OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in the Netherlands



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Foreword

Policies for the *Future of Farming and Food in the Netherlands* is part of a series of country 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 productivity, sustainability and resilience is a challenge common to all countries, but the solutions are unique to a country's specific context and objectives. Following an evidence-based analysis and the comparison of performance indicators across countries, PSR reviews offer country-specific policy recommendations that aim to improve the agriculture and food systems policies of the country under review. These reviews draw upon many data sources, including the OECD Agri-Environmental Indicators and rely on close cooperation with officials and researchers in the study country as well as OECD peers to make recommendations that are relevant, timely and helpful.

This report builds upon previous work: the 2015 report *Innovation, Agricultural Productivity and Sustainability in the Netherlands*. That report found that adoption of innovation has underpinned high levels of productivity growth, but questioned whether continued marginal improvements in technology would be enough to sustainably deliver productivity growth. The evidence presented here provides some answers to this question while identifying new challenges and opportunities for the agriculture sector in the Netherlands.

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This review was declassified by the Working Party on Agricultural Policies and Markets in March 2023.

Acronyms

AKIS	Agricultural Knowledge and Innovation System
AERIUS	Nitrogen calculation tool for the PAS
ASF	African Swine Fever
AWTI	Advisory Council for Science, Technology and Innovation
AWU	Annual Working Unit
BL	Guarantee Credit of Agriculture Fund
CAP	Common Agricultural Policy
CBS	Statistics Netherlands *(Centraal Bureau voor de Statistiek)*
CDW or KDW	Critical deposition threshold
CEI	Center for Economic Information Provision
CGIAR	Consultative Group on international Agricultural Research
CHP	Combined heat and power
CIV	Centre for innovative craftsmanship
CTM	Coalition for the Future-proof Dairy Farming
DLO	the Agricultural Research Service
EAFRD	European Agricultural Fund for Rural Development
EAGF	The European agricultural guarantee fund
EIP	European Innovation Partnership
EO	Earth Observation
EHS	National Ecological Network
ESD	Education for sustainable development
EU	European Union
EZK	Ministry of Economic Affairs and Climate Policy
FADN	Farm accountancy data network
FAO	Food and Agriculture Organisation
FotF	Farm of the Future
FTE	Full Time Equivalent
GACSA	Global Alliance Climate Smart Agriculture
GDN	Large-scale nitrogen deposition map of the Netherlands (*Grootschalige Depositiekaarten Nederland*)
GDP	Gross Domestic Product
GERD	Gross domestic expenditure on R&D
GHG	Greenhouse gas
GKN	Green Knowledge Network
GSSE	General Services Support Estimate
GVA	Gross Value Added
H2020	Horizon 2020
HEU	Horizon Europe
ICT	Information and communications technology
Index NL	Index of Nature and Landscapes
IPO	Interprovincial Consultation
IPR	Intellectual Property Rights
KIA	Knowledge and Innovation Agenda TKI
KWIN	Quantitative Information Livestock Farming
LBV	National Termination Scheme for Livestock Farm Locations

LNV	Ministry of Agriculture, Nature and Food Quality
LTO	Netherlands Agricultural and Horticultural Association
MGO	Targeted Purchase Measure *Maatregel Gerichte Opkoop*
MIA	Environmental investment deduction
MINAS	Mineral Accounting System *Mineralen Indication System*
MIP	Mission-oriented Innovation Policy
MIRT	Multi-Year Programme for Infrastructure, Spatial Planning and Transport
MiT	SME innovation Stimulus for regional and top sector
MMIP	Multi-year Mission-oriented Innovation Programs
MTIP	Mission-oriented Top Sector and Innovation Policy
NEN	National Ecological Network
NLA	Netherlands Labour Authority
NPPL	National test Farm Precision Agriculture
CSP	CAP Strategic Plan
NWO	Dutch Research Council
OCW	Ministry of Education, Culture and Science
OECD	Organisation for Economic and Cooperative Development
PAS	Program Approach Nitrogen registration system
PBL	Netherlands Environmental Assessment Agency
PBR	Plant Breeder Rights
PMR	Product market regulations
PPP	Public Private Partnership
PSE	Producer Support Estimate
PSN	Nitrogen Reduction and Nature Improvement Program
R&D	Research and Development
RDA	Research and Development Deduction
RDP	Rural Development Programme
RPAV	Provincial Purchase of Livestock Farms Near Nature Areas Regulation
RVIM	National Institute for Public Health and the Environment (*Rijksinstituut voor Volksgezondheid en Milieu*)
RVO	the Netherlands Enterprise Agency
SABE	Subsidy Module Agricultural Business Advice and Education
SCAR	Standing Committee for Agriculture
SEA	Strategic Evaluation Agenda
SKNL	Quality initiative for nature and landscape (*Kwaliteitsimpuls natuur en landschap*)
SME	Small and Medium Enterprise
SRSS	Nitrogen registration system
SRV	Subsidy scheme for the remediation of pig farms
SWOT	Strengths, Weaknesses, Opportunities and Threats
TKI	Knowledge and innovation teams
TFP	Total Factor Productivity
TO2	Applied research organisation(s)
UAA	Utilisable agricultural area
USDA	United States Department of Agriculture
VAMIL	Arbitrary depreciation of environmental investments
VDP	Sustainable Animal Products market program
VHR	Birds and Habitats Directive
WBSO	Research and Development Work Promotion Act
WFD	Water Framework Directive
Wnb	Nature Conservation Act
Wsn	Nitrogen Reduction and Nature Improvement Act
WUR	Wageningen University and Research

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Executive summary

Key messages

- While improved productivity has been good for the competitiveness of the sector and has reduced emissions intensity, it has not enabled an ambitious path to sustainability. Nutrient surpluses remain high, ammonia emissions contribute to the degradation of natural areas, water quality is insufficient in many areas and biodiversity on farmland continues to decline.
- Immediate action is required to reduce nitrogen deposition to protect sensitive nature areas. Reducing agricultural emissions of ammonia quickly will play an important role in achieving this. At the same time, other longstanding environmental challenges must be definitively addressed. This requires:
  - Decisive action to bring the sector into a sustainable path guided by a strong government vision of a viable future for the sector.
  - Setting rules and policy incentives to clearly define environmental limits in a way that incentivises the agricultural knowledge and innovation system (AKIS) and provides planning certainty for farmers.
  - An ambitious strategy to create a data-driven sector that can assess and adjust dynamically to its economic and environmental performance
  - Boosting the capacity of advisory services to encourage adoption of sustainability innovations and providing more incentives for farmers to take advantage of the AKIS system with respect to environmental performance.

The Dutch food, agriculture and horticulture sector is efficient, productive and export oriented, with high value added along the food chain and significant world export shares for many products. The mild maritime climate, flat fertile terrain, geographical position and sea, river, road and aviation infrastructure are advantageous for both agricultural production and trade. A few hundred million potential consumers reside within a 500 km radius.

The innovation system is at the forefront of value creation. The Top Sectors system creates a "triple helix" of cooperation between governments, research institutions and the private sector that ensures innovations are relevant and widely adopted. But it has not succeeded in reconciling productivity and sustainability in the innovation process. The recommendations of the *Innovation, Agricultural Productivity and Sustainability in the Netherlands* (hereafter "2015 Innovation Review") have been followed by actions to reduce financing gaps, improve participation by SMEs and reduce administrative burden. The *Groenpact* initiative allows better anticipation of future demands, more relevant education and higher impact research. Agri-food innovation benefits from high quality education and research institutions such as Wageningen University and Research (WUR), but more can be done to ensure that the system is as effective as possible in targeting issues of public importance such as environmental sustainability.

But there are many headwinds facing the sector. Reducing excessive ammonia emissions will sharply limit opportunities for livestock-based production. At the same time, OECD agri-environmental indicators show that longstanding problems with nutrient surpluses and declining farmland biodiversity have not been solved despite an improved environmental footprint per unit output. Land and labour costs are among the highest in the EU and the small, densely populated country makes agriculture's impact on surrounding areas an important limitation.

The government needs to do more to shape incentives for environmental sustainability. The circular agriculture vision set out by the government in 2018 needs to be leveraged to create an agricultural policy for the entire agri-food chain that recognises the need to maintain a healthy and profitable sector that lives well within its environmental limits. There are many ways to help farmers adjust to new realities, but those limits must be accurately reflected in regulations and other policies in a way that minimises uncertainty for producers as they plan future investments and provides clear signals for the innovation system to address sustainability issues.

Mainline agricultural policy is increasingly being repurposed for multiple objectives. The Netherlands has generally used CAP flexibilities to direct resources towards rural and environmental objectives. The new CAP Strategic Plan provides opportunities to deepen this approach by embracing eco-schemes and moving funding from Pillar 1 to Pillar 2 for cooperation, knowledge, innovation and investment for sustainability.

Lifelong learning for farmers and farm workers is a challenge. Preparing farmers for the transition to sustainable agriculture calls for an education system that can address issues holistically and not only specific elements of production. Farmers need incentives to engage more strongly with the AKIS on sustainability issues. Efforts are being made to match skills and improve the capacity of the education and extension system to respond to needs of farmers and farm workers (including migrant and temporary workers), but further tailored investments in this area will likely be required.

Dutch farmers are well-placed to take advantage of future digital opportunities. The overall good enabling environment for digitisation in the Netherlands still could use some tweaking to achieve the full potential of digitisation for agriculture. The Netherlands is well-placed to be a leader in using farm-level data collection to aid farmers decisions and policy design but needs an overall data strategy. Resolving questions surrounding data ownership, platforms, sharing, portability and trust can accelerate progress.

Recommendations for improved policy in the Netherlands cover four main areas

- **Bring down the environmental pressure of the sector quickly and accelerate the transition to a sustainable future.** Environmental limits need to be clearly identified to provide policy certainty for farmers. Decisive action in the short term to bring the sector into a sustainable path should be combined with a strong government vision of a viable future for the sector. A deeper engagement with stakeholders, including with respect to agenda-setting can increase buy-in and help make policies less susceptible to short-term political forces.
- **Realign economic and regulatory incentives to ensure that negative environmental externalities of agriculture are fully internalised.** Clear policy objectives combined with better data and analysis can reduce uncertainty for farmers and induce innovation. Defining responsibilities for regional and local governments and other stakeholders can set the stage for effective partnerships. Build upon the success of existing innovative agri-environmental programmes to make results-based approaches a larger part of the policy framework.
- **Develop an ambitious strategy to create a data-driven sector that can assess and monitor its economic and environmental performance**. Develop a strategic vision for the sector that provides clear priorities towards an environmentally sustainable path and improve the government

capacity to lead innovation in that direction. Use data to design and implement better policies based on results and to inform farmers regarding their environmental performance. Create an overall data strategy to lift barriers to digital technology adoption on farm and by advisory services.

- **Keep the strengths of the innovation system while boosting its capacity to improve the sustainability of the sector**. Making incentives for social and environmental sustainability factors more present in the innovation system requires reflecting environmental limits in regulation and markets, targeting funding towards environmental innovation and a stronger government role in agenda-setting in the AKIS. Advisory services need more capacity related to adoption of environmental sustainability innovations. Farmers need more incentives to engage with knowledge opportunities by linking on-farm environmental planning to existing support programmes.

Overall assessment and recommendations

An innovative and productive sector that must address longstanding sustainability problems

The agriculture and food sector in the Netherlands is innovative and productive, competing in global markets on both price and quality. The sector has followed a development path common to most countries where ongoing consolidation reduces the number of farms while average farm size increases. The agriculture sector has become one of the most efficient in Europe and the world. Trade has expanded fourfold in the past 20 years and the Netherlands is the second largest agricultural exporter in the world, in part due to its role as a major trading hub for Europe. The importance of the greenhouse and horticulture sector as a share of agricultural production value is unique in Europe. The horticulture sector operates on a different model than does the rest of Dutch agriculture; it uses relatively little land, receives a small amount of support from agricultural policy and is exposed to different risks than other forms of production.

Dutch agriculture is highly efficient, and many products have relatively low emission intensity of production when compared with other countries. The environmental footprint of the sector per unit output has been steadily improving via productivity growth and technical innovation. However, increasing and intensive production is running up against environmental limits and may be beyond them in many areas. A 2019 court ruling found that past nitrogen policy was not in line with the requirements of the Birds and Habitats Directive, prompting a costly and painful adjustment of the sector to come in the next years to reduce ammonia emissions that harm sensitive landscapes. Other issues such as GHG emissions, water quality and biodiversity will also require difficult choices to address as targets in many cases remain far off.

There is a new realisation that the overall system limits are such that some readjustment of the sector is required. In particular, the need to reduce nitrogen deposition via ammonia emissions to the point where it no longer threatens sensitive nature cannot be achieved in a reasonable timeframe by technological improvements alone and not everything will be possible everywhere. This is an important turning point for the sector, and significant financial resources have been allocated to support the transition to a more sustainable agriculture.

Many of the factors affecting objectives for water quality, GHG emissions, ammonia emissions and more are rooted in livestock density, but there is no single solution that addresses all problems at once. Reducing the size of the animal herd will be necessary in many areas, and specific mitigating actions for each objective are also available. Some objectives require local solutions, such as for “peak loaders” with high emissions near Natura 2000 sites where nitrogen deposition subsequent to ammonia emissions poses a particular risk to ecosystem health. Other objectives, such as GHG emissions reductions, are not sensitive to the distribution of emissions.

As identified in the 2015 report, the strength of the agricultural innovation system is not focused on solving pressures from environmental externalities

A strong innovation system led by the private sector has been a key driver of productivity gains and is a central feature of policy, but it has not been able to solve the acute environmental problems facing the sector. Indeed, the orientation of the innovation system towards private over public objectives was a concern raised in the 2015 Innovation Review of the Netherlands. Despite some useful new programmes, the limitations of the innovation system to address environmental problems have not been fully addressed.

The 2015 Innovation Review recommended that the Netherlands strengthen the ability of agricultural policy to improve the environmental performance of agriculture, by focusing agri-environmental measures to objectives and outcomes rather than on process and meeting EU regulation constraints and revisit the balance between regulation and economic incentives in view of fostering environmentally friendly innovation. This review finds that the Netherlands has made many improvements that align with the recommendations of the 2015 review, but more remains to be done in many areas. Progress is especially notable in the agricultural education system, which effectively brings togethers famers and research institutions to enable change at the farm level. This helps build a strong foundation for the future of the sector. However, the farm advisory system still has not fully adapted to the need for holistic advice regarding farm sustainability.

The circular vision for agriculture put forward in 2018 expresses the government's aspirations for the sector. This vision needs to be made more concrete and compelling to change the mindset of all actors in the sector and it needs to be more present in the policy making process if ambitious sustainability goals are to be realised. The absence of early and effective action with respect to ammonia emissions has led to the current crisis, and the lessons of this must be learned if similar situations are to be avoided in the future. There are still many areas where policy actions have been insufficient to solve environmental challenges, in particular with respect to farmland biodiversity, nutrient surpluses and water quality. The policy perspective for the sector must move away from short-term maximisation of opportunities subject to environmental constraints, to one of finding a long-term balance between agriculture and nature values. Trying to operate at the very edge of environmental limits is difficult and poses substantial risks if policy makers get the balance wrong.

