All farmers	2016 Young farmers
Practical experience only	8.1 million 81%	7 million 71%	6.6 million 68%	0.6 million 57%
Basic training	2.2 million 22%	2 million 20%	2.2 million 23%	0.2 million 21%
Full agricultural training	0.7 million 7%	0.9 million 9%	0.9 million 9%	0.2 million 22%

Notes: Basic agricultural training is any training course completed at a general agricultural college and/or an institution specialising in certain subjects (including horticulture, viticulture, silviculture, pisciculture, veterinary science, agricultural technology and associated subjects); a completed agricultural apprenticeship is regarded as basic training.
Full agricultural training refers to any training course continuing for the equivalent of at least two years' full-time training after the end of compulsory education and completed at an agricultural college, university or other institute of higher education in agriculture, horticulture, viticulture, silviculture, pisciculture, veterinary science, agricultural technology and associated subjects.
Source: EC (2022[18]).

In addition, the 2014-20 Rural Development Programme's sub-measure M6.1 (Start-up Aid for Young Farmers) has contributed to increasing young farmers' participation in training. The measure aims to provide financial aid to young farmers no more than 40 years old who are setting up for the first time or who have already set up an agricultural holding during the five years prior to their first application to the scheme. To be eligible for this sub-measure, most countries require a certain level of education and professional skills. For instance, in Greece, young farmers need to become professional farmers within 18 months of acceding to the sub-measure and have adequate skills or obtain them within 36 months of acceding to the sub-measure (Staboulis et al., 2022[91]). No specialisation is required for those with middle education in agriculture majors or those with a university degree and above. As Table 5.2 shows, although there has been significant progress in the total number of farm managers with full agricultural training (an increase of 2.2 percentage points over 6 years), still less than one farmer in ten had full agricultural training in 2016. Furthermore, 68% of all farmers and 57% of young farmers still had only practical experience that year.

5.4.2. Farm advisory services

Despite the growing importance of the need for farm advice, the relevant instruments remain a marginal expenditure within the overall CAP budget and their uptake is limited

There were two main provisions in the CAP 2014-22 that deal with farm advisory services. The first is the "Farm Advisory System" (FAS), which was an obligation for all Member States to provide advice on cross-compliance requirements. The FAS, operated by designated public advisory organisations and/or selected private organisations competent on cross-compliance in each Member State, aimed at helping farmers to better understand and meet the EU rules for environment, public and animal health, animal welfare, and good agricultural and environmental condition (GAEC). The implementation of a FAS had been made mandatory for all Member States since 2007 to provide access to adequate technical support to help the farmers reach cross-compliance goals. Its scope was enlarged in 2013 to cover new topics such as greening, the Water Framework Directive and integrated pest management. Access to advisory services in the framework of the FAS was open to all farmers, but farmers were free to use it or not. In 14 Member States, the FAS was organised at the national level, while in the remaining countries, it was regionalised (EC, 2022[18]).

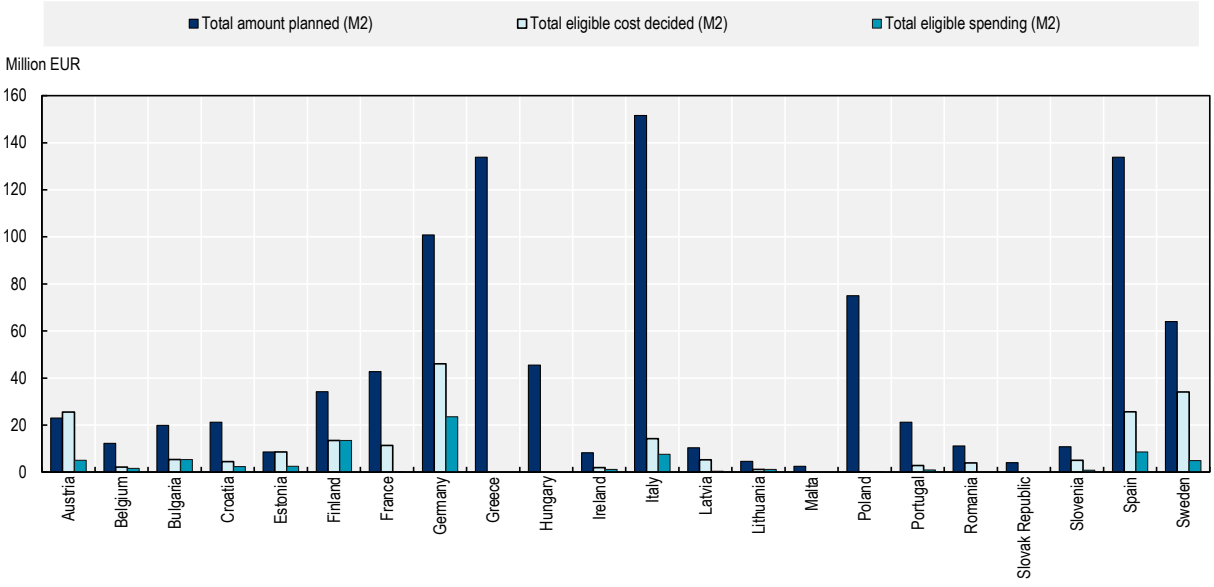
The second provision is a non-compulsory measure to financially support the use of FAS (M2) set within the framework of rural development programmes (RDPs) (the CAP Pillar 2). The RDP advice measure in

the previous period (2007-13) was exclusively used to support the obligation laid upon Member States to set up the FAS and covered only cross-compliance issues. In the 2014-20 period, only 52 out of 112 RDPs used this option (EC, 2022[18]). Five countries (Cyprus, the Czech Republic, Denmark, Luxembourg, and the Netherlands) and 40 regions (20 in France, 6 in Germany, 6 in Italy, 7 in Spain and 1 in Belgium) did not plan to use the M2 as many of them supported farm advice in a more flexible way through national or regional funds. The obligation to use public procurement for the organisation of FAS in RDPs created a lot of administrative burdens, which delayed and refrained expenditure of the measure for those regions and countries where it was planned.

Despite the increasing importance of support for farm advice, due to the delivery mechanism, it remained a very marginal expenditure within the overall CAP budget, with an average of only 0.2% of the Pillar 2 budget in 2014-20. When the expenditure for advisory services (M2) was planned in 2014, it was positively reflected in the overall initial budget allocation of each Member State (dark blue bars in Figure 5.14). However, the actual budget agreed for M2 (light blue bars in Figure 5.14) and the actual expenditure of most Member States (blue bars in Figure 5.14) were much lower in the later stage, and lower than in the previous CAP period (2007-13) due to administrative constraints related to the application of strict public procurement procedures (Labarthe and Beck, 2022[95]; Beck et al., 2020[89]). This did not necessarily imply a decrease in public support for farm advice, since some countries and regions chose to use national or regional funds.

Figure 5.14. Resources planned, decided, and spent on Measure 2 (advisory service) in EU Member States for 2014-20

Total expenditure (EU and national)



Notes: Resources planned refer to the preliminary budget for 2014-20 as of 2014. Resources spent refer to actual expenditure as of 31 December 2018. Five countries (Cyprus, the Czech Republic, Denmark, Luxembourg and the Netherlands) did not choose M2 in their rural development programmes.
Source: Beck et al. (2020[89]).

Under the CAP 2023-27, Member States have to clarify in their CAP strategic plans how measures on advisory services are integrated into the wider innovation policies and approach to AKIS. While there is no longer any reference to the former separate FAS system, the scope of FAS has been widened, and it must cover economic, environmental and social sustainability issues and offer impartial and independent advice

to farmers. In fact, Member States are required to ensure that advisors are appropriately qualified and trained and that they do not have conflicts of interest, by granting financial support only for advisory services that comply with these criteria. This principle is intended to help avoid public funding of advice that may be explicitly biased, e.g. advice offered by private sales representatives of inputs, equipment or machinery (Labarthe and Beck, 2022[95]).

The reach and effectiveness of the advisory measure are unclear due to difficulty in monitoring

Over the past 30 years, there has been a transformation in farm advisory services in countries across Europe with a trend towards privatisation, decentralisation and more demand-led systems (OECD, 2015[82]; Knierim et al., 2017[96]). This change has resulted in pluralistic advisory systems comprising a diverse mix of public, private and farmer-based organisations, with differing objectives, priorities and delivery approaches, and employing advisers with variable skill sets (Birke et al., 2022[97]) (Table 5.4). In many Member States, public organisations are still the key advice providers. Farmer-based organisations, including chambers of agriculture, are also major advisory suppliers in Denmark, France, Portugal and Sweden. In countries such as Italy, the Slovak Republic, and Spain, multiple types of advisory suppliers including public organisations, farmer unions, farmer co-operatives, chambers and private advisory services, interact with farmers at comparable degrees (Birke et al., 2022[97]).

Several studies found that the changing policies and the EU legislative framework encouraged private advisory organisations to flourish in many countries, although they are not always well co-ordinated (Prager et al., 2016[98]; Knierim et al., 2017[96]). Due to the federal system, German and Spanish advisory suppliers are highly diverse among the states and regions as well as in the number and type of organisations directly interacting with farmers (Birke et al., 2022[97]). The main subject of the advice varies depending on the type of advisory supplier. Public organisations support farmers in particular on compliance with regulations and areas of public interest, such as promoting sustainable production (OECD, 2015[82]), while farmer-based organisations and private-commercial organisations cover subjects more directly linked to the farm economy, such as farm management and marketing (Table 5.4).

Despite recent improvements, the evidence shows that EU-funded farm advice only reaches a small proportion of farmers (Beck et al., 2020[89]). Labarthe et al. (2022[99]) also highlight that the enhanced uptake and provision of services are mostly by farmers that are already engaged with the AKIS and there has been relatively little improvement so far in accessing hard-to-reach farmers. Hard-to-reach farmers for FAS are diverse (Klerkx, 2020[100]), and include smaller scale farmers, female farmers, and farmers at the extremes of the age spectrum (i.e. older and younger) (Prager et al., 2016[98]). Also part-time farmers are hard to reach, as their time for farming activities is more limited. Farm labourers, new entrants (or “career changers”) and late adopters are often overlooked by FAS, and connecting with these groups has a strong potential to increase the economic and social cohesion of European agriculture (Labarthe et al., 2022[99]). To stimulate advice on environmental sustainability, in 2020, the Netherlands established the subsidy scheme *Subsidieregeling Agrarische Bedrijfsadvisering en Educatie* (SABE) (OECD, 2023[101]). Under this scheme, farmers can apply for a government-funded voucher to finance impartial advice from an independent registered advisor. The advice is requested based on the farmer’s specific needs.