Many opportunities remain for the agriculture sector in The Netherlands, and its future is bright. But that future can only come if all sustainability concerns are addressed as quickly as possible. Delay only brings higher costs, uncertainty and reduced prospects for the future. Once on a sustainable footing, the promise of innovative R&D that responds to both environmental concerns and the opportunities of new markets for knowledge intensive products can be realised.

The Netherlands uses the space in the new CAP to transfer funding from income support to sustainability and rural development objectives. Broadening who can participate can bring additional benefits.

CAP policy has emphasised making maximum use of flexibilities for environmental and social sustainability issues, and this continues to be the case in the latest CAP cycle. The CAP Strategic Plan (CSP) anticipates a substantial transfer of funds from Pillar 1 to Pillar 2, providing more targeted funding for sustainable development objectives, starting at 15% and increasing to 30% by 2027. Eco schemes in Pillar 1 will be an important part of the overall policy mix, with funding of EUR 152 million per year that is not affected by the progressively higher transfer of funds to Pillar 2. By contrast, the direct payment under Pillar 1 will be reduced from EUR 387 million in 2023 to EUR 290 million in 2027.

The Netherlands is one of only five EU Member States using a multidimensional eco-scheme that bundles all eligible interventions in one programme. Farmers can choose to implement up to 24 different eco-activities, earning a higher number of points and more compensation for greater ambition. This structure

of eco-schemes can help incentivise producers to take more ambitious actions and helps address the phenomenon observed with green direct payments in the last CAP where farmers tended to choose "productive" options that had lower biodiversity benefits.

The trajectory of the CAP orientation towards rural environment and social sustainability is expected to continue. It is likely that at some point, the existing agri-environmental scheme (AES) approach that puts voluntary action by individual farmers at the centre of policy delivery will reach its limits. The Netherlands has demonstrated through its AES for farmland birds that coordinated action through farm organisations can be more effective than individualised effort. This idea is already being extended to other AES subject areas, but it can be taken farther still.

The Local Action Groups of the LEADER programme, which are allocated EUR 67 million in the CSP, are a model that could be expanded to agri-environmental schemes. Farmers are community members connected to the social and economic fabric of rural areas. Finding ways to involve the larger community can make certain types of programmes more effective and attractive. This can be particularly relevant for agro-tourism or where farmland is at close proximity to natural areas such that joint action between farmers and community members is mutually beneficial. It can also help farmers wishing to transition from the sector by giving ex-farmers some opportunity for continued engagement

Transformative change is essential. The sector must embrace it.

The health of the sector and its prospects fundamentally depend on its capacity to produce value in the context of its environmental limits and the changing demands of the market. The 2019 Court ruling on nitrogen deposition on sensitive nature made clear that reducing the number of livestock is necessary to reduce damage to biodiversity in sensitive areas, despite resulting in painful short-term disruption. Farmers who have invested in their operations based on past and expected policy settings may be expected to resist change, but the present situation is still not sustainable and more will need to be done.

The Dutch government has allocated EUR 24.3 billion to a transition fund for the sector, on top of billions already in place to reduce emissions. The idea is a one-off adjustment that moves the sector away from the edge of its environmental limits and makes space for extensification of remaining farmers. The current approach is based on voluntary and compulsory buy-outs or investments in innovation or relocation of livestock farmers for a limited group of "peak loaders" with high emissions in sensitive areas. The pool of willing sellers will set the pace of progress in the early stages, but the evolving nature of the buyout programmes may encourage farmers to wait to see if a better deal will become available. This is recognised and reflected in recently revised policy design that provides for higher payments for early adopters, but strong uptake in the near term will remain the most important metric of success.

Current policy aims to ensure that those that remain have a secure long-term place in the sector and the economy. Giving remaining farmers a perspective is important, but should be without prejudice to the eventual size and distribution of agricultural production and should reflect the market principles that have been an important success factor for the sector to date.

It is unlikely that payments alone can bring the sector to where it needs to be. To build consensus on required actions will require moving beyond consultation and negotiation to involving the sector in data collection and analysis, agenda-setting and program design and delivery. By involving sector representatives in all important phases of the process they can better internalise the difficult choices that must be made, and solutions that they have helped to design will be seen as more legitimate.

While the sector continues to restructure in favour of fewer, larger farms, the productivity benefits of consolidation appear to be slowing

Average farm sizes have increased by 35% between 2005 and 2016, from 24 hectares to 32 hectares and there were about half as many farms in 2020 as there were in 2000. This is a result of consolidation of

smaller farms, and the number of small farms (under 5 hectares) reduced by half between 2005 and 2016. At 20%, these farms make up a smaller share of all farms than in many other EU countries.

Farm consolidation is an almost universal phenomenon in developed countries and by itself is not a cause for concern. Economies of scale have helped drive total factor productivity (TFP) growth and kept the sector cost-competitive with other countries. However, growing farm sizes and intensification has resulted in manure surpluses. Organic nutrients have transitioned from being a valuable by-product to something that must be disposed of, often by export to other countries.

Productivity growth has until recently been an important part of output growth. Increases in productivity have been driven in the past by the exit of labour from the sector (a common phenomenon in the OECD area), production quotas that influence capital spending, and structural changes in the sector that bring economies of scale. Recent low productivity growth is concerning as it coincides with lower output growth and a reversal of past gains in the emissions efficiency of production. This may be related to the sector nearing its environmental limits. Reigniting sustainable productivity growth path will improve the future prospects of the sector, especially in the context of environmental constraints, including GHG emissions reductions commitments.

Reflecting the local situation in policy design can promote change efficiently and effectively, but the enabling conditions must be in place

The government has taken an approach to reducing ammonia emissions that considers the local situation when determining the need for emissions reduction. Part of this is identifying “peak loaders”, those farms whose emissions pose the most risk to sensitive natural areas. This is an important policy feature to ensure that emissions reductions are as cost-effective and efficient as possible. In addition, working closely with local governments and stakeholders can help to build consensus. The national government is overall responsible for setting and achieving the objectives and the Transition Fund, but responsibility for planning and implementation for emissions reductions has to an important degree been devolved to regional governments

Devolving responsibility to regional governments can help with local autonomy and anchoring of plans, but not all governments may have the policy capacity in place or the incentives to create the necessary plans in the given timeframe. There is much that the national government can do to support and accompany regional governments in their planning processes. For example, developing or deploying expert networks to support regional policy makers, creating opportunities for governments and stakeholders to share responsibilities and experiences and other logistical support can help regional partners to create plans, communicate them to their constituencies and implement them successfully.

Regional and local partners also need to be sure that the difficult decisions they make will not be undermined by backsliding or met with additional demands. If the national government can provide a stable policy setting, regional actors will be more able to plan and act with confidence.

The strong Dutch agriculture knowledge and innovation system (AKIS) will continue to be a comparative advantage, but it must prioritise environmental performance

The intensification of production is reaching environmental limits

Highly intensive dairy production is the dominant agricultural land use in the Netherlands. The country has more than four times the average European livestock density and milk yields in the Netherlands are higher than both the EU and OECD averages and amongst the highest in the world. Dutch cereal yields are also higher than both the OECD and EU averages and among the highest in the world reflecting high

productivity built on input intensity. Glasshouse horticulture area increased by 20% since the 1980s. Glasshouse horticulture farms have undergone significant structural change over the last two decades with a steady increase in farm size. However, specialisation and intensive production systems have also led to increased pressure on the sustainability performance of farms. Rebalancing the AKIS system between productivity and sustainability will help prepare the sector for long term sustainability.

The Dutch AKIS system is strong, highly developed, and efficient…

The AKIS is made up of a diverse group of actors at various levels. The main components of the systems are well developed and include vocational education systems, a three-tiered agricultural education structure, and active private sector involvement. These are supported by a proactive government that provides public services, funding, and defines innovation schemes in partnership with companies and research institutions.

The Netherlands has a world-class agricultural education system with many highly rated training institutes and universities and Dutch farmers are relatively well educated. Dutch agricultural research is internationally renowned, with WUR consistently listed as one of the top universities in the world for agricultural education and research. The *Groenpact* initiative, a national support programme for promoting education, lifelong learning and innovating professional practice in agriculture, horticulture, food and nature and the living environment, complements this system.

…based on the Top Sectors approach to public-private-research partnership where private funding plays a leading role

The AKIS system, also called the “Triple Helix” or “golden triangle”, works through cooperation between knowledge institutions, businesses and the government. The system is divided into nine leading export sectors as the “Top Sector” policy (*topsectorenbeleid*), which account for 80% of Dutch R&D. This has been a successful model for both harnessing research funding from a variety of sources and ensuring partnerships across the sector. Government funding for agricultural R&D has increased in recent years, although the private sector (through the Top Sectors) is the main contributor of funding for R&D.

Strong international collaboration and partnerships on R&D lead to success in accessing EU funds like Horizon Europe and increase the profile of Dutch researchers and their work. The Dutch government and the agro-food research sector play an active role in global agriculture initiatives, bilateral cooperation, and development cooperation actions on agriculture. Such strong collaborative efforts, particularly those assisting developing countries to improve the productivity of their agricultural systems, are a valuable contribution to the global food system.

The private sector also plays an important role in delivering extension services

Privatisation has changed the character of agricultural extension services. This approach is consistent with a principle of the private sector paying for private goods, which reduces the financial burden to the public and is a competitive free market approach. However, such advice is often linked to commercial interests of the providers. The government has recently been investing more in independent investment services to provide broader advice to farmers.

The innovation on the farm initiative, particularly, the SABE (*Subsidiemodule Agrarische Bedrijfsadvisering en Educatie*) vouchers to access independent impartial advice, is an effective system that helps to overcome some of the disadvantages of a largely privatised extension service system and provides independent advice without the expensive overhead of a traditional public extension service. Peer-to-peer learning systems, field labs and demonstration farms play an important role in technology transfer to and between farms. The European Innovation Partnership (EIP) innovation instrument can help to take innovations (such as co-creation, investments or monitoring) to the farm level.

Public policy has moved towards promoting competitiveness and innovation in farming systems

The Ministry of Agriculture, Food and Nature (LNV) has focused on promoting competitive and innovative farming systems. The CAP national strategic plan provides funding of EUR 183 million for innovation, knowledge dissemination and cooperation, and the Netherlands dedicates about 8% of its Pillar 2 budget to AKIS, compared with the EU average of around 2%. Despite a higher co-financing rate for research related to public-goods and externalities, these have not been the main focus as it is difficult to monetise this research. A step in the right direction is the mission-oriented innovation policy, in which the public and private Top Sector partners are engaged in the joint drafting and implementation of policy agendas in four societal challenge areas. However, the current approach mainly aims for incremental improvements that may not be sufficient for the needed transformation of the agricultural system.

The innovation system can do more to support environmental sustainability in production if the right priorities and incentives are set

Innovation has always been a key feature of Dutch agriculture but slowed progress on environmental performance suggests that this is an opportune moment to check whether the innovation system is focussed on the right issues. One of the strengths of the AKIS is the world-leading research capability of WUR and the close partnership between public institutions and private enterprises. However, private investments will naturally focus on innovations that are rewarded in the market and not on environmental externalities. This has led to relatively more emphasis on productivity improvements, and farmers engage much more readily with the AKIS for productivity innovations than for environmental performance improvements. While improved productivity has been good for the competitiveness of the sector and has reduced emissions intensity, it has not enabled an ambitious path to sustainability. This was raised as a concern in the 2015 Innovation review, which noted that the Top Sectors approach could lead to insufficient emphasis on public goods. Stronger government leadership is needed to ensure that public funds are used effectively.

The vision of circular agriculture presented in 2018 foresees a marketplace that values and rewards nature-based solutions and the sustainability characteristics of food products. While it is important to inform consumers about the implications of their food choices, changing consumer demand alone is unlikely to drive the needed environmental improvements or fix environmental externalities in a reasonable period, especially considering the importance of exports to the sector. A good policy foundation sets the stage for both public and private innovations that serve the public interest. It is up to the government to set clear conditions via legislation and rules that internalise environmental externalities and incentivise the AKIS to invest in environmental performance. This is also connected to the issue of policy certainty discussed above. Increasing the priority of environmental sustainability in the innovation system will be an important success factor for the future. The challenge is to do this without undermining the features of the Top Sector approach that make it so effective. Government leadership and funding, market signals, regulatory constraints and incentives for producers to engage more will all have a role to play.

Innovation is important for the prospects of the sector and, in the current context, there is urgency to change the incentives for the AKIS. It is critical to set a clear path to achieving environmental objectives in a reasonable timeframe that does not rely on yet-to-be developed or deployed technologies. The current plan for ammonia emissions reductions is a good example of setting a path for progress. Once environmental objectives are attained, innovation can expand the space for future productivity growth and development.

The potential benefits of digital technologies are high, especially for monitoring environmental performance

The Netherlands is well placed to reap the potential of digitalisation. More than 98% of households have fixed broadband internet access, compared with about 80% for the EU-27. But investments are still needed in digital infrastructure and the skills and services that complement digital technologies. For example, the latest digital technologies such as cloud computing require faster fibre networks and next generation 5G wireless networks. Limited data sharing and portability and lack of trust still limit the potential of digitisation for agriculture.

Digital technologies can provide new ways to inform farmers about their environmental performance, help governments improve the efficiency and effectiveness of existing policies and to design better ones. For instance, freely available and high-quality satellite images dramatically reduce the cost of monitoring many agricultural activities. This can allow governments to move towards more targeted policies, which pay (or penalise) farmers based on observed environmental outcomes. In addition to monitoring compliance with environmental policies, digital technologies enable automation of administrative processes for agriculture and the development of expanded government services, such as advisory services.

Focussing policy on results, supported by data and in collaboration with the sector can help avoid future crises

OECD Agri-Environmental Indicators show an environmental situation that is not improving. Nitrogen surpluses, a key challenge, have not improved meaningfully since 2008 and are well above the EU average and that of regional peers. Water stress, while low in absolute terms, is above the OECD average, rising, and sensitive to the effects of climate change. Farmland bird populations are now only 54% of 1990 levels. While relatively more spending is directed to farmland than to natural areas, the outcomes in terms of biodiversity improvements on farmland have been generally worse. The current situation, which exists despite an overall increase in spending on environmental and social objectives, seems to warrant a greater willingness to experiment with the way programmes are delivered.

The 2015 Innovation Review recommended improving the environmental performance of agricultural policy by focusing agri-environmental schemes (AES) to objectives and outcomes rather than on practices or processes to meet EU regulation constraints. It also called for revisiting the balance between regulation and economic incentives to foster environmentally friendly innovation.

Programme design is changing to address sustainability challenges. The Netherlands already has a good example of results-based AES in the form of the *Agrarisch Natuur- en Landschapsbeheer* (ANLb) system for nature and landscape management. Participants are rewarded according to results in terms of observed bird nests and other features, as well as for actions such as delayed mowing. This programme was established in 2016 and covered 92 000 hectares in 2019, so is probably not currently at a scale to solve the overall decline in farmland birds.

The ANLb is being expanded to include climate change and water issues in the new CAP. There are still several known implementation challenges with results-based approaches such as lower incentives for farmers to participate and the difficulty of collecting observational data as part of programme delivery. The valuable experience gained in implementing the ANLb gives the Netherlands a leg up in effective design and implementation of results-based approaches.

Better environmental data can help improve policies…

Result based approaches need data, especially for environmental performance. Data collection via the Farm Accountability Data Network (FADN) in the Netherlands has a relatively good sampling rate on

environment compared with other countries. However, a well-funded and ambitious data strategy covering all farms is still missing. Comprehensive farm-level data allows for better monitoring the evolution in priority areas at the regional and national level and make it easier to identify potential adjustments needed in policy measures. For instance, the new Spanish Farm Information System (SIEX) brings together information from different sources, including a new farm electronic notebook informing farmers about their environmental performance and aiding monitoring of farm practices. A data strategy can enable more comprehensive data collection by addressing concerns about the regulatory environment governing the data collected and balancing data privacy concerns with the potential benefits.

…and building capacity to think strategically is needed to successfully address upcoming challenges…

Despite substantial policy development and implementation capacity within LNV, certain situations such as declining farmland biodiversity, nutrient surpluses and less than good water quality have become chronic issues. The current situation where reducing animal numbers is required to limit ammonia emissions is an example of a longstanding problem that was well known but never definitively addressed until the situation became urgent. As recently as 2018, the strategic objectives of the Agri & Food Top Sector covered environmental issues only in general terms. In retrospect this is an oversight, especially given the fact that the weaknesses of the Integrated Approach to Nitrogen (*Programma Aanpak Stikstof*, PAS) system were already understood at that point. As stated in the Remkes Report *Wat Wel Kan,* "The current government is dealing with the legacy of years of ineffective nitrogen policy. It is now no longer possible to postpone measures".

As mentioned earlier, a focus on results and transformative policy change is necessary, but this is not the whole story. There needs to be a greater institutional capacity to systematically identify and address long term issues. Building this capacity will require a combination of elements, including working in concert with the sector. It is difficult to imagine how a long-term policy initiative that is simply imposed on the sector could be successful. Finally, having the capacity to deploy the tools of strategic assessment and work through the implications of alternative actions is needed to enable a results-based approach.

Strategic foresight should be used to identify and resolve challenges before they can become serious. Strategic environmental assessment should be applied to evaluate the implications of policies, including their cumulative effects. Being more specific about upcoming threats and making concrete plans to address them is the best way to avoid a repeat of the current difficult situation with respect to ammonia emissions. The proposed EU Nature Restoration Law, with its focus on results-based outcomes, can help provide a structure for long-term thinking.

…and develop a vision and an ambitious agricultural innovation strategy that puts the environment in the front and induces innovation towards concrete progress on sustainability

For many years, Dutch agricultural policy aimed for continued expansion of the agricultural sector while reducing over time its environmental impact through technological change and innovation. Indeed, great progress has been made at reducing the environmental footprint of the sector per unit output since the 1990s. This path of technological improvement is far from being exhausted, despite slower progress or reversals in some environmental indicators in recent years. The Netherlands is a leader in technology development and its agriculture sector is one of the most productive in Europe.

The 2015 Innovation Review pointed to the need for a long vision for the sector which recognises the need to improve environmental performance while maintaining productivity growth. A vision of circular agriculture was put forward in 2018 to guide Dutch policy to help the sector live within its environmental limits. Circular agriculture in the Netherlands encompasses matching input quantities to environmental carrying capacity,

circularising waste flows from the food system, reducing waste, and regionalising more of the production chain. Given the global nature of agricultural trade, those elements of circular agriculture having to do with efficient cycling of nutrient and waste flows within the Netherlands itself are the most critical for addressing current environmental challenges. This circular agricultural vision must be more specific with respect to nutrient flows and the respective roles of and incentives for government, consumers and farmers if it is to effectively guide public policy and provide the appropriate signals for private investment.

Less frequent regulatory adjustments will reduce policy uncertainty, but this requires bold action

The 2015 Innovation Review called for policy stability to encourage private investment. This continues to be an area where more work is needed. One way to help with this is to establish policy settings in a way that ensures environmental objectives are achieved with a high probability in a reasonable timeframe. This will avoid having to change the rules in mid-course. In the past, environmental legislation has been continually strengthened to improve sustainability, but this frequent revision of rules and regulations has led to a perception that inconsistent and changeable policy frameworks are a counterproductive risk to farm businesses. While even the best regulatory systems will draw complaints, frequent adjustment of environmental rules not only risks discouraging investment, it also makes it more difficult for regional and local governments to partner effectively with the national government if they have to frequently revise plans.

Policy certainty is not as easy as it might seem. Governments must balance finding opportunities for growth with concerns about sustainably. The more finely this balance is struck, the more likely that environmental limits will be exceeded and further policy tightening required. This continual adjustment to try to find the margins of sustainability leads to policy uncertainty and missed objectives. Witness the fact that the country is on its seventh Nitrogen Action Plan under the Nitrates Directive and that the Fertiliser and Nitrogen Act and Environment and Planning Act have been revised nearly every other year, yet nutrient surpluses remain an important problem. Providing policy certainty requires maximising the probably that targets will be met. This means ensuring that the sector operates well within environmental limits rather than at the edges of them.

Help give farmers perspective for the future, without relying on support payments

The government has clearly stated the objective to give a secure business model and planning certainty to farmers who choose to remain in the sector once the painful adjustments to address ammonia emissions are completed. There are many ways that the government can help accompany the sector through the changes that are to come, but relying only on payments such as for ecosystem services can inject policy risk into farmers' business models and builds an implied obligation on the part of the government with respect to farm profitability that should not be there. Entrepreneurial risk and adjustment to new market realities are normal business features.

There will be parts of the country where intensive agriculture will still be possible, and others where environmental constraints will sharply limit the form of agricultural production. Profits tend to become capitalised in fixed inputs, especially land, so that land price adjustments can in principle account for the different economic potential of each location. But land price adjustments can be disruptive in the short term, especially as land ownership is often financed by or used as collateral for bank loans. Aid with financing and restructuring of debt and finding practical ways to deal with stranded assets can help during a period of transition. Zoning of land use can help maintain agricultural production in areas where the agricultural land value is less than alternatives like residential or commercial construction.

There is a good deal of discussion regarding the need for the government to become involved in the reallocation of farmland as peak loaders either are bought out or relocate and it will be tempting to use

concessionary land prices as part of this. However, this risks short-circuiting the price function of land markets and providing arbitrary and non-transparent windfall profits to certain producers.

Policy recommendations

In the light of the above assessment, the following actions are recommended.

1. Bring down the environmental pressure of the sector quickly, while ensuring a future to remaining farmers

Quickly implement the Transition Programme to address excessive ammonia emissions

- Immediate action is required to reduce ammonia emissions and resulting nitrogen deposition on sensitive natural areas. Delay will mean higher costs and greater dislocation in the future. Targeting "peak loaders" with high emissions near sensitive areas is important for effectiveness. Reducing overall deposition should be prioritised, otherwise, the crisis will continue indefinitely.
- Buy-outs offers for peak loaders should be very generous to start and reduce significantly after the first year to incentivise early action. The government should signal the use of mandatory reductions and restrictive regulations if voluntary action is insufficient, with clearly defined thresholds of progress acting as trigger points.

2. Realign economic and regulatory incentives to ensure that negative environmental externalities of agriculture are fully internalised

Use SMART objectives combined with better data and analysis to prioritise success while reducing risk and uncertainty for farmers

- Set specific, measurable, achievable, relevant and time-bound (SMART) objectives for environmental outcomes with respect to biodiversity, air, water and soil quality at national and sub-national level. Undertake analysis to determine farm-level conditions required to meet these objectives with a high probability. Set appropriate regulations or other measures (including via the CAP) to ensure that these are met, recognising the area-specific nature of such settings. The goal is to avoid frequent changes in policy parameters by moving boldly on a path towards sustainability rather than making incremental progress where action is easier. This will reduce policy risk for farmers while providing appropriate incentives to the AKIS system to develop needed environmental technologies.
- Make better use of data, including at the farm level, to ensure success by establishing a feedback process that connects progress towards objectives with policy adjustments. Ensure that this mechanism is transparent and involves stakeholders to provide greater policy certainly to farmers.

Define clear responsibilities for regional and local governments and other stakeholders

- Regional governments have a large role to play in preserving nature and biodiversity in the Netherlands, including how to achieve national objectives on emissions reductions. How the national government accompanies its counterparts to overcome challenges on the way to achieving targets will be crucial, and careful tracking of progress until 2030 will be required to ensure that ambitious objectives are achieved. A dedicated steering committee to track progress on ammonia emissions reductions that can flag problems could be helpful in this regard.
- Clarify the responsibilities of farmers and other participants in the agro-food value chain with respect to environmental objectives, keeping in mind the polluter-pays-principle. This will help ensure a fair and appropriate burden sharing between taxpayers, consumers and stakeholders.

- Work with regional and local governments, farmers, consumers and other stakeholders to build support and consensus for regional plans to achieve emissions objectives. This could be through expert networks to support regional policy makers, creating opportunities for governments and stakeholders to share experiences and other logistical support that enables regional partners to both create plans and communicate them to their constituencies. Share responsibility for agenda-setting and management of the process with farmers and the public to ensure local anchoring of plans in the communities that will be affected by them. At the same time, do not let consultation be a cause of delay in implementation.

Build upon the success of existing innovative agri-environmental programmes to make results-based approaches a larger part of the policy framework

- Leverage the experience gained in the ANLb system to make greater use of results-based approaches to environmental challenges. The expansion of this programme to climate and water issues in the new CAP is an important step in this regard.
- The points system that will be implemented for eco-schemes under the new CAP is an improvement over past approaches that should increase the prevalence of measures with higher biodiversity and environmental benefits. The principles of results-based approaches can be applied here as well to ensure that eco-schemes deliver real benefits.

3. Develop an ambitious strategy to create a data-driven sector that can assess and monitor its economic and environmental performance

Develop a strategic vison for the sector that provides clear priorities towards an environmentally sustainable path

- Improve the capacity of LNV to carry out long term planning by placing the strategic planning group in the organisational structure such that it can influence policy development horizontally. Give this group a mandate to champion strategic thinking within LNV and operationalise the Circular Agriculture vision. Apply tools such as strategic environmental assessment to current and future policies. Use strategic foresight tools to identify trends that are likely to have significant long-term influence.
- Ensure that the lessons of the Nitrogen crisis are internalised in the LNV by creating experience-sharing opportunities within the Ministry and encouraging staff training that will help officials take advantage of those lessons as they design policy.
- Create a contact group made up of representatives of farmers, consumers and civic society to participate in data collection and analysis to build consensus on the issues facing the sector and the policies that may address them.

Use data to design and implement better policies and inform farmers regarding their environmental performance

- The results-based approaches mentioned above depend on effective data collection for their success. SMART objectives require good information to evaluate progress and adjust policies to ensure success is achieved. The Netherlands already has many of the building blocks in place and should leverage its comprehensive internet connectivity, strong technical capacity and vertically integrated innovation system to become a world leader in agri-environmental information systems.
- Create an overall data strategy to lift barriers to digital technology adoption on farm and by advisory services. A unified and clear data governance arrangement can address concerns about the regulatory environment governing the data collected and increase farmers' willingness to adopt digital solutions. Find a balance between protecting the privacy and confidentiality of data, while leveraging their potential for the sector's growth and innovation.

- Use data to improve the awareness of farmers regarding environmental sustainability problems to help build buy-in and consensus on the need for action.
- Promote digital technologies that can help advance climate, biodiversity, and sustainability goals.

4. Keep the strengths of the innovation system while boosting its capacity to improve the sustainability of the sector

Retain the benefits of the Top Sector approach while giving the government a more active role in setting priorities for research in the public interest

- The government should prioritise environmental sustainability in the innovation system and take a more active role in determining the direction of agricultural research and innovation in the Top Sector Agri & Food. This includes shaping selection criteria, being more selective regarding projects and including more government-led proposals.
- Get the incentives right for the AKIS to invest in environmental performance by correctly reflecting environmental goals in farm-level regulations. Increase government co-funding for public-goods related research and earmarking funding for public goods in the existing research funding framework. Ensure that public funds are used effectively to deliver public goods, including CAP funding for innovation. Adjust the rate of R&D tax credits to favour sustainability projects.
- Help public-goods oriented groups such as advisors, educators and NGOs to participate in the Top Sector process by lowering co-financing requirements for priority projects connected to sustainability objectives.

Building on the vouchers programme, direct advisory services towards knowledge and adoption of environmental sustainability innovations

- Support and expand peer-to-peer learning with a focus on environmental sustainability. A cross-border exchange programme for farmers and advisory service providers could improve awareness of novel solutions. Use advisory services to provide impartial training and advice to farmers to help them address new challenges, especially for environmental sustainability.
- Encourage the development of farmers organisations with a focus on environmental sustainability taking as a model regional groups in which the most advanced farmers in terms of production techniques interact with each other (for example, in France and Argentina). Operational groups should be used to build awareness among farmers, consumers and other stakeholders.
- Increase availability and access to education and training opportunities for farm workers, including temporary and seasonal workers and immigrants with lower skills relative to their Dutch peers. Free vouchers for training temporary workers similar to the SABE approach can eliminate disadvantages and to allow them to participate fully in society, with the consequent benefit for the Netherlands in terms of attracting and integrating young workers. Given the importance of labour in horticulture, education and training programmes could be first targeted to workers of that sector.
- Increase the awareness of sustainable production systems among farmers, consumers, and all stakeholders, including organic. The organic strategy offers a timely opportunity to advance this. Reserve a proportion of SABE vouchers to support a transition to organic or nature intensive agriculture. Include content regarding sustainable agriculture in the education system to help increase awareness and demand for sustainability characteristics of food products.

Provide incentives for farmers to engage more directly with knowledge opportunities by linking on-farm environmental planning to existing support programmes

- Provide collaborative training opportunities for farmers to produce their own environmental assessment and action plan in the form of an environmental management plan for the farm. These

should assess all relevant dimensions of environmental impact and identify an action plan to mitigate them. This action plan should draw on solutions identified by the AKIS.

- Reward farmers who engage with the AKIS on sustainability issues in this way by making funding mechanisms such as the investment incentives provided by MIA/VAMIL (*Milieu-investeringsaftrek*/*Willekeurige afschrijving milieu-investeringen*) contingent on such participation by co-financing the actions identified in farmers' action plans.
- Work with the entire value chain to set the scope and priorities for the content of environmental management plans to maximise consumer benefits and market impact. Consider a certification or labelling scheme to identify products produced under an environmental management plan.