The assessment of the effectiveness of FAS, such as innovation adoption and its linkages to environmental sustainability, is highly needed but very challenging. Several methodological limitations (Herrera et al., 2019[102]) and data issues (Labarthe and Beck, 2022[95]) impede monitoring and comparison with census data or Farm Accountancy Data Network (FADN) (Chapter 3, Section 3.5). As part of the EU-funded FP-7 project “Farm Level Indicators for New Topics in Policy Evaluation” (FLINT), data on the “use of advisory service” was experimentally collected in some EU Member States as one of the social and environmental indicators under the FADN framework (Vrolijk, Poppe and Keszthelyi, 2016[103]), allowing to explore the correlations between contacts with advisory services and a set of farm-level sustainability indicators.

However, the results showed no clear linear relationship between the use of advisory services and environmental sustainability (Herrera et al., 2019[102]).

Table 5.4. Dominant type of advisory service in EU Member States

Dominating type	Countries	Most frequently covered subjects
Public organisation	Bulgaria, Croatia, Cyprus, Hungary, Ireland, Latvia[1], Lithuania	• Compliance with regulations or policy requirements • Sustainable technologies and practices to strengthen environmental performance
Farmer-based organisation	Austria, Belgium-Flanders, Denmark, Finland, France, Poland, Portugal, Sweden and Slovenia	• Farm management • Marketing of product • Compliance with regulations or policy requirements
Private-commercial organisation	Greece, Netherlands	• Technological innovation to increase productivity and competitiveness of production systems • Financial/legal advice
Public/private	Belgium-Wallonia, Czech Republic, Estonia	• Farm management • Sustainable technologies and practices to strengthen environmental performance • Technological innovation to increase productivity and competitiveness of production systems
Public/private/farmer-based organisations	Germany, Italy, Spain, Slovak Republic	
Public/farm-based organisation	Luxembourg, Malta	

Notes: Country classification is based on Birke et al. (2022[97]) from the i2connect project and is a simplification of reality, i.e. different types of agricultural advisory services co-exist within one country, sometimes even almost equally. Covered subjects are based on the OECD survey of Member States. They are presented in descending order of importance.
1. In Latvia, 99% of the dominant agricultural advisory service provider, LLKC company, is owned by the state and 1% by the Latvian Farmers' Federation.
Sources: Authors' representation based on Birke et al. (2022[97]) and OECD (2022[5]).

There is no evidence of the effectiveness of skills-building funding activities

Under the transition of farm advisory services, the traditional role of the farm adviser, linking research and practice, has largely been replaced by a range of new players, such as specialist/generalist agronomist, crop consultant, veterinarians, facilitator, research project partner (Wynands et al., 2022[104]; Ingram and Mills, 2019[105]). In addition to the technical guidance provided by farm advisors, there is growing awareness of the need for advisers to have a core set of "soft skills and competencies" to help farmers navigate the challenges facing the sector (Atkinson, 2010[106]). These may include core social skills, trusted rapport, ability to work collaboratively, as well as to manage conflicts (Rose, 2021[77]). Many of those fall within the scope of entrepreneurial skills.

Furthermore, the transition towards digitalisation also brings new responsibilities for advisors and the need to develop new skills (Eastwood et al., 2019[107]; Rose, 2021[77]). Kernecker et al. (2021[108]) argue that because of the rise of smart farming, a range of specialised advisors are going to enter the agricultural sector who are skilled in specific areas, and thus collaboration will be needed among constellations of actors. Indeed, an EU SCAR AKIS report (2019[15]) looking at the future of farm advice in Europe argued that advisors would need to adopt more of a listening and coaching role and be facilitators of knowledge sharing alongside new technologies. Similarly, Ingram and Mills (2019[105]) explored the roles of FAS for soil health management, and highlight that the "soft" skills of facilitators, intermediaries and network builders are important in addition to technical skills with respect to soil health management.

The above discussions also call for better investment in the professional development of advisors. For instance, a US study highlights that a farm advisor's own perception of weather variability is critical for

effective farm advising in on-farm climate change adaptation (Niles et al., 2019[109]). Here, the perception is formed largely based on personal experience, education and training. The 2014-20 Regional Development Programme sub-measure M2.3 provides financial support for training advisors. However, the actual number of advisors trained is not clear since so far it was not obligatory for Member States to plan target numbers. Only nine Member States had reported results by the end of 2019 – Croatia, Estonia, Germany, Ireland, Poland, Portugal, Spain, Sweden, and the United Kingdom – resulting in a total of 6 540 trained advisors in these countries in 2014-19 (Beck et al., 2020[89]).

5.5. Regulation-innovation interfaces and the protection of intellectual property rights

5.5.1. Regulation-innovation interfaces

Policy makers have long been aware of the effect of regulations on innovation that leads to economic growth and prosperity. Most important among these effects are the deadweight losses that inflexible and poorly designed regulations or heavy regulatory environments may impose. For example, a regulation requiring a specific emissions mitigation technology does not encourage innovation in other approaches, nor does it allow firms to leverage the results of innovation for their own benefit. These lost opportunities are a cost to society. To avoid these losses, policy makers have increasingly turned to more flexible approaches, such as cap-and-trade regulations and performance standards that reward innovations that reduce the cost of compliance. These approaches allow firms to innovate and adjust their operations, minimising the cost of regulation to society. Command and control regulations are much maligned but are often the best choice when other options are impractical and important values or substantial risks are concerned. Economists often prefer market-based approaches, but these require that relevant markets exist or can be created, a difficult task for conserving biodiversity for example.

This makes defining a relationship between regulation and innovation a complex task, as both regulation and innovation encompass a broad range of approaches and interactions depending on circumstances. Regulation is innovation-pushing when it forces stakeholders to adopt a new process and develop alternative products (Pelkmans and Renda, 2014[110]). Regulation can also be innovation-pushing when it creates a new competition framework and stimulates the creation of new markets. Innovation can be a tool for firms to accomplish environmental regulatory objectives (Ashford and Heaton, 1983[111]). It is fair to say that poorly designed regulations can certainly discourage innovation or distort it into directions that do not respond to economic and environmental needs. Well-designed regulations, on the other hand, can encourage beneficial innovations by establishing incentives to invest in R&D, internalising and helping to respond to environmental externalities, helping new products to succeed in the marketplace, encouraging the sharing of technology, promoting public-private co-operation or many other ways.

> *EU regulations such as REACH and the Water Framework Directive may have spurred innovation as measured by the number of patent applications…*

A burst of innovation can follow the adoption of stringent regulations or even bans on certain substances or products (OECD, 1996[112]). For instance, Tuncak (2013[113]) found a noticeable increase in patents (a common proxy for innovation) following the promulgation of the Regulation concerning Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).[26] REACH replaces the old principle of presumption of safety of existing chemicals with a mechanism under which the safety of chemicals must be demonstrated prior to their entry to the market. This approach is a major driver of innovation that has led to the commercialisation of more environmentally friendly chemicals (Centre for Strategy and Evaluation Services, 2012[114]). The Water Framework Directive (WFD) follows a very different approach compared to REACH. It mandates river basin management planning and obtaining good status for water

bodies by a certain date, along with a regular cycle of reporting and evaluation.[27] The WFD seems to have also led to considerable growth in patent applications concerning water-related goods (Peter, Doranova and van der Veer, 2014[115]). However, this correlation over time does not mean causality nor a direct impact of patents on innovation adoption.

Sometimes just the prospect of regulation is enough to stoke innovation. Stakeholders will often pursue new innovations to proactively address issues to stave off potential regulations or get ahead of upcoming ones. The anticipation of future strict regulation can accelerate the development of new solutions; two examples outside the agricultural sector are substitutes replacing asbestos or phosphate detergents (Ashford and Heaton, 1983[111]) and energy efficiency labels before mandatory energy limits were set (Pelkmans and Renda, 2014[110]).

…but the application of the precautionary principle in the European Union extends the period to approve new products and may hamper innovation such as in certain biotechnologies

The future of EU agriculture increasingly depends on innovation-driven total factor productivity growth. Precision farming, digital tools, biotechnology and many other innovations are important ways to increase agricultural productivity while addressing sustainability problems and achieving the objectives of the EGD. Ensuring that the EU approach to regulation does not limit the prospects of the sector is a key concern. There is a large body of practice designed to ensure that EU regulations are well designed and appropriate. This is in the form of the Better Regulation Guidelines (EC, 2021[116]) and significant regulatory assessment requirements, among other things (Regulatory Scrutiny Board of the European Commission, 2020[117]). The European Union has developed a Strategic Foresight tool as part of its better regulations toolbox (EC, 2021[118]). This tool encourages regulators to pay attention, among others, to megatrends that are likely to have a significant long-term influence. One of these identified megatrends is continued climate change and environmental degradation.

The *precautionary principle* is a central feature of EU law. According to this principle, decision makers are to adopt precautionary measures where there is uncertainty about a potential adverse impact on the environment or human health (EPRS, 2015[119]). EU policy on genetically modified varieties, for example, derives from this precautionary principle and has been controversial. Regulatory barriers present the main obstacle to the deployment of new breeding techniques and genetically modified varieties (EASAC, 2020[120]).