From world leader in agricultural productivity to world leader in innovation for sustainability

The Netherlands has built an agricultural sector that is a world leader in productivity and competitiveness. This was achieved in a way that assumed that innovations in technical measures and increased efficiency would ultimately solve the associated environmental pressures. But environmental challenges have grown increasingly urgent, and it is now recognised that "not everything is possible, everywhere" and the sector must fundamentally adjust to stay well within its environmental limits.

To achieve the transition to sustainable agriculture, the government has put substantial resources and effort into its transition plan. The strong innovation capacity of the sector can be a powerful engine if the government sets the right conditions to make it work for addressing the sustainability challenges. Farmers, government and other actors must work together to achieve the vision of the sector as a world leader in innovation for sustainability.

1 Implementation of the 2015 recommendations

This chapter finds that the Netherlands has taken actions that fully or partially address about 80% of the recommendations made in 2015. The innovation system remains a world leader and effectively translates R&D resources into results on the farm. The system is stronger than it was eight years ago thanks to action to improve funding sources, research infrastructure and institutional arrangements. It benefits from a defined vision for the future and associated long term goals. The connection between actors in the agricultural knowledge system has been improved by better integration of research, education and extension. A key challenge is ensuring that the innovation system is as effective as possible in targeting issues of public importance such as environmental sustainability.

Key messages

- Overall, the Netherlands has taken actions that fully or partially address about 80% of the 2015 policy recommendations, displaying a solid engagement with the recommendations and a willingness to transform and future-proof their agricultural production system.
- The Dutch agricultural innovation system remains world-class and is stronger in many ways than it was in 2015. The situation observed in the 2015 review regarding insecure funding and a declining research infrastructure has improved.
- Noteworthy progress has been made in the following areas:
  - A comprehensive bundle of programmes has been put in place to define a vision for agriculture, establish long-term goals and increase policy stability for the involved stakeholders. These include the 2018 circular agriculture vision, the 2018 Dutch Research agenda, the 2019-2030 LNV knowledge and innovation agenda and the mission-driven innovation policy for the *Topsectors* introduced in 2019.
  - Implementation of the CAP for 2023-27 continues to reduce coupled payments and provides increased support for investments in innovation and sustainability.
  - The *Groenpact* initiative has improved integration between education, business and government and helps to address future labour demand. Green education has been integrated into general education and the government continues to provide sufficient funding for institutions and research projects.
  - The Innovation on the Farmyard programme introduced in 2019 encourages individual farmers' adoption of agricultural methods that contribute to biodiversity, sustainability, and mitigation of climate change. More than 10 000 farmers have been supported with knowledge and advice due to this program. The SABE system of training vouchers finances impartial advice on these subjects from an independent registered advisor.
- There is still potential for improvement in some areas, including:
  - The 2015 review pointed to the need for the Top Sector system to pay more attention to public goods. The new "mission driven" approach gives more emphasis on social challenges, but more can be done to ensure that the system is as effective as possible in targeting issues of public importance such as environmental sustainability.
  - The long-term vision for the sector has not sufficiently shaped the decision making of relevant stakeholders in a way that puts the sector on a sustainable path for the future.

1.1. Stocktaking of progress since 2015

The OECD 2015 Report "Innovation, Agricultural Productivity and Sustainability in the Netherlands" (the Innovation Review) examined the conditions in which food and agriculture businesses use innovation to become more productive and environmentally sustainable and provided several recommendations (OECD, 2015[1]) (Box 1.1). This chapter recalls these recommendations and looks at the related actions undertaken in the Netherlands. Overall, it finds that substantial progress has been made with respect to the recommendations of the Innovation Review. The situation faced by the sector has changed since 2015 and further adjustment of the agricultural knowledge and innovation system will be required if it is to be as effective as possible. For example, the Paris Climate Agreement, the ammonia situation, the new CAP reform, the COVID crises and the Russian aggression in Ukraine all occurred subsequent to the 2015 report.

Box 1.1. The 2015 Recommendations for the Netherlands

Four key areas for improvement were identified with respect to the capacity, orientation and approach of the AKIS system:

Improve incentives for private investment including by minimising the transaction costs of compliance to regulations, for registering new products, and improving the architecture of investment support programmes, in particular by revisiting tax incentives and investment support programmes.

Improve capacities and services for innovation including by better anticipating future demand for skills, facilitating labour mobility and on-the-job training, strengthening linkages and breaking institutional boundaries between "green" and general education funding to ensure equal access.

Strengthen agricultural policy incentives to innovation for sustainability and longer-term challenges, by developing a longer-term vision reconciling productivity growth and sustainability; continuing to provide information on current and future opportunities and challenges, increasing further the targeting of CAP rural development programmes towards support for the adoption of innovative practices; improving the capacity of farmers to participate in the agricultural innovation system (farm advisory, producer groups, agri-environmental incentives); and revisit the existing mix of regulation, financial incentives, and innovative market-based mechanisms to improve the preservation of natural resources and foster eco-innovation, i.e. innovation that is less environmentally harmful than relevant alternatives.

Strengthen the long-term performance of the food and agricultural innovation system, by reinforcing the role of the government in shaping the research agenda to improve the consideration of longer-term and public good issues; by including longer-term impacts in policy evaluation; by introducing mechanisms to better reflect societal demand and foster investment in public goods and long terms challenges such as climate change; by identifying new, more stable sources of funding for longer-term challenges; by improving long-term stability in funding, by dedicating some public investment for knowledge infrastructure and institutions, and long-term challenges; by continuing to monitor and evaluate innovation adoption, by including environmentally-friendly practices; and by strengthening the links between agriculture-specific innovation systems and related areas (health, environment).

Source: OECD (2015[1]).

This stocktaking of progress since 2015 sets the stage for the present country review as it allows to consider recent policy actions. At the same time, the 2015 Innovation Review followed a different method than is currently used in PSR country studies. The modern approach is standardised around a broader set of subjects and tools covering productivity, sustainability and resilience. In contrast, the 2015 report, as the name suggests, was focussed on innovation even though it also covered related topics.

Dutch policy makers were asked to respond to a comprehensive survey on the implementation of the 2015 recommendations. This response was complemented with follow-on discussions to establish a clear picture of policy actions taken after 2015. A broader questionnaire covering the full set of issues covered in this current review also provided evidence regarding the implementation of the 2015 recommendations (Box 1.1).

Senior officials from the Ministry of Agriculture, Food and Nature (*Ministerie van Landbouw, Natuur en Voedselkwaliteit* – LNV) have indicated that the findings of the Innovation Review were seriously considered and mostly implemented. While competency for implementing the majority of the 2015 recommendations lies mainly with LNV, some of the recommendations involve other ministries, agencies and the private sector.

Some actions taken since the 2015 Innovation Review that speak to its recommendations are worth highlighting. With respect to the four focus areas of the 2015 review, these are as follows.

1.1.1. Improve incentives for private investment

- Financing gaps have been identified and investment support programmes have been revised. New programmes have been established providing targeted support to young farmers and those farmers looking to transition to sustainable business practices.
- Recent reforms of product market regulations (*Integral Afwegingskader,* IAK) have lowered administrative burden by removing burdensome regulations. The process for the design of new regulations has been adjusted and stakeholders such as SMEs are now consulted at an earlier stage.
- The 2018 SME Action plan (*MKB-actieplan*) provides better support to SMEs and facilitates research and development (R&D) as well as market uptake of innovations.
- The new strategic Evaluation Agenda increases policy stability and predictability. It evaluates the effectiveness and efficiency of policies pursued to achieve policy goals set out by the strategic agenda in a 4–7-year cycle.

1.1.2. Improve capacities and services for innovation

- The *Groenpact* initiative brings education and businesses together to provide training of in-demand skills for the labour market. Green education is now more tightly integrated with the general education system.
- The *Subsidy Module agricultural business advice and education* (SABE) helps producers to access independent farm advisory services on a range of topics including nitrogen management and precision agriculture.
- In 2017, the distinction between general and green education was eliminated, ensuring equal access to funding.

1.1.3. Strengthen agricultural policy incentives to innovation for sustainability and longer-term challenges

- Steps were taken to develop a long-term vision reconciling productivity growth and sustainability and reduce policy uncertainty in 2018, with the launch of the long-term vision for the Netherlands as a world leader in circular agriculture.
- The design of the new CAP 2023-27 improves over past implementations in several ways.
  - Reduced use of coupled payments and direct income payments.
  - Broader consideration of environmental and social objectives and better integration with EU directives.
  - Support for producer and branch organisations, as well as support for the participation of farmers or farmers' organisations in knowledge networks.
  - Focus on young farmers and generational renewal.

1.1.4. Strengthen the long-term performance of the food and agricultural innovation system

- The new strategic evaluation agenda (SEA) lengthens policy cycles and improves evaluations of policies on effectiveness and efficiency with respect to long-term objectives.

- The circular vision for agriculture set out in 2018 helps establish directions for policy that is compatible with environmental and social goals, though more is needed to refine this.
- The 2019-30 LNV Agricultural Knowledge and Innovation Agenda (KIA) translates the circular agriculture vision and guides stakeholder engagement along outlined societal challenges.
- The new Dutch Research Agenda (NWA) introduced in 2018 outlines the research focus areas and objectives. It displays stronger goal setting by the government and includes targeted programmes for long-term challenges such as sustainable production of safe and healthy food.
- In 2019 the government introduced mission-driven innovation policy for the *Topsectors*. To increase the predictability of the policy mix, there is an increasing effort to switch from means and action-oriented to goal-oriented policies.
- Since 2020 the Subsidy Module Agricultural Business Advice and Education (*SABE*) enables farmers to learn about sustainable agriculture through independent advice.
- With the introduction of the National Growth Fund, the Dutch government has dedicated EUR 20 billion between 2021 and 2025 for knowledge development, R&D and innovation across all sectors.
- Co-financing by the government enabled Dutch researchers to participate successfully in EU-funded programmes such as Horizon 2020.

Overall, the Netherlands has taken actions that fully or partially address about 80% of the 2015 policy recommendations, displaying a solid engagement with the recommendations and a willingness to transform and future-proof their agricultural production system. Improvements are noticeable across all four policy areas.

Some of the challenges identified in 2015 still require sustained effort to achieve lasting improvements:

- Administrative burden on start-ups, especially licenses and permits, is an area where the regulatory system still can improve.
- R&D support remains skewed towards tax incentives. While targeted programmes have increased in use that benefit SMEs, tax incentives are still the main support vehicle for R&D.
- The agricultural vision has not motivated the involved stakeholders to deliver on long-term goals. Farmer's protests against plans to reduce ammonia emissions demonstrate that acceptance of the current policy path remains low both in the private sector and within the farming community.
- While substantial success has been achieved through the *Groenpact* initiative, some skill gaps persist. Migrant and seasonal workers remain under-skilled and would benefit from additional training. Moreover, the willingness of farmers to participate in lifelong learning is below the EU average, which can slow progress towards the circular agriculture vision.
- There are still insufficient mechanisms to ensure that private companies' contributions to the system are at the same level as the benefits they draw from it.

1.2. A changing situation between 2015 and 2023 brings new challenges

A lot has happened since the 2015 Innovation Review and not all the 2015 recommendations will sit at the top of the government's priority list. The 2019 court ruling has major implications for ammonia emissions from agriculture. The situation in the Netherlands is highly dynamic as policy responses are developed and refined. The food chain disruptions due to the COVID pandemic, Russia's war on Ukraine and the ensuing shortages of staff, fertilisers, commodities and energy have revealed the food system's vulnerability to external shocks. The mainstreaming of sustainability, climate mitigation and resilience in every policy area, in concert with public demand, private company interest and in conjunction with a broader shift of policy objectives at the EU level, has drawn increased attention to the responsibility of the agricultural sector to

deliver on their share of these objectives. A common thread running through the new reality for the sector is that agriculture policy must better integrate with national priorities and the sector must thrive within its environmental limits.

Multiple programmes were established in 2022 and their design is yet to be finalised. This includes the Agreement on agriculture (*Landbouwakkoord*) based on recommendations by a report of mediator Johan Remkes. The result will later feed into the National Rural Area Programme (NPLG – *Nationaal Programma Landelijk Gebied*). It aims to translate country wide policy objectives down to the local level. The central government and the provinces expect to produce the NPLG which by July 2023. The LBV+ scheme (*LBV plus-regeling*) is a modification of the LBV programme that targets peak loaders for early action. Details of the process and eligibility of farmers for LBV+ is forthcoming as of this writing.

The evidence shows that the Dutch government has taken substantial action to address past shortcomings and build upon the strengths of the innovation system that were identified in the 2015 Innovation Review. At the same time, many of the concerns raised in the 2015 assessment have come to pass and will require more action to address. Most prominent among these are the risk that the *Topsector* approach would pay insufficient attention to public goods issues and the need to establish a long-term plan for the sector that puts it on a sustainable path for the future while increasing policy certainty. For these and other matters, this current PSR Review of the Netherlands makes new recommendations for actions to help put the sector on a productive and resilient transition to a sustainable future.

1.3. Actions taken to implement selected recommendations from the 2015 *OECD Innovation, Agricultural Productivity and Sustainability in the Netherlands*

Each of the four major themes are organised into sub-themes and specific recommendations (Table 1.1). Policy changes act systemically and although specific recommendations fall mostly into one of the outlined key policy areas, they are often relevant for others. While recognising these spill-over effects, to avoid redundancy the recommendations are primarily discussed solely within the context of the most fitting policy area.

Table 1.1. Recommendations made in Innovation, Agricultural Productivity and Sustainability in the Netherlands 2015 and related actions taken

Major theme	Sub-theme	#	2015 Recommendation and actions taken
Improve Further incentives for private investment	Investment in RDI	11	**Recommendation**: Rebalance the policy mix by complementing the current focus on R&D tax credits with competitive, well-designed direct support instruments, e.g. for joint R&D projects with knowledge institutes, and instruments used in the top sectors approach, such as the SME Innovation Stimulation Top sectors (MIT).
			Actions taken: Direct support programmes including the SME Innovation Stimulation Top sectors (MIT) continue to exist and other promising programmes such as the Knowledge and Innovation Covenant (KIC) have been adapted to better suit the needs of SMEs. The National Science Fund makes several specific calls per year in the field of the Research Agenda on Agriculture, Water and Food (KIA LWV). The SME action plan and other programmes that encourage cooperation between research institutions have been put in place. The overall ratio of tax incentives to direct business R&D support has remained stable.
			Result: Important progress but more remains to be done to help SMEs and organisations with less resources to participate in the AKIS 🟡
	Entrepreneurship and investment incentives	22	**Recommendation**: Efforts to minimise administrative costs of compliance and reduce the costs of registering products, and reduce length and simplify procedures, need to continue. Regulators need to keep up pace with innovation (food safety, novel food) and when possible, avoid regulation on processes that hinder future innovation. Focus on the reduction of administrative burdens for corporations and barriers in services and network sectors, and the lowering of legal barriers to entry to strengthen competition.

Major theme	Sub-theme	#	2015 Recommendation and actions taken
			Actions taken: Through the government wide action programme for better regulation and service delivery, the LNV aims to lower the administrative burden. The LNV has improved the process of drafting new rules by involving stakeholders such as agricultural entrepreneurs and branch organisation at an earlier point. Through similar cooperation, bottlenecks in existing regulations have been identified and resolved. Farmers and entrepreneurs can report unnecessary regulatory burdens to the Agroloket.
			Result: Overall, the 2021 OECD Regulatory Policy Outlook finds that in recent years the Netherlands has made some progress on its regulatory environment, in particular with regard to reducing regulatory burdens. 🟡
		23	**Recommendation**: Foster stability and minimise the burden imposed on businesses by frequent changes in the policy mix. Predictability could be improved by linking major policy changes to system evaluation cycles agreed upon in advance (e.g. over five-year periods)."
			Actions taken: The Strategic agenda outlining the long-term vision of the LNV has increased policy stability. The introduction of the strategic evaluation agenda is a notable improvement to increasing policy predictability. However, increasing pressure to introduce stark measures against environmental degradation may are currently putting the predictability of the policy environment under pressure. Goalpost shifting in the past has led to a decrease in trust by important stakeholders.
			Result: The frequency of major revisions of regulations and policies has likely accelerated after the 2019 Court of Auditors ruling with respect to the *Programma Aanpak Stikstof* (PAS) system of nitrogen allocation. This has led to a dynamic policy situation where establishment of new polices, reforms of existing policies, and elimination of policies have taken place in short timeframes. The regulatory framework is frequently revised (Fertiliser and Nitrogen Act, Environment and Planning Act) and a number of new programmes have been put in place since 2018 to reduce livestock numbers and improve environmental performance. 🔴
	Finance	24	**Recommendation**: Identify market failures in credit and land markets to design better targeted policies to facilitate investment and farm transfer. Focus public support to investment in areas where financial markets fail to provide funds. Continue efforts to help the banking sector regain its former strength. Simplify the architecture of credit support programmes to improve access and targeting.
			Actions taken: The former financing instrument was replaced in 2017 by the Guarantee Credit for Agriculture Fund (*Borgstellingskrediet voor de Landbouw* - BL) which increased the maximum loan amount and added additional funding options. Since 2020 young farmers can apply for start-up support through the *Vermogensversterkend Krediet* program. The CAP 2023-27 replaces the current top-up of basic support and with a one-time startup payment support of EUR 25 000. The payment is conditional on farmers having established a sustainability plan. The Environmental Investment Deduction (*milieu-investeringsaftrek* - MIA) and Arbitrary Depreciation of Environmental Investments (*Willekeurige afschrijving voor milieu-investeringen* - Vamil) schemes provide additional opportunities to bridge financing constraints and increase liquidity. A new LNV pilot investment fund for sustainable agriculture that enables farmers to transition to sustainable agriculture: Investeringsfonds Duurzame Landbouw - Nationaal Groenfonds. The new CAP 2023-27 is also in line with the recommendation to provide targeted investment support where the financial market fails to provide funds. It will phase out top-up programmes employed in previous CAPs, instead dedicating the funds to a newly introduced young farmer establishment support grant. In total, EUR 120 million will be available to young farmers.
			Result: Notable progress has been made, but ongoing efforts are necessary 🟡
Improve capacities and services for innovation	Education and skills	19	**Recommendation**: Ensure public funding for education and knowledge institutions to enable them to continue to offer relevant education and training, and participate actively in the agricultural innovation system. In particular, whatever the ministry in charge, public resources for education should be equally distributed on the basis of the number of students in order to enable students to move to areas with attractive employment prospects such as agri-food education.
			Actions taken: In 2017 the government transferred responsibility for green education from to the Ministry of Economic Affairs to the ministry of Education, Culture and Science. Funding for green education is now provided through the general education budget, stabilising funding, and increasing interlinkages with adjacent sectors. The introduction of the *Groenpact* initiative complements the approach with closer ties between public and private stakeholders.
			Result: Actions taken are fully in line with recommendation. 🟢
		20	**Recommendation**: Facilitate discussion between education and knowledge institutions and the industry to identify current and future skills for the development of the sector and the improvement of productivity and sustainability performance. Find innovative ways to improve systems' reactivity to new demand by facilitating further life-long learning and upgrading of skills in the labour force.
			Actions taken: With the introduction of the Groenpact initiative the Netherlands has significantly improved the connection between education and industry.

Major theme	Sub-theme	#	2015 Recommendation and actions taken
			Result: Notable progress has been made, but ongoing efforts are necessary. to prepare farmers for new digital opportunities. Specific areas might need additional support, including trainings for under-skilled migrant workers and the below average willingness to engage in lifelong learning. However, solutions are currently under development. 🟡
		21	**Recommendation**: Continue to develop business management programmes, including for future researchers and farmers, to facilitate the valorisation and adoption of knowledge. Learning how to deal with uncertainty and cope with problems will become an ever more important asset.
			Actions taken: LNV stimulates operational groups in which farmers learn and work together on specific topics and also provides a subsidy to operational groups for a three-year period. The innovation system makes good use out of "operational groups", with more than 300 Operational Groups supported under the RDP EIP-AGRI. The National Centre for Innovative Craftmanship (*CIV Groen*) aids co-operation between entrepreneurs, green MBO educational institutions and the government in the field of practical innovation, the labor market and educational innovation.
			Result: Notable progress has been made, but ongoing efforts are necessary 🟡
	Labour	25	**Recommendation**: Increase the flexibility of employment and migration policy to facilitate labour force moving into areas with strong demand, such as agri-food and nature management.
			Actions taken: Since 2022 the Civic Integration Act aids participation of migrants in Dutch society and the labour market. The responsibility for the integration of newcomers has been shifted to the municipalities to increase language learning and the uptake of work. Work placement and increased languages skills offer opportunities for continued education in the agri-food sector and better skills matching.
			Result: The share of both temporary and direct-employed migrant workers has increased consistently after 2015. Skills imbalances continue to be a problem. 🟡
Strengthen agricultural policy incentives to innovation for sustainability and longer-term challenges	Broad domestic	1	**Recommendation**: Continue to limit the provision of coupled payments to very targeted and temporary measures to improve traceability and sustainability, through innovative investments and tools.
			Actions taken: The Dutch CAP 2023-27 CAP Strategic Plan (CSP), makes maximum use of the opportunities provided in the CAP to tailor spending to country-specific needs. Coupled payments have been eliminated, and direct income payments will reduce in importance over time. CAP spending on AKIS continues to represent a robust share of total spending.
			Result: Actions taken are fully in line with recommendation. 🟢
	Measures encouraging adoption of environmental practices	2	**Recommendation**: Strengthen the ability of agricultural policy to improve the environmental performance of agriculture, by focusing agri-environmental measures to objectives and outcomes rather than on process and meet EU regulation constraints; revisit the balance between regulation and economic incentives in view of fostering environmentally-friendly innovation, building on the analysis of the pros and cons of the Dutch experience in this area, such as the Mineral Accounting System (MINAS).
			Actions taken: In 2021 the Netherlands introduced an "internal project on goal-oriented policy making'', that confirmed the focus on action-oriented processes for most policies. The project identified several bottlenecks to adopting more goal-oriented policies including a lack of appropriate measurements to monitor the results and a stated concern that goal oriented policies might not align with EC standards. The ANLb approach is being expanded from biodiversity to also cover climate and water issues in the CAP 2023-27
			Result: Most policy continues to be action-oriented, but the Netherlands is in advance of many EU countries. Spending on environmental objectives on farmland is high relative to natural areas and increasing, yet outcomes have been better in natural areas. This indicates that the balance between regulation and economic incentives on farmland has not yet been found. 🔴
	Long-term strategy	4	**Recommendation**: Develop a long-term vision reconciling productivity growth and sustainability and reduce policy uncertainty.
			Actions taken: In 2018 the Circular Agriculture vision was introduced which tries to reconcile growth and sustainability through wide-spread adoption of circular agriculture and innovative farming approaches. It plans to position the Netherlands as a global leader in circular agriculture by 2030. A transition fund allocates EUR 24.3 billion until 2030 to achieve government objectives.
			Result: While the vision outlines a desirable long-term future for the sector, more needs to be done for the vision to play a strong role on policy making. Specific goals for farmers and regions are expected in 2023. More needs to be done to set policies to be well within environmental limits to avoid frequent adjustments. 🔴
	Knowledge flows	10	**Recommendation**: Identify and fund areas not covered by public-private partnerships, with specific attention to food safety, sanitary and phyto-sanitary issues, economic analysis, societal issues of no direct interest to the private sector, longer term and more risky issues.

Major theme	Sub-theme	#	2015 Recommendation and actions taken
			Actions taken: Societal issues of no direct interest to the private sector such as welfare of pets, nature conservation, rural area policies, economic analysis and international food security are identified and funded in special national and EU public programmes. Food safety, sanitary and phyto-sanitary issues are part of the Knowledge and Innovation Agenda. For these subjects the contribution of private companies is only 30% instead of the usual 50% co-financing, thus reflecting the major public interest in these issues. The Dutch Research Agenda (NWA) and the National Growth Fund dedicate substantial funding to societal challenges.
			Result: The output of public goods innovations likely needs to accelerate further to meet the challenges facing the agricultural system. 🟡
		14	**Recommendation**: Make use of the opportunity given by the CAP to recognise Producer and Branch Organisations and support the participation of farmers or farmers' organisations in knowledge networks.
			Actions taken: The current CAP includes support both for producer and branch organisations as well as farmer organisations in knowledge networks. In 2019, the Innovation on the Farm initiative was introduced to facilitate adoption of innovative agricultural methods through multiple tools.
			Result: Actions taken are fully in line with recommendation. 🟢
	Information and communication technology	17	**Recommendation**: Maintain a good information base and analytical capacity to monitor progress, evaluate policies and guide farmers' decisions, with specific attention to innovation adoption and environmental practices.
			Actions taken: Additional instruments have been added to an already good system to improve guidance for farmers. The SABE voucher system helps guide decision making by providing farmers with tailored information on environmental practices. Subsidy programmes such as MIA and VAMIL create financial incentives and support for investment in and adoption of innovative, sustainable farming practices.
			Result: The information base has been maintained and new instruments improve the guidance of farmers' decisions for innovation and environmental practices. 🟢
Strengthen the long-term performance of the food and agricultural innovation system	Institutions	3	**Recommendation**: Improve policy co-ordination amongst agricultural, industrial, innovation, education, and regional policies, and policy stability.
			Actions taken: The transfer of responsibility for green education from to the Ministry of Economic Affairs to the MINISTRY of Education, Culture and Science helps improve coordination of education policy across sectors. The implementation of the mission driven knowledge and innovation agenda in 2019 has led to a better policy co-ordination and harmonisation between agricultural, industrial, innovation, education and regional policies. The clear outline and long-term perspective of these long-term issues helps increase policy stability. To avoid overlap the selection process for new projects includes referencing a database to check whether similar projects are being put forward in other departments.
			Result: The increased integration and focus on societal challenges has streamlined policies and improved co-ordination between stakeholders and the government on a national and regional level. 🟢
	Long-term strategy	5	**Recommendation**: Strengthen the role of the government in defining long-term objectives for R&D and innovation, taking into account long-term challenges and societal demand.
			Actions taken: The main mechanisms are the Missions for the top sectors and innovation policy, the agricultural knowledge and innovation agenda, and the Dutch Research Agenda (NWA). In 2019 the government introduced a Mission-driven Innovation Policy for the Topsectors (*Missies voor het topsectoren- en innovatiebeleid*) to the KIA. It sets 25 fundamental societal challenges across all Topsectors, Within the LNV, the *agricultural knowledge and innovation agenda LNV 2019-2030* (KIA-*Kennis- en innovatieagenda*) reaffirms the Dutch commitment to circular agriculture as the leading principle described in the agricultural vision. It specifically tackles three challenges: climate-friendly agriculture, careful use of raw materials, resources and the natural environment and a stronger relationship between agriculture and nature.
			Result: With the implementation of the Missions for the top sectors and innovation policy, the agricultural knowledge and innovation agenda, and the new Dutch Research Agenda the Netherlands has made strong progress in defining the long-term objectives for R&D and innovation. 🟡
		6	**Recommendation**: Explore ways to generate new (breakthrough) ideas to overcome current constraints, for example, through demand-driven mechanisms, including to develop technologies and systems allowing for a better management of natural resources and improved resilience to risks.
			Actions taken: KIA and NWA both include pathways to generate breakthrough innovations which overcome current constraints. They particularly target nonlinear breakthroughs in the areas of future-proofing the agricultural system, strengthening the economic and social position of farmers and finding innovative approaches to the bottlenecks in the way to becoming a circular agricultural system.

Major theme	Sub-theme	#	2015 Recommendation and actions taken
			Result: While the Netherlands has made substantial progress in most policy areas, more remains to be done with regard to environmental and sustainability challenges, especially for water quality and biodiversity. The government's agricultural vision has not been fully internalised by stakeholders such as farmers, businesses and research institutions. Private investment in public good research remains insufficient. 🟡
	Investment in RDI	7	**Recommendation**: Strengthen the stability of R&D funding, by dedicating some public investment for the maintenance of knowledge infrastructure and for issues with a longer term horizon.
			Actions taken: In addition to the clearer vision and research agenda for long-term public good challenges mentioned above, the government has also improved access to funding for these objectives. Substantial funding has been earmarked for public investments into issues with a longer-term horizon. Between 2021 and 2025 the National Growth Fund (Nationaal Groeifonds - NGF) dedicates EUR 20 billion to projects deemed to have the highest potential for structural and durable economic growth. The fund supports knowledge development; and research, development and innovation across all sectors.
			Result: Actions taken are fully in line with recommendation. 🟢
		8	**Recommendation**: Facilitate access to other sources of funding: How could revenues from intellectual property rights (IPRs) be increased? Explore ways to increase IPR revenue or generate additional funding from royalties or levies.
			Actions taken: Each public-private partnership under the umbrella of the KIA is facilitated with a standard consortium agreement, arranging IPR. The Knowledge Transfer Offices of the universities play an important role in increasing IPRs revenues from the knowledge generated. A recent evaluation has been undertaken to come up with recommendations to improve revenue generation from IPR through knowledge transfers offices at universities
			Result: The situation is largely stable, though first steps have been taken for additional action. 🔴
		9	**Recommendation**: Ensure the contribution that business makes to public-private partnerships is commensurate with the benefits they get.
			Actions taken: The Dutch triple helix approach to innovation involving government, private sector and research institutions hinges significantly on the role of the private sector. The approach aims to use public-private partnerships where it can and rely on public financing where it must.
			Result: The growing orientation towards societal challenges has not led to a decrease in private investments in public private partnerships. The private sector benefits from both government co-financing in the Top Sector system as well as R&D tax credits that lower their costs. The effective government share of R&D financing including this tax expenditure is not as transparent as it could be and obscures the level of public support relative to the level of attention paid to public good interests in the research agenda. 🟢
	Performance of the innovation system	12	**Recommendation**: Develop indicators and tools to evaluate the performance of the agricultural innovation systems in general, and innovation policy regularly, taking longer term effects into account, possibly in collaboration with other countries and organisations.
			Actions taken: The Netherlands plans to conduct a review of the effectiveness and efficiency of its innovation policies in the agricultural sector in 2023
			Result: The Netherlands has a strong information system and research capacities to carry out this work, but it remains in early stages. 🔴
	Knowledge flows	15	**Recommendation**: Facilitate the organisation of producers and the industry to enable them to contribute more effectively and efficiently to the agricultural innovation system, including through participation in networks or formulation of demand.
			Actions taken: New developments to improve the position of farmers organisation within the AKIS include the right to access independent farm advisory services on nitrogen management or precision agriculture through the *Subsidy Module agricultural business advice and education* (SABE), meeting points for interpersonal exchange and the interactive digital knowledge sharing platform *Groen Kennisnet*. The Multi-year Mission-driven Innovation Programs (MMIP's) foster collaboration across a wide range of stakeholders, including industry and producers.
			Results: Notable progress has been made, but ongoing efforts are necessary. Organisations that cannot provide co-financing are less able to participate in Top Sector process. 🟡
		16	**Recommendation**: Ensure public co-financing is available for participation in EU programmes and international collaborative efforts.
			Actions taken: Multiple co-financing programmes have been established to participate in EU programmes, including dedicated partnerships between the LNV and WUR, as well as the Encouraging European Regulation (EER) regulation. Support is also dedicated to international co-operation programmes e.g. through CIGAR and the Merian programmes.
			Result: Actions taken are fully in line with recommendation. the Dutch application success rate has been above average for EU programmes like Horizon 2020. 🟢