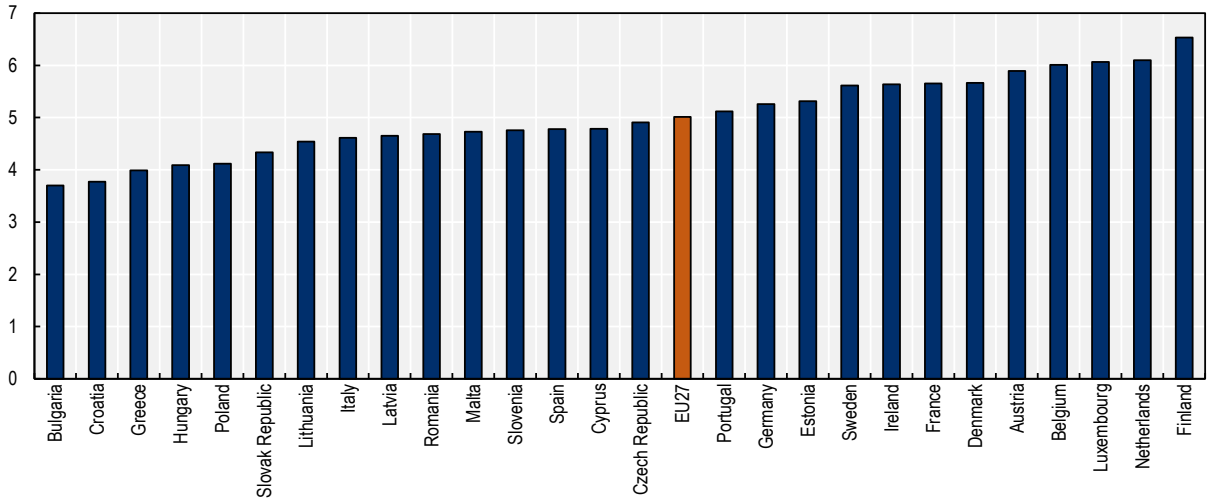
The EU regulatory framework applies the same approval procedures for gene-edited crops as for genetically modified organisms (GMO) products.[28] They must undergo a risk assessment and lengthy approval process to be authorised to enter the market.[29] This can take five years or more to complete (Garcia-Alonso et al., 2022[121]). This may generate uncertainty and discourage companies from investing in related R&D or compels them to move those research activities outside the European Union. Moreover, the EU regulatory approach to gene-edited products may negatively affect the development of these products in other countries, especially developing countries that adapt their export strategies to match EU market requirements.

5.5.2. Protection of intellectual property rights

Although the European Union has some common frameworks and supranational institutions governing the protection of intellectual property rights (IPRs), each EU Member State has its own national intellectual property protection system. This explains the heterogeneity of levels of the World Economic Forum's patent protection index (Figure 5.15). In 2019, the scores ranged between 3.7 in Bulgaria and 6.5 in Finland, while the average for the European Union was 5.0.

Figure 5.15. Intellectual property protection index across EU Member States, 2019

Scale from lowest (1) to highest (7) protection



Note: EU27 is the simple average of member countries' indices.
Source: WEF (2019[122]).

The European Patent Office (EPO) acts as an executive body that provides a single patent grant procedure, but not a single patent from the enforcement point of view. Hence, a patent granted by the EPO is not a single or unitary EU patent or uniformly recognised Europe-wide patent, but a bundle of national patents. Patents granted by the EPO can, however, be challenged centrally at the EPO via opposition proceedings.

The European Union protects intellectual propriety rights related to agriculture through national plant variety protection systems and the Community Plant Variety Rights system, which is valid throughout the European Union

Plant breeding innovations and plant variety protection are relevant components of agriculture and have significant impacts on global health, agricultural systems, food security, biodiversity and the environment. Regulating and providing IPRs to protect new seeds is a challenging task. Seeds are an essential start of any crop production; a very important component of agricultural livelihoods in food, ornamental and industrial value chains; of local and global food security; and a determinant of sustainability. Therefore, seeds have become subject to an increasing and more complex number of regulations pursuing different policy objectives (Louwaars and De Jonge, 2021[123]).

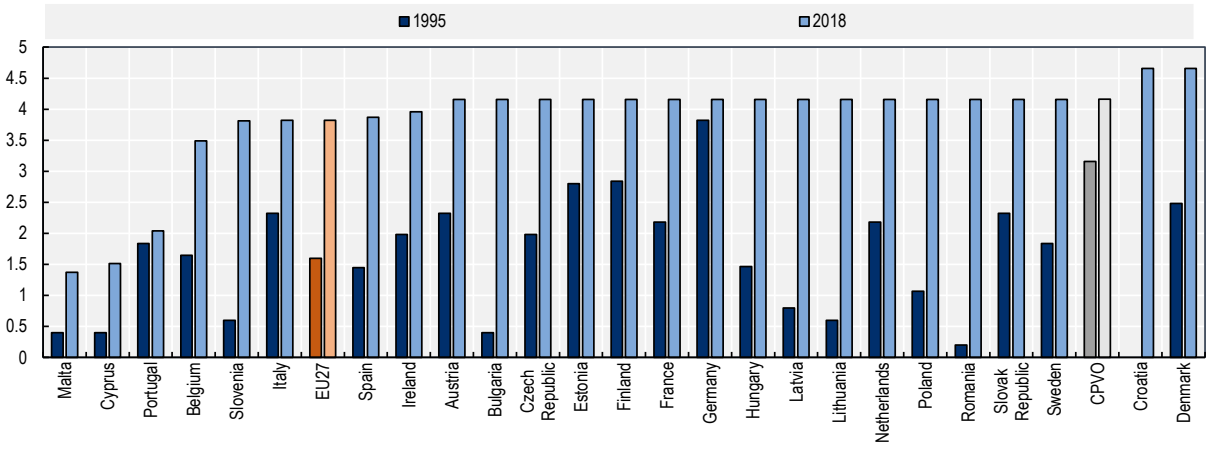
EU Member States have national IPR systems protecting their plant varieties and agricultural-related innovations in place. However, these nationally defined systems are based on certain common standards defined by international conventions, such as the International Union for the Protection of New Varieties of Plants (UPOV) and the Agreement on Trade-Related Aspects of Intellectual Property Rights, which allows comparisons between them.

Globally, IPR systems have become more homogeneous and their strength has been increasing, in particular, since the signing of the Agreement on Trade-Related Aspects of Intellectual Property Rights together with the creation of the World Trade Organization (WTO) in 1994.[30] As shown in Figure 5.16, departing from relatively heterogeneous levels in the mid-1990s, IPR systems in agriculture strengthened

and harmonised over the next two decades. Notably, in all European countries intellectual property protection increased and reached much greater homogeneity by 2018.

Figure 5.16. Index of legal intellectual property rights protection for plant varieties across EU Member States, 1995 and 2018

Score from lowest (0) to highest (5) protection



Notes: CPVO: Community Plant Variety Office. EU27 is the simple average of member countries' indices, which are built using national legislation.
Source: Campi and Nuvolari (2021[124]). Data are available at www.openicpsr.org/openicpsr/project/121001/version/V1/view.

Interestingly, there exists one supranational organisation ruling on plant variety protection in the European Union. The Community Plant Variety Office (CPVO) was established by EU Council Regulation 2100/94 in 1994 and became operational as of April 1995. The Community Plant Variety Rights (CPVRs) system was created as an independent protection scheme for new plant varieties with a unitary effect throughout the European Union. It is based on the Union for the Protection of New Varieties of Plants 1991 Act, and implemented by the CPVO.

The CPVO grants CPVRs, a type of "plant breeder's rights" (PBRs), which often refer to the types of IPRs granted by national-level authorities. Both CPVRs and national-level PBRs provide the breeder of a new variety of plants exclusive control over associated propagating and harvested material for a certain number of years. The CPVR is legally valid throughout the entire European Union, which provides exclusive exploitation rights for a plant variety, in all EU Member States through a single application to the CPVO (Würtenberger et al., 2021[125]). This makes the Community system for protecting new varieties very attractive.

However, the CPVRs system is not intended to substitute or harmonise the national laws regarding plant variety protection in EU Member States, but rather to exist alongside them as an alternative. Even after the introduction of the CPVO, individual EU countries retain their ability to grant PBRs (which are valid only within their own borders). The requirements for granting a CPVR directly follow those stipulated by the UPOV 1991 Convention for all types of PBRs. These include requirements for the "distinctness, uniformity and stability", novelty, and denomination of plant varieties (Theobald, 2020[126]).

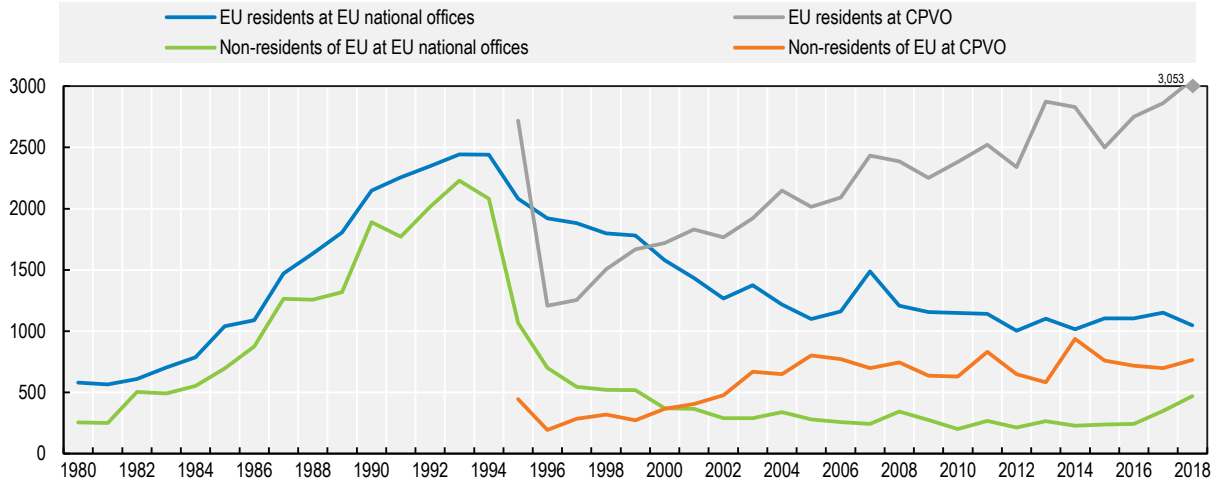
When the CPVO was created in 1995, average protection among the EU Member States was 1.6, which increased to 3.8 in 2018. Similarly, the index score for the protection of the CPVO also increased and, in 2018, the breadth of the protection offered by the CPVO was similar to that of most individual countries in the European Union (Figure 5.16). Moreover, the duration of a CPVR is comparable to that of PBRs in individual EU Member States.