Major theme	Sub-theme	#	2015 Recommendation and actions taken
	Information and communication technology	18	**Recommendation**: Continue developing information systems, including market intelligence (big data) and research results, as innovation and policy evaluation become more complex and require a wealth of information. In particular, continue to monitor innovation adoption and environmental performance in surveys, in addition to economic performance, to better understand determinants and policy impact. Continue to use and share innovative methods to reduce collection costs and improve farm and firm participation.
			Actions taken: The LNV continues to provide information on innovation adoption for instance through the Innovation adoption monitor of WUR. Reports by WUR and CBS provide detailed information about innovation adoption and environmental performance on the farm level. An abundance of digital data platforms for farmers prevents more efficient and comprehensive data collection. KPIs are being developed for improved assessment of progress in many areas.
			Result: Notable progress has been made, but ongoing efforts are necessary 🟡

Notes: 🟢 Actions fully or mostly align with recommendation and results substantially address the basis of the recommendation.
🟡 Actions mostly align with recommendation and results substantially or somewhat address the basis of the recommendation.
🔴 More actions are needed or results do not yet address the basis of the recommendation.

Source: OECD (2015[1]).

Reference

OECD (2015), *Innovation, Agricultural Productivity and Sustainability in the Netherlands*, OECD Food and Agricultural Reviews, OECD Publishing, Paris, https://doi.org/10.1787/9789264238473-en. [1]

2 Context, drivers and outcomes

The Netherlands is the world's second-largest exporter of agricultural products, and agricultural products represent 17% of Dutch exports. Horticulture, grazing livestock and granivores (pig and poultry) contribute the most to agriculture gross value added. This chapter examines trends in agro-food production, consumption, and trade, as well as the policies that most affect this sector. The main drivers and outcomes are presented, with a focus on the evolutions in productivity, input use, and emissions. Sustainability is higher on the agricultural policy agenda, driven by concerns about ammonia and nutrient emissions, issues with water quality and lack of progress in climate change mitigation. The national CAP Strategic plan (CSP) increases emphasis on innovation and environmental sustainability by transferring funds from Pillar 1 to Pillar 2 and emphasising eco-schemes.

Key messages

- The Netherlands is a major agri-food exporter and re-exporter mostly towards the European Union. Horticultural food and non-food (flowers and plants) products have the largest share of exports.
- Dutch agricultural Total Factor Productivity (TFP) growth has slowed since 2000 after impressive growth in previous decades. Reductions in input use and improvements in labour productivity have been the main contributors to recent TFP gains.
- The proportion of agricultural land under different farming systems have remained relatively stable since 2010. However, the number of farms has almost halved over the last 20 years, with a corresponding increase in average farm and herd sizes.
- Sustainability is higher on the agricultural policy agenda, driven by ammonia and nutrient emissions, issues with water quality and lack of progress in climate change mitigation.
  - A 2019 court ruling on nitrogen deposition on sensitive landscapes has focussed attention on the need to reduce ammonia emissions from farms.
  - After significant progress in reducing agricultural emissions since 1990, progress has stagnated over the last decade. Improved performance early on was mainly due to a decrease in emission intensity of production factors.
  - The share of organic farmland at 4% is low compared to the EU average. Per capita organic food purchases are half of German and a quarter of that of Danish consumers.
- There are about 175 000 regular full-time workers in the primary agricultural sector, about two-thirds of which is farm household labour. Eighty-eight per cent of labour on dairy farms is carried out by the farm household, but only 11% in glasshouse horticulture (which relies more on hired workers).
- Intensive glasshouse systems have become the most profitable farm enterprises. Recent high EU gas prices are expected to negatively impact glasshouse horticulture, which is dependent on gas for heating and energy co-generation.
- The national CAP Strategic plan (CSP) increases emphasis on innovation and environmental sustainability by transferring funds from Pillar 1 to Pillar 2 and emphasising eco-schemes in Pillar 1.

2.1. General context for food and agriculture

The Netherlands is a highly developed and knowledge-intensive economy whose fundamental strengths are a stable political climate, a highly developed financial sector, strategic location, a well-educated and productive labour force and high-quality physical and communications infrastructure. The Netherlands is urbanised and densely populated. Eighty-five per cent of the Dutch population lives in urban areas, the highest share in the OECD. It is the second most densely populated country in the OECD (OECD, 2008[1]).

The Dutch economy has benefited greatly from globalisation, through international trade and investment, access to overseas markets, immigration, and the free exchange of knowledge. The achievements of the "golden age" of the Dutch republic of the 17th century created a strong science, technology and engineering base which has continued to this day (OECD, 2014[2]). At the end of the 19th century, in reaction to the threat of grain imports from the United States, the Netherlands decided to become more competitive by investing in education, research and information services. Since then, a market-oriented philosophy has been an integral part of Dutch agriculture.

Despite its relatively small size and high population density, the Netherlands is an important agricultural producer and exporter. Its mild maritime climate, flat fertile terrain, geographical position and sea, river, road and aviation infrastructure are advantageous for both agricultural production and trade and a few hundred million potential consumers reside within a 500 km radius. Dutch primary agriculture mainly produces plants, flowers, milk, pigs, and vegetables (Eurostat, 2019[3]).

Dutch agricultural policy has focussed on increasing production at lower cost while generating a liveable income for the farmer (Baptist et al., 2019[4]). Over the past decades, Dutch agriculture has experienced remarkable growth and the sector is increasingly high tech and capital intensive. This is reflected in the Netherlands having the highest arable land prices in Europe, estimated at EUR 70 000 per hectare in 2019 (Eurostat, 2021[5]). The transformation of farming into a knowledge-based and capital-intensive activity was part of a broader drive for value enhancement across the food chain.

2.1.1. Share of the agricultural complex in the economy

The agricultural sector plays an important role in the economy. On average, Dutch agriculture occupies relatively more land, generates relatively more value in the economy and is more trade-oriented than in most OECD countries (Table 2.1). Within the primary agricultural sector, horticulture (open and glasshouse), crop and animal production are the most important activities. The contribution of the food and beverage industry to value added is lower than the primary agricultural activities. About 3.2% of the Dutch workforce worked in the agri-food sector (including primary and manufacturing activities) in 2020, almost half the EU average but similar in proportion to its nearby European peers (Belgium, Denmark, and Germany). The sector also represented 17% of exports and 13% of imports.

Extensive agriculture systems (grazing livestock and arable farming), have declined as a percentage of GVA since 1995 (Table 2.2), while intensive systems (glasshouse, open field horticulture, pig and poultry) increased their share. Extensive systems still employ close to half of the agriculture workforce. Glasshouse horticulture represented 79% of the energy use of the agricultural sector, despite covering only 0.6% of the total utilised agricultural area (UAA). The horticultural sector also produces a significant amount of electricity via natural gas-fuelled combined heat and power (CHP) plants. Greenhouse operations use CHP to generate and sell electricity while making use of the residual heat and CO_2 produced.

Table 2.1. Agriculture is more important to the Dutch economy than in other OECD countries

Share of the agricultural sector in the economy in the Netherlands and selected countries(%) by land use, share of gross value added, employment and agri-food trade, 2020[1]

	Agricultural land area[2]	Gross value added[3]					Employment[4]				Agri-food exports [5]	Agri-food imports [5]
		Total: Agriculture, forestry and fishing	Crop and animal production and hunting	Forestry and logging	Fishing and aquaculture	Total: Manufacture of food and beverages	Total: Agriculture, forestry and fishing	Crop and animal production and hunting	Forestry and logging	Total: Manufacture of food and beverages		
Netherlands	**53.89**	**1.77**	**1.71**	**0.02**	**0.04**	**2.40**	**1.75**	**1.71**	**0.00**	**1.51**	**16.80**	**12.60**
Belgium	45.07	0.75	0.72	0.02	0.01	2.08	0.83	0.81	1.79	2.45	12.43	10.75
Denmark	65.5	1.00	0.86	0.07	0.06	1.29	1.93	1.75	0.12	2.12	16.52	12.50
Germany	47.5	0.86	0.78	0.08	0.00	1.52	1.14	1.02	0.11	1.72	6.12	8.50
Ireland	65.5	0.99	0.94	0.01	0.05	2.17	3.57	3.31	0.00	2.45	8.20	11.13

	Agricultural land area[2]	Gross value added[3]					Employment[4]				Agri-food exports [5]	Agri-food imports [5]
		Total: Agriculture, forestry and fishing	Crop and animal production and hunting	Forestry and logging	Fishing and aquaculture	Total: Manufacture of food and beverages	Total: Agriculture, forestry and fishing	Crop and animal production and hunting	Forestry and logging	Total: Manufacture of food and beverages		
EU27[6]	41.03	1.78	1.54	0.20	0.05	2.00	4.03	3.70	0.26	2.31	9.39	7.08
OECD[7]	33.52	1.50	…	….			4.77	….	….	….	13.34	10.34

Notes: "…" means not available.
1. or the latest available year.
2. Share of total land area.
3. Share of total gross value added.
4. Share of employed persons, aged 15 years and over, in total NACE activities.
5. Share of total exports (or imports). The agri-food definition does not include fish and fish products. Agri-food codes in H0: 01, 02, 04 to 24 (excluding 1504, 1603, 1604 and 1605), 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360
6. For EU27, imports, and exports include only extra-EU trade.
7. For OECD, imports and exports include both intra- and extra-OECD trade.
Source: Authors' calculations based on OECD (2022), System of National Accounts and Annual Labour Force Statistics (databases), http://stats.oecd.org/; UN (2022), UN Comtrade database, https://comtrade.un.org/; Eurostat (2022), [nama10_a10], [lfsa_egan2], http://ec.europa.eu/eurostat/data; FAO (2022), FAOSTAT, Land use (database), http://www.fao.org/faostat/en/.

Table 2.2. Intensive agricultural systems have become more important

Share of the agricultural sub-sector in the total agricultural sector by share of gross value added, employment and energy use, 1995-2020

Sub-complexes	Gross value added					Employment					Energy use				
	1995	2005	2010	2015	2020	1995	2005	2010	2015	2020	1995	2005	2010	2015	2019
Arable farming	18.0	17.1	19.6	16.6	15.5	18.0	17.1	18.2	16.0	15.5	9.3	11.3	2.3	3.6	3.1
Outdoor horticulture	8.6	8.0	10.0	9.7	10.4	8.6	8.0	9.9	9.6	9.8	2.9	3.4	3.8	3.7	3.9
Greenhouse horticulture	18.4	22.0	24.4	24.7	23.3	18.4	22.0	19.8	18.2	20.1	52.9	51.7	81.8	77.1	79.1
Grazing livestock	33.6	30.2	24.6	28.5	25.9	33.6	30.2	30.5	35.0	32.4	17.1	17.3	5.4	7.5	7.5
Granivore farming*	18.2	21.3	19.3	18.7	23.4	18.2	21.3	19.5	19.5	20.8	13.9	12.8	4.6	5.8	4.3
Fisheries	3.3	1.3	2.2	1.7	1.5	3.3	1.3	2.0	1.7	1.3	4.0	3.5	2.0	2.3	2.1
Agricultural complex	100.1	99.9	100.0	100.0	100.0	100.1	99.9	100.0	100.0	100.0	100.1	100.0	100.0	100.0	100.0

Note: *Intensive pig and poultry farming systems.
Source: Agrofood portal, WAGENINGEN (University & Research). Accessed August 2022.

2.2. Agricultural trade

The Netherlands is the largest importing country within the European Union and is the second largest exporter of agricultural products in the world (by value), after the United States (USDA, 2021[6]). Exports of agricultural goods (primary unprocessed goods and secondary processed goods) totalled EUR 122.3 billion in 2022 (Jukema, Ramaekers and Berkhout, 2023[7]). Of this, EUR 79.8 billion was domestically produced goods and EUR 45.2 billion in re-exported agricultural goods which originated from other countries. In 2022, an estimated 16.7% of Dutch goods exports were agricultural goods.

The combined horticultural categories (Ornamental and food) generated the biggest share of agricultural export value, totalling USD 31 billion in 2021 (Table 2.3). Food preparations was the second largest category grouping, with exports worth almost USD 25 billion in 2021. The third most exported product is meat, with meat exports in 2021 worth USD 11 billion.

Table 2.3. Horticulture and food preparations make up the biggest share of agricultural export value

Summary: Categories of Dutch Agri-food imports and exports in USD million, 2021

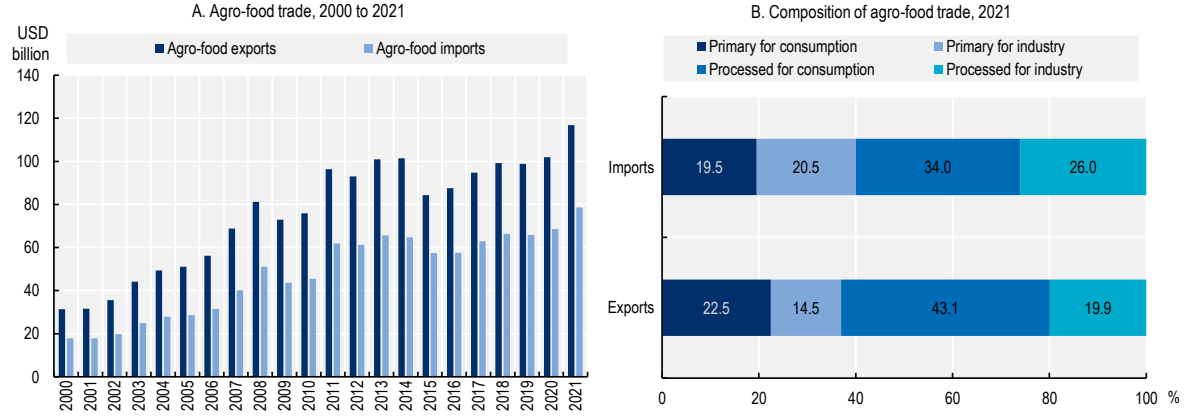
HS code	Product description	Exports (USD millions)	Share in agri-food exports	Imports (USD millions)	Share in agri-food imports	Trade balance	Total trade (X+M)
	Total horticulture	31 147	26.7%	14 862	18.9%	16 285	46 009
	Horticulture non-food	14 040	12.0%	3 122	4.0%	10 919	17 162
06	Live trees and other plants; bulbs, roots, etc.; cut flowers and ornamental foliage	14 040	*12%*	*3 122*	*4%*	*10 919*	*17 162*
	Horticulture food	17 107	14.6%	11 740	14.9%	5 366	28 847
07	Edible vegetables and certain roots and tubers	8 528	7.3%	3 263	4.1%	5 265	11 791
08	Edible fruit and nuts; peel of citrus fruit or melons	8 578	7.3%	8 477	10.8%	101	17 056
	Food preparations	24 718	21.2%	10 068	12.8%	14 650	34 787
18	Cocoa and cocoa preparations	5 736	4.9%	4 665	5.9%	1 071	10 401
19	Preparations of cereals, flour, starch or milk	6 123	5.2%	3 081	3.9%	3 042	9 205
20	Preparations of vegetables, fruit, nuts or other parts of plants	6 376	5.5%	3 315	4.2%	3 060	9 691
21	Miscellaneous edible preparations	6 484	5.5%	3 671	4.7%	2 813	10 155
02	Meat and edible meat offal	11 051	9.5%	4 642	5.9%	6 409	15 693
04	Dairy produce, eggs	9 840	8%	4 486	5.7%	5 354	14 325
	Dairy products	8579	7%	4024	5%	4555	12604
0402	Milk and cream products	1 673	1.4%	833	1.1%	840	2 506
0406	Cheese and curd	4 582	3.9%	1 525	1.9%	3 057	6 107
	Other dairy products[2]	2 325	2.0%	1 666	2.1%	659	3 991
	Eggs[3]	1 260	1.1%	462	0.6%	799	1 722
15	Animal or vegetable fats and oils and their cleavage products; prepared edible fats; animal or vegetable waxes	8 341	7.1%	10 033	12.8%	-1 692	18 375
10	Cereals	575	0.5%	4 060	5.2%	-3 486	4 635
	Total agri-food trade[1]	116 864		78 665		38 199	195 529

1. Agri-food trade (Not including fish and fish products) codes in H0: 01 to 24, 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360.
2. Other dairy products include products in H04: 0403,0404 and 0405..
3. Birds' eggs include products in H04:0407 and 0408.
Source: Authors' calculations based on UN (2022), UN Comtrade (database), http://comtrade.un.org/ (accessed July 2022).

Trends show an almost linear rise in agri-food imports (and associated exports since 2000), with some elevated levels between the 2011-14 period reflecting a global food price spike (Figure 2.1, Panel A). Imports as a proportion of agri-food exports have remained relatively stable over the last decade. A significant share is related to foreign raw materials as the port of Rotterdam is a major European entry point for many products. This includes tropical products like coffee, tea, and cocoa, but also flowers, plants, animal feed and other raw materials. This can be seen in the higher proportion of exports (43.1%) processed for consumption than imports (34%) (Figure 2.1, Panel B).

Figure 2.1. Dutch agri-food exports have increased by almost 400% since 2000

Development of Dutch agro-food trade, 2000-2021



Note: The definition of agri-food trade does not include fish and fish products. Agri-food codes in H0: 01, 02, 04 to 24 (excluding 1504, 1603, 1604 and 1605), 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360.
Source: UN (2022), UN Comtrade (database), http://comtrade.un.org/ (accessed August 2022).

2.2.1. Main trading partners

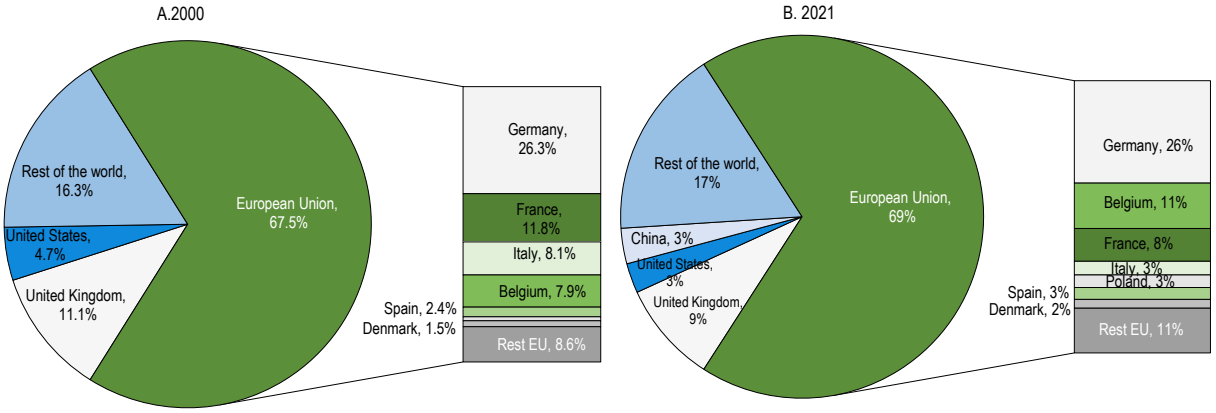
In 2021, most agri-food exports were within the European Union. The top four destinations are Germany (26%), Belgium (11%), the United Kingdom (9%) and France (8%). These shares have been stable since at least 2000 (Figure 2.2).

Even though total agricultural output as expressed in farmgate prices has increased by 11% since 2016 to EUR 30.3 billion in 2021, the Dutch share of total EU agricultural production decreased slightly from 7.2% to 6.8%. France is the European Union's largest agricultural producer with EUR 81.2 billion (18.4%), along with Germany at EUR 59.4 billion (13.4%). Local peers like Denmark or Belgium contribute around EUR 11.5 billion (2.6%) and EUR 9.8 billion (2.2%) respectively (Eurostat).

Natural capacity limits and high labour costs may limit future growth rates relative to other EU producers. Spain and Denmark have strengthened their positions in the vegetable and pig meat markets, respectively while Germany and France are also taking some dairy market share from the Netherlands (Berkhout et al., 2021[8]).

Figure 2.2. Over 65% of Dutch agri-food exports go to the European Union

Dutch agri-food exports as share of destination countries, 2000 and 2021

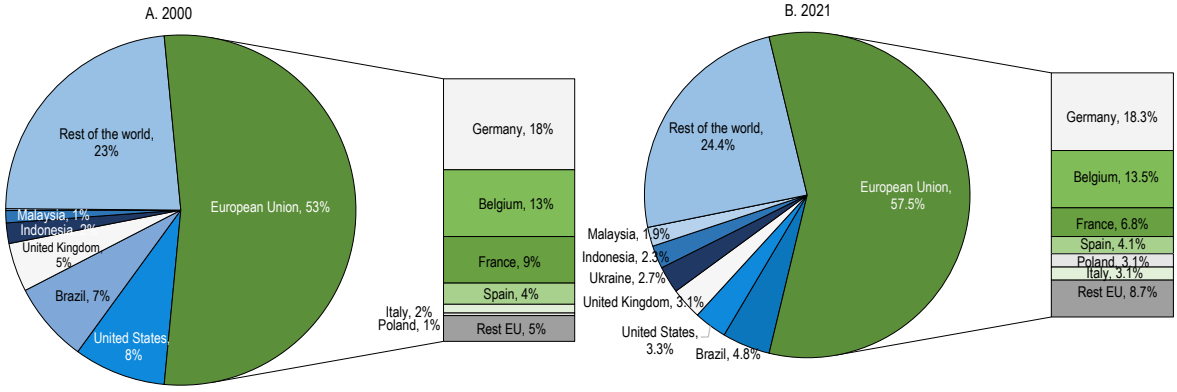


Source: Authors' calculations based on UN (2022), UN Comtrade (database), http://comtrade.un.org/ [accessed July 2022].

The European Union was the source of 58% of agri-food imports in 2021 (Figure 2.3). As was the case for exports, neighbouring countries Germany (18%), Belgium (14%), and France (7%) are the top trading partners. Imports from Brazil have dropped from 7% to 5% since 2000 and imports from the United States have dropped from 8% in 2000 to 3% in 2021, indicating a more regional market orientation.

Figure 2.3. Over 50% of Dutch agri-food imports come from the European Union

Dutch agri-food imports as share of source countries, 2000 and 2021



Source: Authors' calculations based on UN (2022), UN Comtrade (database), http://comtrade.un.org/ [accessed July 2022].

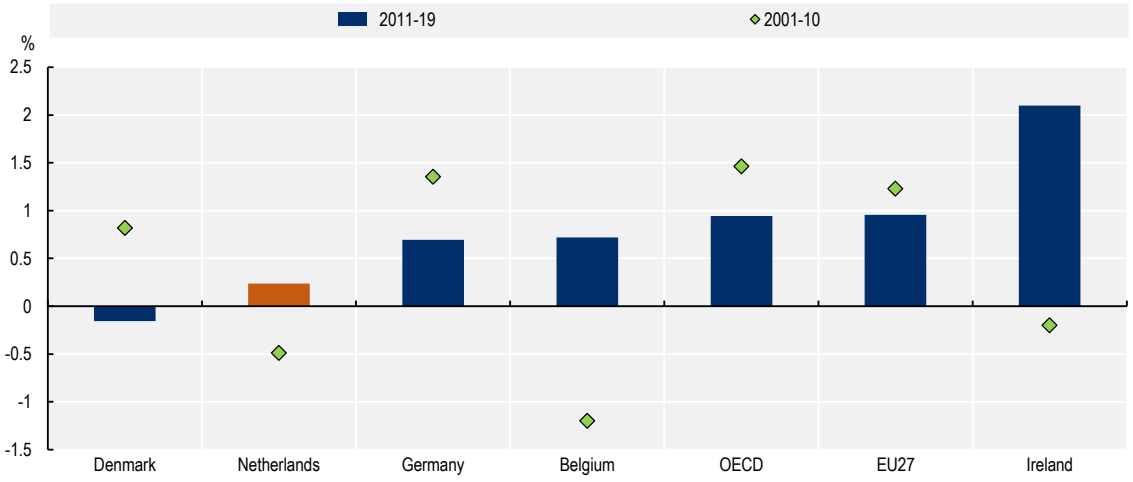
2.3. Trends in agricultural productivity

2.3.1. Total Factor Productivity growth has slowed down over the long term

Total Factor Productivity (TFP)[1] growth in agriculture from 2011-19 was 0.24%, below the EU and OECD averages (Figure 2.4). However, between 1960 and 2000 TFP grew at significantly higher rates than the EU27 and its level of productivity is high by OECD standards.

Figure 2.4. Since 2001 the Netherlands had low growth in agricultural total factor productivity compared with its regional peers

Average annual growth in agricultural total factor productivity in the Netherlands and selected countries, 2001-2010 and 2011-2019

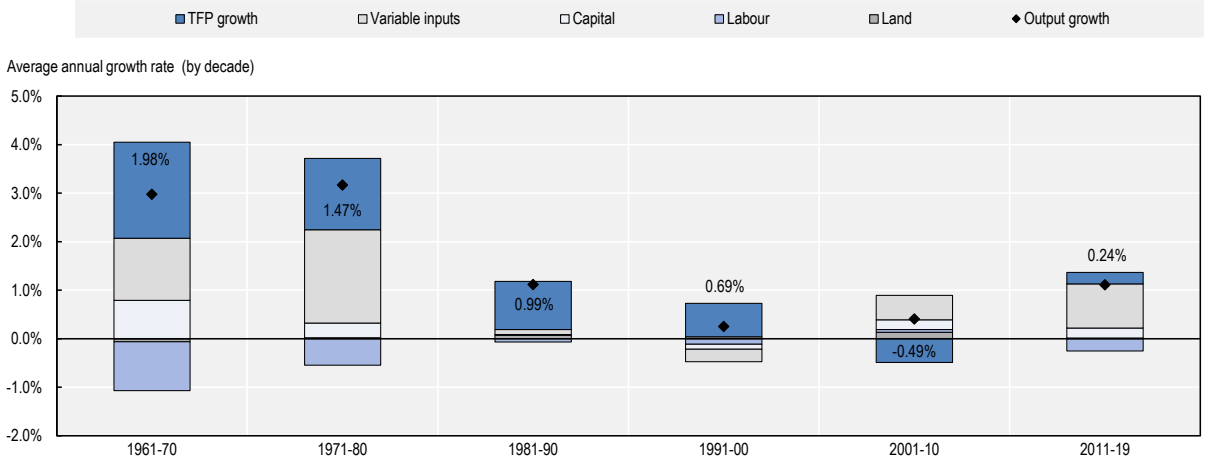


Output growth in the 1960s and 1970s was driven by a combination of strong TFP growth and industry expansion (as seen by high rates of input growth). In the 1980s and 1990s TFP became the main growth engine as input use stabilised, likely due to environmental constraints. In the last two decades TFP growth has been weak and growth in inputs has once again become the main driver. The growth in inputs in the last decade is likely due in part to the elimination of dairy quotas and a larger dairy herd (Figure 2.5). Larger average farm size and intensification are likely to have contributed to the rise in TFP as well as higher input use (Kimura and Sauer, 2015[9]).

Exit of labour from agricultural has been a major contributor to TFP growth up to the 1980s and since 2011. Labour productivity in agriculture has increased more than any other partial factor productivity in the last six decades (Figure 2.6).