Since the creation of the CPVO, the use of national offices for the protection of agricultural-related IPRs has decreased

Since 1995, there has been a shift of IPR applications from national offices to CPVO (Figure 5.17). Although there are differences depending on the country, in most cases, applications at national offices have been decreasing, particularly, those made by non-residents, while CPVR applications from both EU Members and from other countries have followed increasing trends.

The CPVO aims to create incentives for innovation and investment in new plant varieties. Supporting its stakeholders in accessing, using and exploiting the IPR system for the protection of plant varieties based on a cost-efficiency approach remains an important challenge for the CPVO. Working together with its stakeholders and the network of examination offices, EU agencies and other IP players, the CPVO has promoted the sharing of information and expertise and has helped implement EU policies more efficiently, responding to particular needs identified by the EU institutions and Member States. The CPVO fosters the highest technical harmonisation of practices and legal certainty on a high-quality level, aiming to ensure reliable and defendable decisions on plant variety rights in the European Union. This remains a challenge for the CPVO that will require even better co-ordination between all players, both at the EU level and internationally, to address the needs of the stakeholders (CPVO, 2017[127]).

Figure 5.17. Number of applications for plant breeder's rights and Community Plant Variety Rights by EU residents and non-residents, 1980 to 2018



Notes: PBRs: plant breeder's rights (applications at EU national offices); CPVRs: Community Plant Variety Rights (applications at the Community Plant Variety Office [CPVO]).
Residents and non-residents at European Union national offices consider the sum of residents and non-residents in the corresponding individual national offices. For the CPVO, residents refer to EU members while non-residents refer to non-EU members, considering the year of accession for each country. For the period of analysis, the European Union includes the United Kingdom.
Source: Authors' calculations based on data from the UPOV *PLUTO: Plant Variety Database*, https://www.upov.int/pluto/en; CPVO *Plant Varieties Database*, https://cpvoextranet.cpvo.europa.eu/mypvr/#!/en/publicsearch.

5.6. Farmer-led innovation and adoption of agricultural innovation

5.6.1. Farmer-led co-innovation

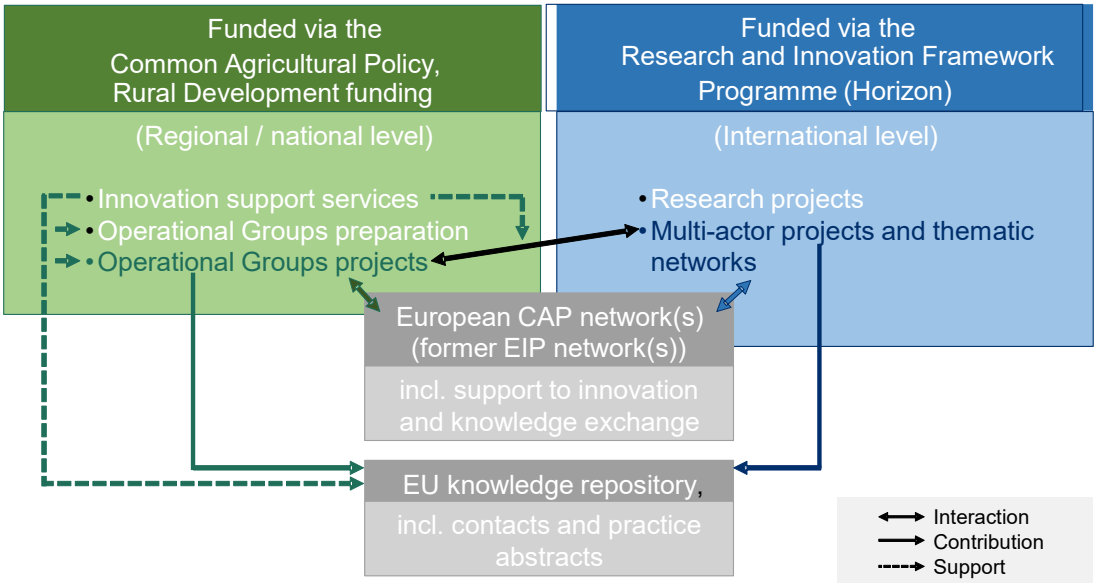
The EIP-AGRI initiative is the main instrument put in place by the European Commission to strengthen the AKIS and close the gap between research and farming practice (EC, 2012[128]).[31] It was launched in 2012 to promote multi-actor innovation through different types of projects (Figure 5.18). The first are operational

groups' innovation projects, supported under the EU RDPs (RDP Pillar 2 of the CAP), which function mostly within a country or a region; the second are multi-actor research projects and thematic networks, funded by the Horizon programme, which operate at the transnational level and involve partners from at least three countries.

The EIP-AGRI is based on the principles of the interactive innovation model. The so-called EIP Operational Group (OGs) were conceived to tackle practical problems or explore emerging opportunities that may lead to innovative solutions; hence, their composition is tailored to the purpose of the individual projects. For instance, innovation brokers and other advisors are to help actors, such as farmers and researchers, to set up OGs and disseminate and share relevant information.

The actors involved together form the EU-wide EIP network, which was integrated into the CAP networks under the CAP 2023-27 (Section 5.2). EIP innovation support services facilitate activities at the EU, national, regional and local levels by encouraging the establishment of OGs and communicating their results. The EIP web database with information from OGs and Horizon Multi-Actor Projects acts as an EU repository for projects with practice impact and as a one-stop shop for practical knowledge in agriculture (Coffey, 2016[129]).

Figure 5.18. European Innovation Partnership for Agricultural Productivity and Sustainability



Notes: EIP: European Innovation Partnership. Operational Groups (OGs) are composed of farmers, advisers, researchers, business, non-governmental organisations, etc.
Source: Authors' representation based on Van Oost (2021[130]).

The rural development co-operation measure (M16) played a key role in implementing the EIP-AGRI. Support could be given both for the establishment and operation of OGs and for the implementation of their projects. This support could be combined with support under other measures, such as training, advice, investment aids and producer groups. RDPs could fund such bottom-up innovation projects, with up to a 100% support rate and 80% EU co-funding.

The EIP-AGRI is an important policy tool, but its effectiveness has not yet been fully evaluated

The implementation of the EIP-AGRI at the national level differs substantially. It has been widely programmed, with up to 3 200 OGs planned by the end of the 2014-20 programming period (Coffey, 2016[129]). By the end of 2022, 2 400 OGs were reporting on their operation or had accomplished their activities and calls were still being launched. Most of the OGs are located in Italy, Spain, the Netherlands and Germany, together accounting for about half of all OGs (EIP-AGRI, 2023[131]). Furthermore, under Horizon 2020, more than 190 multi-actor projects, worth EUR 1 billion, were implemented (Van Oost, 2021[132]).

Plant production and horticulture, as well as the competitiveness and diversification of farming/forestry, are two thematic areas most often explored in OGs' projects (EIP-AGRI, 2020[133]). In total, already about 60% of the OGs worked on climate-environment themes, even before the launch of the EGD. OGs can also provide space for policy learning. For instance, in Ireland, they have been used for testing new CAP measures aimed at improving agri-environmental performance (Conway, 2020[134]). Specifically, two themed projects – the Hen Harrier Project and the Fresh Water Pearl Mussels Project – focused on the delivery of biodiversity and habitat protection by combining a results-based approach (rewarding farmers for agri-environmental improvements) with training and advice.

So far, there is no single comprehensive assessment of the functioning of the OGs across Europe. However, some conclusions can be drawn from early assessments of this policy tool and case studies, as well as from the information that OGs provide to the Commission. The distinctive bottom-up approach of the EIP-AGRI was well appreciated by stakeholders, as it allows farmers to take the leading role in the projects and strengthen their co-ownership of innovative solutions (Coffey, 2016[129]). Two barriers were also identified: concerns about the perceived administrative burden and the lack of advance funding, which is particularly relevant for smaller businesses. These two issues are expected to be addressed in the new CAP 2023-27.

The cross-border elements, multi-actor projects and thematic networks under the Horizon programme were perceived as important to facilitate the exchange of expertise, dissemination of results and awareness-building among farmers about OGs' projects. However, Zezza (2017[135]) pointed out potential problems with disseminating project outputs and results to the great majority of farmers, who are not OG members. Also, the Italian case study (Giarè and Vagnozzi, 2021[136]) highlighted the need for effective communication and dissemination of results, as well as the active engagement of advisors and training experts. Furthermore, the SCAR AKIS Strategic Working Group warned that despite the substantial amount of knowledge available, it remains fragmented across Europe and is still insufficiently applied in practice (EU SCAR AKIS, 2019[15]). As described in Section 5.2, the more strategic approach to AKIS under the CAP 2023-27 aims to respond to these concerns by fostering the functioning of national AKIS.

5.6.2. Adoption of innovation on farms

The decision about innovation uptake can be described as a "process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (Rogers, 2003[137]). Multiple socio-economic factors, such as features of farm business and personal characteristics of farmers, the attitude of decision makers on the farm, as well as their embedment in social networks, strongly impact farmers' decision regarding the uptake of innovation. Therefore, policy incentives can stimulate the adoption of innovations by facilitating the different stages of innovation-decision.

Financial support may provide additional resources for the innovation uptake on farms, but it currently does not sufficiently target low-level adopters or non-adopters

Farm characteristics such as size and income may constitute an economic barrier to adoption innovation, as found by Barnes et al. (2019[138]) in a study on the uptake of precision agricultural technologies (PATs) on arable crop farms in Belgium, Germany, Greece, the Netherlands, and the United Kingdom. Sauer (2017[139]) identified own product- and process-related development activities, farm size, the age of the farm operator as well as confidence in business and sector developments as farm characteristics decisive for the magnitude and success of innovations in the context of the Dutch dairy farms. While the impact of farm size on productivity and sustainability is debated in the scientific literature, larger farms have been shown to be more innovative than smaller ones. They have more potential to adopt scale-dependent innovation, such as GPS-equipped precision agriculture technologies that optimise input use. Compared to smallholders, larger operations also have an advantage in access to knowledge, due to better human and financial opportunities. However, this factor appears to be less important for sustainability (OECD, 2019[43]).

Investments are crucial for modernising agriculture and improving sustainability outcomes. In line with the findings of Barnes et al. (2019[138]), decoupled income support payments under the CAP may theoretically provide an indirect incentive to farmers to adopt new technologies, as more stable income may allow for greater risk taking (Détang-Dessendre et al., 2018[140]). However, over the past two decades, total CAP support has been reduced and is predicted to follow this trend (Chapter 3). As a result, farmers with larger operations, mostly driven by profit, will be the primary users of precision agriculture tools, while smaller farms will likely be low-level adopters or non-adopters. Reducing subsidies may thus remove the incentive for low-level adopters and widen inequalities. Compared to direct payments, having a direct impact on current income but also potentially creating dependence on this support, investment support can contribute to the long-term viability of the farms. Also, further investments in enabling infrastructure, e.g. broadband (see Chapter 2, Section 2.3) and data solutions required by PATs, can send a strong signal to the farming community, trigger expectations of positive economic returns and facilitate the uptake of new technologies.

Farm advisory services should direct their efforts to inform farmers about new technologies and practices for sustainable agriculture

Attitudinal differences can also play a role in the decision to adopt innovative practices and technologies. Farmers who have built a positive belief towards the economic return of the technology are more likely to adopt it (Barnes et al., 2019[138]). Under the CAP 2023-27, in their CSPs, EU Member States are expected to support sustainable farming practices, such as organic farming, integrated pest management, agro-ecological measures, animal welfare, “high nature value” farming or carbon farming, and improved nutrient management (EC, 2021[141]) (see also Chapters 3 and 4). Therefore, the discussion around sustainability management standards is both timely and relevant. Hannus and Sauer (2021[142]) studied the decision-making process for adopting comprehensive farm sustainability management standards on a sample of German farmers. They found that the absence of wider adoption of sustainability standards can be explained by a lack of clarity about the relative advantages of applying sustainability standards, thus implying insufficient communication of the possible benefits, such as saving time or resources or improving their farm image. They also analysed the design of such standards and identified six key elements: 1) consideration of the desire for higher product prices; 2) existence of data for sustainability assessment; 3) technical support for users; 4) ease of integration of new standards into current processes and routines; 5) limited level of complexity; and 6) promotion of benefits.

Data-intensive technologies require additional investments in knowledge transfers to close the gap between training provided by industry and users’ optimal ability to run machines (Barnes et al., 2019[138]). Moreover, based on the sample of Italian farms, Vecchio et al. (2020[143]) found that higher exposure to information about precision farming tools, e.g. through magazines, journals, training courses, helps

overcome perceived complexity and associated barriers to adoption. Also, better-educated farmers revealed a higher propensity to adopt new technologies compared to less educated ones (Vecchio et al., 2020[143]). Additionally, the inability to independently assess the rate of return on investment in technology creates disincentives for farmers. Communication activities around PATs' effects specific to different regions and contexts can help overcome uncertainty, foster the farmer's belief in a positive return and support the technology purchase decision (Barnes et al., 2019[138]). Due to attitudinal and resource constraints, the public sector has an important role to play in fostering farmers' awareness of new technologies and practices deemed to enhance sustainability, helping them upskill (Section 5.4) and thus stimulating PAT adoption. FAS are fundamental to this process, highlighting the need for well-informed, professional and independent advisors (Section 5.4).

Demonstration farms provide an opportunity to influence farmers' decision on adopting new practices and tools thanks to peer learning

In addition to economic and personal considerations, farmers' decision to innovate is strongly influenced by embedment in social networks. Change-promoting actors, including buyers, input providers, local authorities, farmers' groups and others, can foster openness to innovation and limit barriers to innovation uptake (Fieldsend et al., 2021[144]). Farmers may build micro-AKIS where they interact only with selected AKIS actors, excluding others, e.g. educational actors (Fieldsend, 2020[145]). In this context, friends and family are a vital source of information and knowledge, especially for family farmers. Moreover, farmers are likely to be the most influenced by exposure to successful agricultural methods used by their peers (Fieldsend, 2020[145]), potentially including sustainable farming practices. Hence, fostering peer-to-peer learning, e.g. through demonstration farms' activities, is crucial to effective knowledge transfer towards farmers, in particular those less involved in innovation co-creation activities.

Demonstration farms are considered to be an effective way of providing farmers with opportunities to exchange knowledge with their peers and experts, jointly solve problems and gain experience through hands-on activities (Ingram et al., 2018[146]). Farm Demo Hub, launched in 2018, aims to help connect farmers carrying out demonstration activities with those interested in participating by providing an online platform, resources and tools. The AgriDemo-F2F and PLAID projects, funded under Horizon 2020, collaborated on the development of a European-wide georeferenced inventory of demonstration farms. At the end of 2022, the inventory contained over 1 500 entries, with additional information on, among others, farm types, demonstration topics and available languages. The AgriDemo-F2F project carried out an in-depth comparative analysis to deepen understanding of farm demonstration activities in Europe. A synthesis of 35 case studies, representing a variety of demonstration approaches and activities, identified seven categories of "best practices" for the organisation of such events: 1) setting clear objectives linked to the target group; 2) co-ordination at the national level combined with the provision of an enabling environment and long-term funding opportunities; 3) leveraging on existing structures and networks; 4) recognising it as the farmers' learning pathways and encouraging their involvement in the development of programmes and topics; 5) presence of a trustworthy host who is an expert in his field and has demonstration and facilitation skills; 6) attention to group structure and dynamics, e.g. a smaller group increases active participation and discussion; and 7) post-event evaluation of achievement of primary objectives, but also softer outcomes like peer-to-peer learning or empowerment (Marchand et al., 2019[147]).

5.6.3. Digitalisation in the agricultural sector

Evidence gathered by the OECD (2019[43]) points to a wide range of productivity-enhancing innovations being adopted in the reviewed countries. The innovations encompass genetic improvements of seeds and animal breeds; input-saving technologies such as no-till cropping, milking robots, more energy-efficient buildings that also allow for higher animal welfare; technologies and practices for precision agriculture and

better risk management, e.g. irrigation systems, GPS-assisted tractors, satellite image, drones; and changes in production management and marketing practices. Digitisation may enable or create favourable conditions for some of them.[32]

The twin digital and green transition stands high on the agenda of the European Union, including in the field of agriculture and rural areas, as it is well reflected in multiple strategic documents under the headline ambitions "The European Green Deal" and "A Europe Fit for the Digital Age" (Chapters 1 and 2). The CAP 2023-27 also recognises the "enabling potential" of digital technologies to contribute to meeting its objectives. Hence, as part of the CSPs, EU Member States have been asked to develop digital strategies, i.e. a strategic approach to digitalising agriculture and rural areas (van Oost, 2022[148]). To this end, countries can make use of a wide range of CAP measures, including those dedicated to training, advice and investments, precision farming under eco-schemes, as well as collaboration (LEADER and EIP-AGRI). Ideally, the implemented measures will share a degree of complementarity with other EU or national instruments.

Digitalisation offers the potential to help address the productivity, sustainability and resilience challenges…

The ongoing digital transformation provides multiple opportunities for agriculture and food systems. Digital tools can be used, among others, to create value added for farmers, encourage consumers to buy healthy and nutritious foods produced through sustainable farming practices (Baragwanath, 2021[149]), facilitate trade (OECD, 2021[150]), and improve policy making (OECD, 2019[78]). The COVID-19 crisis has further reinforced the demand for digital solutions. For instance, as reported in the *Agriculture Policy Monitoring and Evaluation 2021* (OECD, 2021[151]), many countries have decided to step up their efforts towards measures with the potential to improve market functioning and, thus, the resilience of the sector.

Focusing in particular on farmers and their businesses, digitalisation may foster wider use of communication platforms and online courses, precision agricultural technologies, Internet of Things[33] or big data for day-to-day management decisions. Thus, if steered in the right direction, digital technologies can be beneficial for the sector: facilitating the building of human capacity in the sector (Bellon-Maurel et al., 2022[152]; Détang-Dessendre et al., 2018[140]) and making farm operations more profitable, efficient, resilient, safer and environmentally friendly (McFadden et al., 2022[153]; ADB, 2021[154]; OECD, 2019[78]). Digitalisation, and the changes it causes, also bring with it certain barriers (and risks), such as high investment and maintenance costs (discussed above); underdeveloped digital infrastructure; lack of relevant skills among farmers; non-compatibility with farmers' needs and societal demands; lack of trust from farmers (Bellon-Maurel et al., 2022[152]; Détang-Dessendre et al., 2022[155]; McFadden et al., 2022[153]; McFadden, Casalini and Antón, 2022[156]). It is, therefore, vital to take these challenges into account when guiding and incentivising the research, development, and deployment of digital technology.

…but it requires further investment in ICT infrastructure and developing skills among future users to enable wider adoption

Technological infrastructure and human capital are prerequisites for the digitalisation of the agricultural sector (Brunori et al., 2021[157]), as their shortcomings may exacerbate inequalities and exclude certain groups of farmers. Despite the increasing access to broadband Internet in European households and the narrowing urban-rural divide (Chapter 2, Section 2.3), the lack of reliable, affordable and widely available high-speed Internet continues to be a barrier to the adoption of digital solutions on farms. In an OECD survey of EU Member States (OECD, 2022[5]), the availability and performance of the digital infrastructure for the agricultural sector were assessed as "good" or "very good" by less than half of participating countries, compared to 70% for the country as a whole. Hence, there is a clear need to step up efforts to increase the connectivity of remote areas and ensure equal access to digital technologies.

Digital technologies have the potential to strengthen the inclusion and upskilling of farmers, but also to foster their exclusion. As discussed in Section 5.4, competences needed to take advantage of digital technologies need to be strengthened in the agricultural sector. The current average status of digital skills and literacy among farmers was evaluated as "good" or "very good" in only 6 out of 21 European countries participating in the survey (OECD, 2022[5]). FAS have an important role to play in upskilling farmers in the use of digital technologies. However, they often need to first gain the relevant expertise themselves, and currently seem not to fully leverage the use of ICTs. Among the respondents to the survey (OECD, 2022[5]), only 1 out of 19 considered the use of ICTs for training, and 6 out of 19 considered the inclusion of remote farmers as representative of the practices of their local FAS. In this context, the current CAP measures dedicated to knowledge transfer and advice could be further strengthened and guided in this direction. Synergies should also be pursued with the Digital Europe Programme (DIGITAL), which provides funding to projects in key areas such as advanced digital skills, and ensures a wide use of digital technologies across the economy and society (EC, 2020[158]).

Digital technologies must help meet farmers' needs and societal demands…

Digitalisation should be seen as "the means to an end rather than the end in itself" (Brunori et al., 2021[157]). Going even further, digital technology must help answer both the needs of farmers and the societal demand for environmentally sustainable agriculture. The literature points to the potential for a "rebound effect", where changes in producer behaviour might offset resource saving from technical improvements, thus leading to a further increase in environmental pressures, e.g. greater water use (Paul et al., 2019[159]). The expected collaboration between the regional European digital innovation hubs dedicated to digital innovation in the agri-food sector, introduced under DIGITAL (EC, 2021[160]), and the EIP-AGRI Operational Groups has the potential to find promising solutions through experimentation and to provide directionality to the development of digital technologies for sustainable farming.

…while the general policy environment has a role to play in fostering farmers' trust in such technologies

Finally, farmers' lack of trust in digital technologies is another barrier. Four main issues can explain it: data ownership and confidentiality concerns; misalignment of incentives for sellers and buyers of digital technologies combined with an imbalance of power; the perceived high complexity of digital technologies ("black box"); and the lack of standards for comparing and certifying the functionalities of digital technologies (McFadden, Casalini and Antón, 2022[156]). To encourage farmers to adopt digital technologies, McFadden, Casalini and Antón (2022[156]) recommend governments encourage companies to separate the sales of problem assessment from the sales of solutions; strengthen public sector extension services and enhance farmers' learning about digital agriculture; facilitate the development of risk-sharing arrangements between technology providers and farmers; and explore ways to promote the standardisation of evaluation and certification of digital agricultural technologies. However, trust-related policies need to be tailored to farmers' specific concerns, which need to be further explored.

The effectiveness of policies targeting greater digitalisation in the agricultural sector cannot be properly assessed without adequate data. McFadden et al. (2022[153]) point to a lack of evidence on the uptake of digital technologies across OECD countries in animal husbandry and speciality crop farms, contrary to crop farms where the widespread adoption is more documented. Cross-country comparisons are further hampered by differences in the construction of indicators (per area or per farm). To fill this gap, the European Commission intends to harmonise the collection of data on the use of precision technologies on crops and livestock farms by introducing new modules to the 2023 Integrated Farm Survey.[34]

5.7. Reflections on transformative approaches to policies

The previous sections depicted the complexity of actors, incentives, as well as selected elements of the environment that can enable the generation and uptake of innovation for sustainable agriculture. This is, however, only a partial picture, as many other factors may influence these processes. This section proposes a reflection going beyond innovation and agricultural policies focusing on the key characteristics of policies with the potential to promote transformation.

Transformative policies can be defined as policies that contribute to transforming incumbent socio-technical systems. They tend to address the root causes of problems rather than just fixing them by isolating them from their systemic context. The advocates of transformative policies view policy making as a set of complex processes involving a multiplicity of actors, networks and institutions – each of them with different values, principles, interests, rules – which interact with each other. This complexity, as well as historically established commitments, may create systemic barriers to change (Smith and Stirling, 2007[161]), which must be challenged. To be transformative, according to Weber and Rohracher (2012[7]), policies need to address their four weakness: 1) directionality; 2) policy co-ordination; 3) market articulation; and 4) reflexivity.

Directionality refers to the capacity of the political system to steer innovation in a market context, with "grand challenges" set as innovation goals. Given that innovation cannot be obtained solely by law, the issue of gaining consensus over goals that could encourage businesses, civil society and consumers to innovate in a way that is consistent with societal challenges is becoming increasingly crucial. In the area of agricultural policies, the basic structure of the CAP since the Treaty of Rome has been aimed at supporting farmers' incomes, productivity and competitiveness. A narrative based on "addressing market failures" was translated into support for prices, market intervention measures and trade tariffs. Support for investments was supposed to create a level playing field, allowing smaller farms to compete with bigger ones. While the following CAP reforms have introduced additional objectives and instruments (Chapter 3), innovation policies have largely focused on supporting technological developments rather than on innovative business models and social and institutional innovation (Chiffoleau and Loconto, 2018[162]).

The EGD, and the related Farm to Fork and Biodiversity Strategies, have set a new direction and a new narrative, which starts from the evidence that business as usual is no option, and, backed by the Paris Agreement and the Sustainable Development Goals, advocates for an ecological transition which will lead to a carbon-neutral European economy. The vision of the Green Deal is turned into sector-based goals and numeric targets, and the implementation of the strategy will be subject to an indicator-based monitoring framework (Section 5.1 and Chapter 3, Section 3.5).

Policy co-ordination (or policy coherence) is another property of transformative policies. It refers to the fact that policy systems are articulated into multiple policy areas and multiple administration levels, and that each of them follows a given set of rules, has a specific knowledge base, and refers to specific coalitions of interests. Reform at one point of this system might encounter resistance at other points, hence hampering innovation. Policy co-ordination is a key issue in the implementation process of the EGD. The multidimensionality of food systems makes it evident that the vast structure created by the CAP cannot be reformed only "from within", that is by the European Commission's Directorate-General for Agriculture and Rural Development, but requires a horizontal (across policy areas) and vertical (across scales of governance) co-ordination. The implementation of the EGD is led by the Vice-President of the European Commission, and involves several directorates-general (Marti, 2020[163]) (Chapter 3, Section 3.5).

Market articulation can be described as "making innovation economically sustainable". For the agricultural sector, for instance, the issue is creating market mechanisms that encourage sustainable agricultural production. In this context, questions like "How to make organic farming affordable to consumers and remunerative for farmers?" or "How to make nutritious food more attractive than junk food?" become very pertinent. Some potentially relevant measures, e.g. "school fruit, vegetables and milk scheme", are

included in the “CAP toolbox” that EU Member States have at their disposal when developing their CSPs (Chapter 3, Section 3.5). Nevertheless, it is unclear to what extent CSPs will be able to prioritise such measures and link them to better nutrition and sustainability goals.

Reflexivity relates to the need for policy systems to accompany, adapt to or even anticipate the dynamics of change. Reflexivity implies the capacity of policy systems to experiment and learn. The success of transformational policies will be based on the capacity of the governance system to evolve in a way that will make transformation forces prevail over conservation drivers. Given the complexity and the uncertainty of the problems at stake, the critical issue is how to provide spaces for experimentation and policy learning. Some of the CAP measures, e.g. the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI), can foster experimentation through its operational groups and establish links to EU R&I policies (Section 5.6). Moreover, research policies are more and more clearly “mission-oriented” (Section 5.3) and emphasise the impact of projects. The main targets identified by the Farm to Fork – increase of organic farming area and protected areas – could be seen as experimentation spaces for new practices and new business models. A performance-based policy implies a radical enhancement of the quality and quantity of available data and of evaluation methods. However, a key question remains over how to make monitoring and evaluation the core of learning spaces that involve, through deliberation, all actors, policy makers and civil society.

Annex 5.A. Statistical Annex

Annex Table 5.A.1. Government budget allocation for R&D (GBARD) on agriculture by EU Member State

	GBARD on agriculture			Agriculture's share in total GBARD		
	(Million purchasing power standards at 2005 prices)			(%)		
	2006	2021	change	2006	2021	change
EU27	2 375	2 547	+	3.7	3.0	-
Austria	29	31	+	1.9	1.2	-
Belgium	22	42	+	1.3	1.8	+
Bulgaria	29	39	+	16.4	17.4	+
Croatia	4	13	+	1.0	2.7	+
Cyprus	11	6	-	20.9	7.1	-
Czech Republic	53	70	+	5.2	4.5	-
Denmark	66	77	+	5.8	4.5	-
Estonia	10	9	-	10.3	4.7	-
Finland	81	44	-	5.8	3.2	-
France	193	259	+	1.5	2.0	+
Germany	371	819	+	2.3	2.9	+
Greece	46	58	+	6.0	3.5	-
Hungary	75	40	-	14.3	5.7	-
Ireland	63	60	-	10.6	8.9	-
Italy	342	228	-	4.0	2.5	-
Latvia	14	11	-	20.1	13.1	-
Lithuania	11	10	-	8.4	5.2	-
Luxembourg	0.05	0.10	+	0.06	0.04	-
Malta	0.41	0.98	+	3.5	2.8	-
Netherlands	185	163	-	4.9	3.3	-
Poland	10	204	+	0.7	6.3	+
Portugal	21	17	-	2.6	2.3	-
Romania	54	25	-	9.0	5.9	-
Slovak Republic	19	13	-	9.0	2.7	-
Slovenia	5	14	+	2.3	5.1	+
Spain	600	441	-	8.7	6.8	-
Sweden	47	51	+	2.2	1.9	-

Notes: 2006 and 2021 or the nearest available year.
Government budget allocation for research and development (GBARD) is a funder-based approach for reporting R&D, which involves identifying all the budget items that may support R&D activities and measuring or estimating their R&D content. It allows linking these budget lines to policy considerations through classification by socio-economic objective. GBARD on agriculture covers all R&D aimed at the promotion of agriculture, forestry, fisheries and foodstuff production, or furthering knowledge on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture, as well as concerning the impact of agricultural and forestry activities on the environment. This also covers R&D aimed at improving food productivity and technology. It does not include R&D on the reduction of pollution; on the development of rural areas; on the construction and planning of buildings; on the improvement of rural rest and recreation amenities and agricultural water supply; or on energy measures.
Source: Authors' calculations based on Eurostat (2022[37]), GBARD by socioeconomic objectives (NABS 2007) (database).

Annex Table 5.A.2. R&D expenditure intensities by EU Member State

Field of R&D	All		Agricultural science		All		Agriculture		All sectors		Agriculture		Food and beverages	
Sector of performance	All sectors		Public (government and higher education)		All sectors		All sectors		Business		Business		Business	
Source of funds	All sources		All sources		Government		Government		All sources		All sources		All sources	
Indicator	GERD[1] total as a % of GDP		Public GERD on Ag. science[2] as a % of sector's value added		GBARD[3] total as a % of GDP		GBARD on agriculture[4] as a % of sector's value added		BERD[5] total as a % of GDP		Agriculture BERD[6] as a % of sector's value added		Food and beverage BERD[7] as a % of sector's value added	
	2006	2020	2006	2019	2006	2020	2006	2020	2006	2020	2006	2019	2006	2019
EU27[8]	1.70	2.20	...	..	0.66	0.77	1.42	1.33	1.07	1.44	0.27	0.43	0.82	0.95
Austria	2.36	3.20	2.48	1.58	0.63	0.87	0.92	0.94	1.66	2.22	0.05	0.11	0.50	0.59
Belgium	1.82	3.48	7.55	8.90	0.60	0.74	0.85	2.01	1.26	2.53	1.07	0.33	1.43	2.45
Bulgaria	0.44	0.86	...	..	0.54	0.46	..	1.24	0.11	0.56	0.01	0.01	0.03	0.10
Croatia	0.74	1.27	...	..	..	5.91	..	0.72	0.27	0.54	0.28	0.06	0.57	0.33
Cyprus	0.38	0.85	...	..	0.29	0.54	2.68	1.50	0.09	0.26	0.04	0.01	0.30	0.06
Czech Republic	1.23	1.99	1.64	1.82	0.52	0.67	1.24	1.39	0.72	1.21	0.13	0.18	0.25	0.29
Denmark	2.40	2.96	5.60	3.76	0.72	0.97	3.57	2.13	1.61	1.82	..	0.15	..	2.18
Estonia	1.11	1.79	1.04	1.48	0.50	0.70	1.62	1.71	0.49	0.98	0.02	0.02	..	0.29
Finland	3.33	2.91	2.88	2.17	0.98	0.96	2.83	1.03	2.38	1.95	0.01	0.10	2.47	2.04
France	2.05	2.35	...	0.50	0.79	0.74	0.79	0.93	1.29	1.56	0.38	0.59	0.64	0.85
Germany	2.47	3.14	3.70	4.96	0.74	1.10	2.26	4.15	1.73	2.11	0.48	0.68	0.86	0.61
Greece	0.56	1.50	...	0.72	0.31	0.89	0.59	0.62	0.17	0.69	..	0.11	..	0.83
Hungary	0.98	1.61	1.30	0.72	0.36	0.53	1.44	1.11	0.47	1.23	0.21	0.58	0.31	0.54
Ireland	1.20	1.23	6.55	2.76	0.41	0.23	4.74	2.68	0.79	0.91	..	0.05	..	0.89
Italy	1.08	1.53	1.48	0.86	0.59	0.67	1.21	0.89	0.53	0.93	0.001	0.07	0.54	0.96
Latvia	0.65	0.71	1.73	1.49	0.25	0.27	1.52	0.92	0.33	0.22	..	0.04	0.05	0.38
Lithuania	0.79	1.16	1.34	1.82	0.32	0.33	0.70	0.64	0.22	0.55	..	0.07	0.10	0.27
Luxembourg	1.65	1.13	...	..	0.30	0.59	0.05	0.21	1.42	0.61	..	..	..	..
Malta	0.58	0.69	...	1.48	0.15	0.26	0.29	2.23	0.38	0.36	..	0.08	0.80	0.31
Netherlands	1.74	2.29	1.20	2.17	0.73	0.76	1.83	1.72	0.94	1.54	0.60	1.94	2.25	2.07
Poland	0.55	1.39	1.29	1.08	0.31	1.93	0.08	1.11	0.17	0.87	0.03	0.18	0.14	0.89
Portugal	0.95	1.62	1.78	4.96	0.41	0.37	0.47	0.41	0.44	0.92	0.01	0.30	1.55	1.48
Romania	0.46	0.47	0.32	0.44	0.33	0.18	0.38	0.23	0.22	0.28	0.37	0.04	0.03	0.01
Slovak Republic	0.47	0.91	1.34	1.98	0.26	0.42	1.29	0.97	0.20	0.49	0.21	0.03	0.06	0.14
Slovenia	1.54	2.15	0.92	0.72	0.55	0.52	0.59	1.26	0.93	1.57	..	0.15	0.30	1.61
Spain	1.18	1.41	1.93	0.97	0.67	0.62	2.42	1.34	0.65	0.78	0.28	0.31	0.94	0.90
Sweden	3.47	3.53	1.93	3.00	0.79	0.76	1.29	0.75	2.60	2.55	..	..	1.09	0.99

Notes: 2006, 2020 and 2019, or the nearest available year.

1. Gross domestic expenditure on research and development (GERD) is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad, but excludes domestic funds for R&D performed outside the domestic economy.

2. GERD for agricultural and veterinary.

3. Government budget allocation for research and development (GBARD) is a funder-based approach for reporting R&D, which involves identifying all the budget items that may support R&D activities and measuring or estimating their R&D content. It allows linking these budget lines to policy considerations through classification by socio-economic objective.

4. GBARD on agriculture covers all R&D aimed at the promotion of agriculture, forestry, fisheries and foodstuff production, or furthering knowledge on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture, as well as concerning the impact of agricultural and forestry activities on the environment. This also covers R&D aimed at improving food productivity and technology. It does not include R&D on the reduction of pollution; on the development of rural areas; on the construction and planning of buildings; on the improvement of rural rest and recreation amenities and agricultural water supply; or on energy measures.
5. Business expenditure on research and development (BERD) is the measure of intramural R&D expenditures within the business enterprise sector (regardless of the sources of R&D funds).
6. BERD on agriculture, forestry and fishing.
7. BERD on manufacture of food products, beverages and tobacco products.
8. The European Union (27 countries) aggregate was estimated for the BERD on agriculture and on food and beverage.
Sources: Authors' calculations based on OECD (2022[40]), *Research and Development Statistics* (database), [Gross domestic expenditure on R&D by sector of performance and field of R&D (FORD); Government budget allocations for R&D; Business enterprise R-D expenditure by industry (ISIC 4)]; *STI Main Science and Technology Indicators* (database), [BERD as a percentage of GDP]; and *National Accounts* (database), [Gross domestic product (GDP) – Gross value added at basic prices by activity, ISIC rev4; Value added and its components by activity, ISIC rev4], https://stats.oecd.org (accessed in August 2022); Eurostat (2021[41]), BERD by NACE Rev. 2 activity [RD_E_BERDINDR2], "GBARD by socioeconomic objective (NABS 2007)" [GBA_NABSFIN07], GDP and main components [NAMA_10_GDP], National accounts aggregates by industry (up to NACE A*64) [NAMA_10_A64], http://ec.europa.eu/eurostat/data/database (accessed in August 2022); USDA ERS (2017[42]), *Agricultural Research Funding in the Public and Private Sectors*, https://www.ers.usda.gov/data-products/agricultural-research-funding-in-the-public-and-private-sectors (accessed in February 2020).

Annex Table 5.A.3. Agriculture and food science R&D outcomes

Agriculture and food science R&D outcomes, 2010-20 (publications) and 2008-18 (patents)

	Specialisation: Agri-food science outputs as a share of country's total (%)		Contribution: Country's share of world agri-food science output (%)		Importance/visibility: Outstanding agricultural/biological science publications as a share of country's total in this field (%)
	Patents[1]	Publications[2]	Patents[1]	Publications[2]	Publications[2] (top 10% most cited)[3]
EU27	5.0	5.1	30.0	24.0	12.3
Austria	3.8	4.5	0.8	0.5	12.8
Belgium	10.9	5.6	1.7	0.8	14.6
Bulgaria		7.7		0.2	2.1
Croatia		7.0		0.3	4.4
Cyprus		2.9		0.0	14.4
Czech Republic	3.5	8.5	0.1	1.1	5.4
Denmark	11.6	5.5	1.5	0.7	16.5
Estonia		9.2		0.1	9.3
Finland	3.8	5.8	0.6	0.6	12.4
France	4.5	4.2	4.6	2.6	15.0
Germany	3.9	3.9	11.1	3.7	14.2
Greece	7.6	4.7	0.1	0.5	10.3
Hungary	6.1	7.5	0.1	0.4	5.3
Ireland	5.7	4.9	0.2	0.3	16.1
Italy	5.5	4.9	2.7	3.1	13.4
Latvia		11.6		0.1	3.3
Lithuania		6.5		0.1	4.3
Luxembourg		3.2		0.0	
Malta		3.7		0.0	
Netherlands	9.5	4.2	3.3	1.2	18.6
Poland	7.0	6.4	0.3	1.8	5.9
Portugal	8.2	6.0	0.1	0.8	13.0
Romania		2.7		0.3	4.5
Slovak Republic		7.4		0.3	2.6
Slovenia	4.6	5.2	0.1	0.2	7.4
Spain	7.6	6.5	1.2	3.3	13.2
Sweden	3.7	4.5	1.1	0.8	14.6

Notes: Shares for economies having less than 50 patents or publications in a given period are shown.

1. Patents filed under the Patent Co-operation Treaty (PCT) by earliest filing date and location of inventors using fractional counts for specialisation and contribution, and using whole counts for collaboration. Agri-food includes patents from IPC classes: A01, A21, A22, A23, A24, B21H 7/00, B21K 19/00, B62C, B65B 25/02, B66C 23/44, C08b, C11, C12, C13, C09K 101/00, E02B 11/00, E04H 5/08, E04H 7/22 and G06Q 50/02. Data refer to patents filed in at least two offices worldwide, one of which being any of the five largest intellectual property offices: the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the US Patent and Trademark Office (USPTO) and the National Intellectual Property Administration of the People's Republic of China (NIPA).

2. Publications in the field of agricultural and biological science refer to the SCOPUS 2-digit All Science Journals Classification and include the following categories: agronomy and crop science, animal science and zoology, aquatic science, ecology/evolution/behaviour and systematics, food science, forestry, horticulture, insect science, plant science, soil science, and miscellaneous agriculture/biological sciences. Data are based on fractional counts.

3. Top 10% of the world's most cited publications in the field of agricultural and biological science.

Sources: Authors' calculations based on OECD (2022[64]), *STI Micro-data Lab: Intellectual Property Database*, http://oe.cd/ipstats (accessed August 2022); OECD (2022[65]), OECD STI calculations based on Scopus Custom Data, Elsevier, Version 1.2018; 2018 Scimago Journal Rank from the Scopus journal title list (accessed August 2022).

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Notes

[1] More information on the survey can be found in Annex 1.B.

[2] The term AKIS, normally used in the European context, roughly corresponds to the Agricultural Innovation System (AIS), which is the terminology usually used by the OECD in its Productivity, Sustainability and Resilience Framework (OECD, 2020[63]).

[3] Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021.

[4] The reviews of the Netherlands (OECD, 2023[101]) and Spain (OECD, 2023[167]) provide a full discussion of the national-level actors and initiatives in these two countries.

[5] The results of the EU Member States survey on agricultural innovation policies (OECD, 2022[5]) show that 9 out of 19 responding units considered the ministry responsible for agriculture as the main actor responsible for the strategic direction of agri-food innovation. See Annex 1.B for more information on the survey.

[6] Other end-users may include forest owners, food businesses, engineers, local authorities, etc.

[7] "Public goods are goods that are non-rival (many persons can consume or use them without diminishing their availability to others) and non-excludable (once available to one person it is difficult to exclude others from using it)" (Heisey and Fuglie, 2018[32]).

[8] R&D intensity is defined as expenditure for R&D in the agricultural and food and beverages sectors, and in the economy as a whole, in relation to the size of the sector or the economy.

[9] "Agriculture", under both the CAP and the Horizon 6 cluster, should be seen from a broader perspective as encompassing all activities related to agriculture and rural areas.

[10] In this chapter, the funding shown for Measure 16 also includes sub-measures that do not target innovation or knowledge exchange.

[11] These are intermediate figures, the Operational Group's projects and related measures of the 2014-22 period payments can be made until the end of 2025.

[12] Calculated based on data provided by the European Commission in the frame of the OECD "Agricultural Policy Monitoring and Evaluation" (2022[34]). The percentages only cover expenditure from the rural development budgets, both national and EU, and exclude resources additionally provided by countries from other national budget lines.

[13] Due to the high degree of autonomy within the Belgian federation, Belgium (Flanders) and Belgium (Wallonia) are treated as two entities in this survey. For more details refer to Annex 1.B.

[14] Co-programmed European Partnerships are initiatives between the European Commission and mostly private (sometimes public) partners. The co-operation is based on a memorandum of understanding or a contractual agreement which defines the objective of the partnership, the commitments from both parties and the governance structure. Implementation takes place primarily through the Horizon Europe work programmes and their calls for proposals, with grants fully funded by Horizon Europe. Complementary R&I

activities developed by the European Commission's partners are not funded by Horizon Europe but are included in the Strategic Research and Innovation Agendas of the partnerships.

Co-funded European Partnerships are initiatives between the European Commission and a consortium of partners structured around research funders and other public authorities. They are based on a grant agreement resulting from a call for proposals for the co-financing of a programme activity under Horizon Europe's work programme. It is suitable for partnerships involving public authorities, but it is also possible to include foundations and international partners.

Institutionalised European Partnerships are initiatives between the European Union, several EU Member States and/or industry. They are based on a Decision by the Council and the European Parliament in accordance with Article 185 the Treaty on the Functioning of the European Union, or by bodies established through a Decision of the Council pursuant to Article 187 of the Treaty on the Functioning of the European Union. Such partnerships will only be implemented if other instruments under Horizon Europe, including other forms of European Partnerships, would not achieve the objectives or generate the expected impacts, and if justified by a long-term perspective and high degree of integration.

[15] BRICS is an acronym for six economies: Brazil, Russia, India, China, and South Africa.

[16] The EU Labour Force Survey (EU-LFS) is a large household sample survey providing quarterly/annual results on labour participation of people aged 15 and over as well as on people outside the labour force (e.g. students and pensioners). These data are comparable across countries, sectors and occupations at the European level. Chapter 2 of this review uses data from the Farm Structure Survey to analyse "farm" labour force. The Farm Structure Survey is conducted across the European Union every three or four years as a sample of agricultural holdings survey and once every ten years as a census. The EU-LFS and the Farm Structure Survey differ in terms of sample definition (household vs agricultural holdings), and therefore results from these data sources may not be comparable.

[17] Section 5.4 refers to the whole sector of agricultural, forestry and fishing due to the availability of EU-LFS data on skills. Sector classification in the EU-LFS is based on the NACE at 1 digit level (or Level 1). The NACE Level 1 consists of 21 sectors, including "Agriculture, Forestry and Fishing". Due to limit of sampling methods in some Member States, it was not possible to disaggregate data only for the agricultural sector.

[18] According to the International Standard Classification of Occupations (ISCO) 2-digit code, skilled farm workers is officially labelled as skilled agricultural, forestry and fishery workers (ISCO61), while agricultural labourers (ISCO92) is part of elementary workers. Other occupation groups include, for example, science and engineering technicians, technical managers, and clerks

[19] Skills imbalances are misalignments between the demand and supply of skills in the economy, and comprise skills shortages and surpluses, and skills mismatches.

Skills shortages refer to a disequilibrium condition in which the demand for a specific type of skill exceeds its supply in the labour market at the prevailing market wage. Skills surpluses arise when the supply of a specific type of skill exceeds its demand in the labour market.

Skills mismatches are when workers have higher or lower skills proficiency than what is required by their job. Skills mismatches can be measured in different ways:

- *Qualification mismatch*: when workers have an educational attainment that is higher or lower than what is required by their job. If their qualification level is higher, workers are classified as overqualified; if it is lower, they are classified as underqualified.

- *Field-of-study mismatch*: when workers are employed in a different field from that in which they have specialised (OECD, 2016[84]).

[20] Training and education skills refer to knowledge of the principles and methods of curriculum and training design, teaching and instructing individuals and groups, and measuring the effects of training, as well as of the ability to teach others how to do something.

[21] Data on skills shortage and mismatch are from the *OECD Skills for Jobs Database*, which covers the whole agriculture, forestry and fishing sector. Although skills shortages and mismatches among forestry and fishing workers might differ from those in the agricultural sector, overall, the majority of agricultural, forestry and fishing workforce in the European Union is engaged in agricultural activities. However, the importance of the forestry and fisheries sectors is not evenly distributed across Europe, which may influence the skills imbalance profiles at Member State level.

[22] The level of skills mismatch depends on multiple factors, such as labour market conditions and the age structure in the sector. It is possible that the skills mismatches among young farmers, who are subject to certification requirements, e.g. to benefit from the Young Farmer Scheme, will be lower than among older farmers. However, due to the low proportion of farm holders under 35, e.g. 5% in Ireland in 2016 (Central Statistics Office, 2018[166]), upskilling in the sector may not be visible. Further analysis is needed to explore drivers of skills mismatches across EU Member States.

[23] "OECD Skills Strategies – Assessment and Recommendations" country reports cover Austria, Belgium, Northern Ireland, Italy, Latvia, the Netherlands, Poland and Spain. They are available at: https://www.oecd.org/fr/competences/oecd-skills-strategies.htm.

[24] Belgium is excluded due to multiple counting.

[25] The Advanced Certificate is a Level 6 award on the National Framework of Qualifications. Most certificates at this level enable students to develop a wide range of skills relevant to their chosen career path. Modules include advanced vocational and occupational skills.

[26] Regulation (EC) No. 1907/2006/EC of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) and establishing a European Chemicals Agency. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006R1907-20140410.

[27] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32000L0060&qid=1674225575750.

[28] In 2018, the European Court of Justice applied the precautionary principle on the matter of gene-edited species and ruled that they are to be considered as legally identical to GMOs and, therefore, they fall within the scope of Directive 2001/18/EC on the release of GMOs into the environment, being simultaneously governed by strict rules applicable to GMOs under this directive. Case C-528/16 of 25 July 2018, available at: https://curia.europa.eu/juris/liste.jsf?language=en&num=C-528/16.

[29] It shall be noted, however, that the Directive 2001/18/EC lays down an exemption for organisms obtained through certain techniques of genetic modification which have conventionally been used in a number of applications and have a long safety record. In its recent ruling, the European Court of Justice, for instance, clarified that organisms obtained by the *in vitro* application of a technique of mutagenesis shall benefit from this exemption. Case C-688/21 of 7 February 2023, available at https://curia.europa.eu/juris/document/document.jsf;jsessionid=5A657ACA97A3B45503CF3DC82E9C6E42?text=&docid=270253&pageIndex=0&doclang=EN&mode=req&dir=&occ=first&part=1&cid=2200376.

[30] The Agreement on Trade-Related Aspects of Intellectual Property Rights made compulsory the protection of plant varieties either by patents or by a *sui generis* system. Moreover, it made patentability of microorganisms and non-biological and microbiological processes for the production of plant varieties compulsory for signatory countries of the World Trade Organization.

[31] The European Innovation Partnership concept resulted from the European Commission's thinking on the Innovation Union flagship initiative of the Europe 2020 growth strategy (EC, 2010[165]).

[32] Digitalisation can be defined as "the adoption of information communication technologies, including the Internet, mobile technologies and devices, as well as data analytics, to improve the generation, collection, exchange, aggregation, combination, analysis, access, searchability and presentation of digital content, including for the development of services and applications" (McFadden et al., 2022[153]).

[33] Internet of Things describes physical objects, or groups of such objects, with sensors, processing ability, software and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks.

[34] Commission implementing Regulation (EU) 2021/2286 of 16 December 2021.

OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in the European Union

The European Union is one of the world's largest agro-food players. In an ever-changing economic and policy environment, the EU agro-food system has demonstrated its resilience and the ability to keep productivity growing. More needs to be done for the agricultural sector to improve its environmental sustainability performance in line with expectations.

Policies for the Future of Farming and Food in the European Union applies the OECD Productivity, Sustainability and Resilience (PSR) analytical framework along with the latest data from the OECD Agri-Environmental Indicators to benchmark the sustainable productivity performance of the EU's agricultural sector and to identify the main challenges ahead. The EU´s Common Agricultural Policy (CAP) is called to play an important role in implementing the European Green Deal's vision and objectives. Responding to pressing environmental concerns will require redesigning CAP payments, addressing the implementation gap on sustainability, implementing an ambitious data and digitalisation strategy, and bringing innovation to the centre of the agricultural policy.

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