Figure 2.5. The output growth rate is slowing, with a smaller role for TFP growth recently

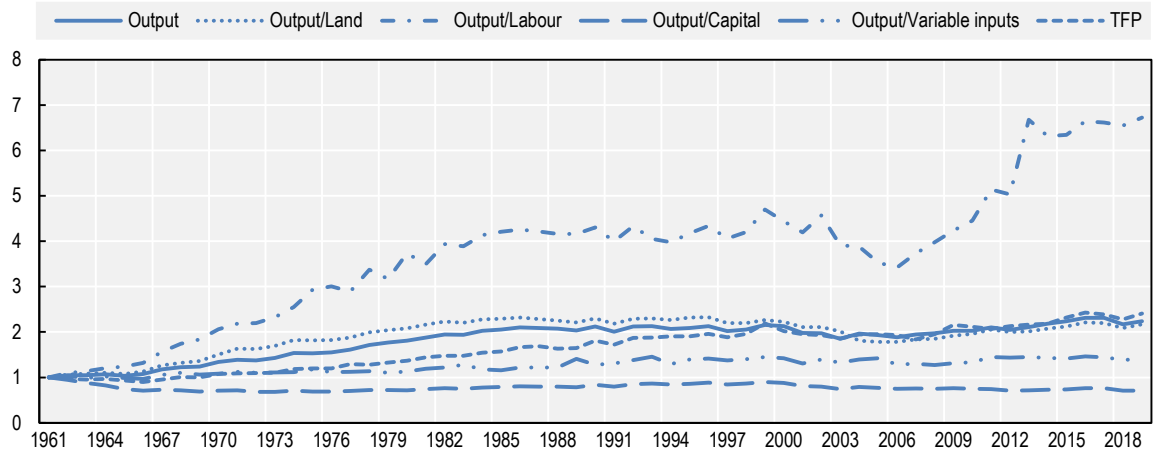
Decomposition of Dutch output growth in average annual growth rate (by decade), 1961-2019



Source: Authors calculations based on USDA ERS (2021), International Agricultural Productivity database.

Figure 2.6. Increased labour productivity is driving overall productivity growth

Development of production, partial and total factor productivity in % growth per year, 1961-2019



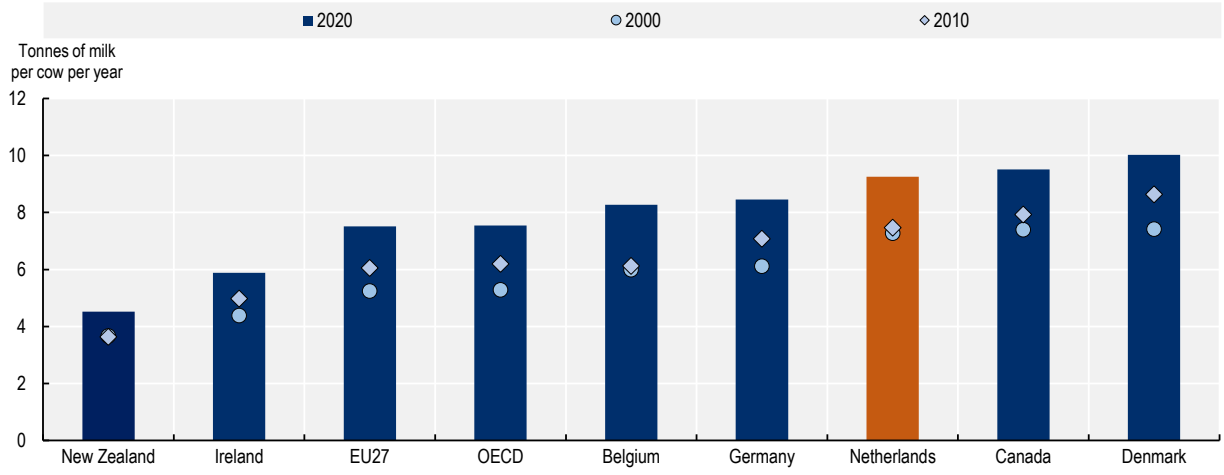
Note: All values are normalised with 1961 being the base year.
Source: Authors calculations based on USDA ERS (2021), International Agricultural Productivity database.

2.3.2. High milk and cereal yields

Highly intensive dairy production is the dominant agricultural land use in the Netherlands. The country has more than four times the average European livestock density and is the European Union's fourth-largest milk producer by volume (EC, 2020[10]). Milk yields are higher than both the EU and OECD averages and amongst the highest in the world (Figure 2.7).

Figure 2.7. Milk yields in the Netherlands are above EU and OECD average

Milk yields in tonnes of milk per cow per year, 2000-2020

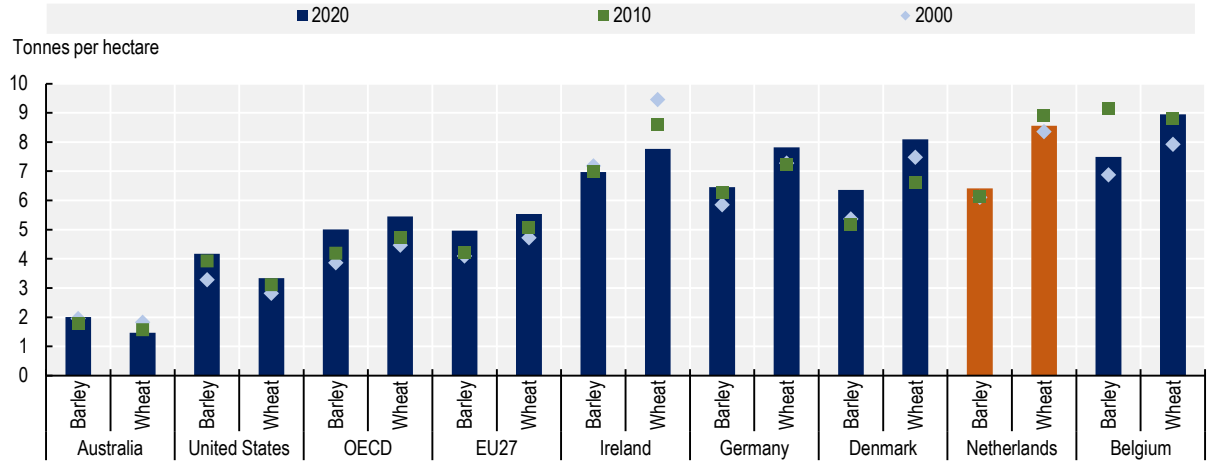


Note: The removal of EU milk quota restrictions has had a possible impact on EU Member States milk yield increases since 2015.
Source: FAO (2022), FAOSTAT, Livestock primary(database) [Yield: Milk, whole fresh cow].

Cereal yields (wheat and barley) are higher than both the OECD and EU averages and among the highest in the world (Figure 2.8), reflecting the high level of intensity of their cereal systems. However arable farms have declined in importance as a share of total agricultural GVA since 1995.

Figure 2.8. Dutch cereal yields are among the highest in the world

Cereal yields in tonnes per hectare, 2000-2020



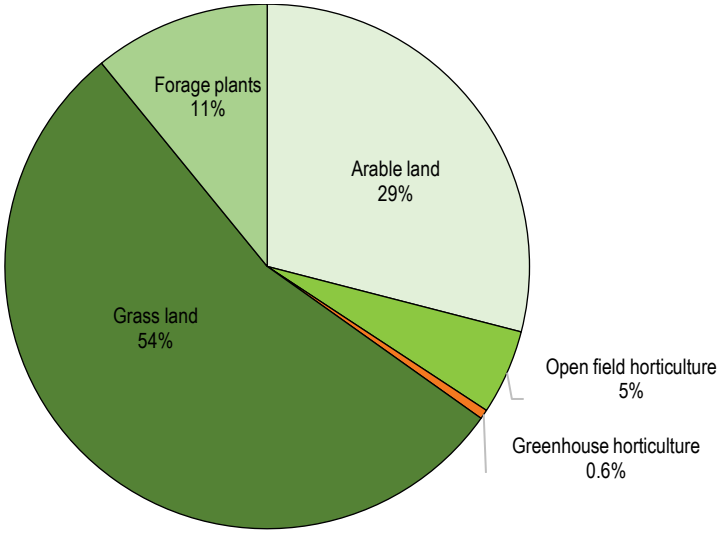
Note: Countries are ranked according to 2020 wheat levels.
Source: FAO (2022), Crops [Yields] database, Accessed August 2022.

2.4. Evolution of agricultural production

In 2020 total area of utilisable agricultural land (UAA) was 1.81 million hectares, down from 1.98 million hectares in 2000 as urbanisation, recreation and nature cover more land (WUR, 2022[11]). Over the past 20 years, the average decrease is around 0.4% per year (WUR, 2022[12]). Of the total UAA 54% is permanent, temporary or natural grassland, 11% is used for green fodder crops, 29% for other arable production, 5% for open-field horticulture and 0.6% for greenhouse horticulture (Figure 2.9).

Figure 2.9. Grassland accounts for over 50% of agricultural land use

Shares of utilised agricultural area, 2021



Source: CBS Statistics Netherlands. Accessed August 2022.

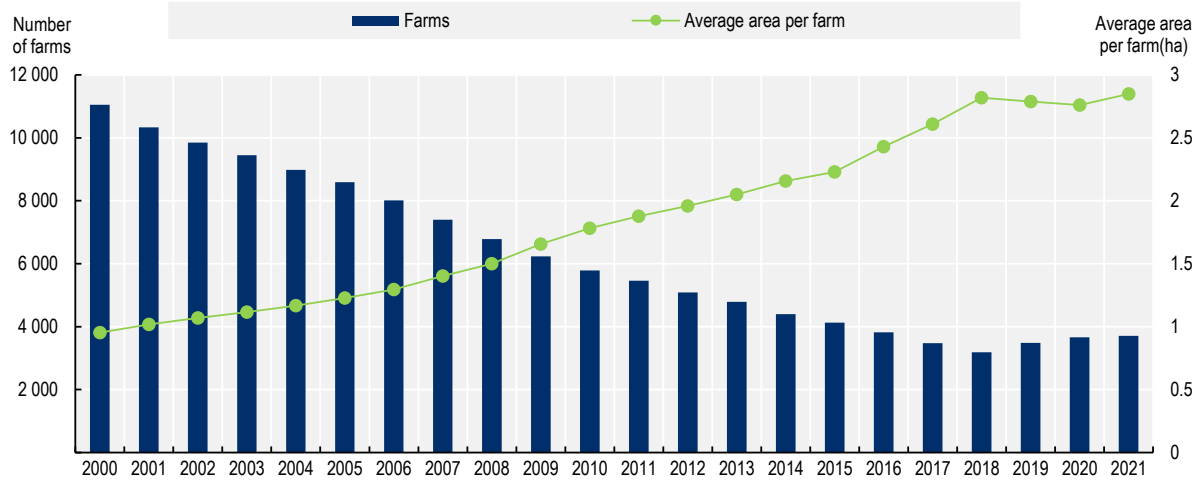
The dairy sector is the largest sub-sector in terms of added value and employment (based on domestic raw materials). In 1970 there were more than 110 000 dairy farms with about 25 dairy cows on each. In 2019 this number had decreased to about 16 300 while the average herd size had increased to 96 cows (USDA, 2021[6]). Milk production until 2015 had been limited by the EU milk quota regime, yet manure quotas continue to restrain dairy expansion. Co-operatives collect and process most raw milk, more than half of which is processed into cheese.

Friesland-Campina is the fifth largest dairy company in the world, employed 22 000 workers and had a turnover of EUR 11.5 billion in 2021 (FrieslandCampina, 2022[13]). In 2019, the gross production value of the dairy sector was EUR 5.5 billion, which was over 19% of the total agricultural production value of the Netherlands. Two-thirds of milk production is exported, mainly to other EU countries. The Netherlands is the fifth largest exporter of dairy products in the world (ZuivelNL, 2020[14]) with an export value of EUR 7.9 billion (Kok et al., 2020[15]).

Due to its economic importance and unique characteristics, horticulture has its own Top Sector status under the national *Topsectorenbeleid* (policy on leading sectors), while the rest of agriculture and food is under a separate top sector (see Chapter 4 for more on the Top Sector system). Open field horticulture has grown to cover 95 000 hectares in 2021. Between 1980 and 2021 glasshouse horticulture area increased from 8 800 hectares to 10 600 hectares. Like the dairy sector, glasshouse horticulture farms have undergone significant structural change over the last two decades, with a significant reduction in the number of farms and a steady increase in farm size (Figure 2.10).

Figure 2.10. Fewer, larger greenhouse horticulture farms

Number and average area in hectares of greenhouse horticulture farms, 2000-2021



Source: CBS-Landbouwtelling, bewerking Wageningen Economic Research.

In 2022, the export value for floriculture (flower bulbs, nursery products, cut flowers and indoor plants) was estimated to be EUR 11.5 billion or 9.4% of all agri-food exports (Jukema, Ramaekers and Berkhout, 2023[7]). There are 1 000 companies that produce cut flowers, 590 companies that grow house plants and 250 companies that grow garden plants (CBS, 2021[16]). There were an estimated 110 companies involved in the propagation material for cut flowers under glass. In addition, there are also companies that are engaged in growing crops from seed. Despite their small size (in hectares), these companies are very active internationally.

In 2021, about 5 550 companies grew fruit or vegetables using open ground production systems, down from about 8 640 in 2000, and 1 250 companies that grow vegetables under glass compared to around

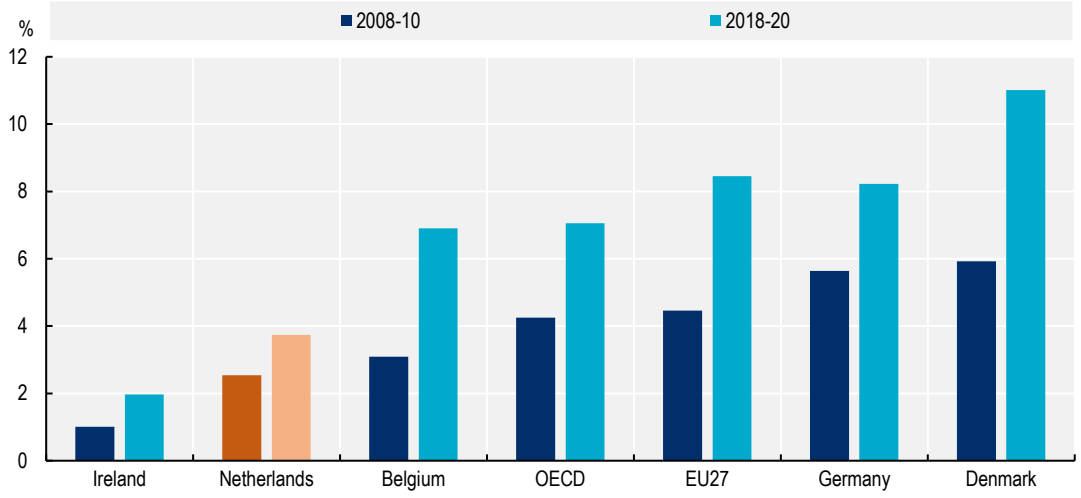
3 430 in 2000. The number of companies growing fruit under glass has declined from 140 to 115 companies (CBS, 2021[16]).

Brussels sprouts, white and red cabbage, broccoli, and asparagus are important crops (measured in hectares) in open field vegetable cultivation. Apples and pears are the most important fruit crops. In greenhouses, the three most important crops are tomatoes, peppers, and cucumbers. Some varieties of fruit are also grown under glass, including blackberries, and raspberries. Strawberries have become the fourth largest greenhouse product, where these were traditionally cultivated on open ground. Organic greenhouse cultivation of vegetables is less than 1% of the total area. For open-ground vegetables, the percentage of organic area is much higher at 12%.

The share of land in organic agriculture has increased over the last decade but is still less than half of the EU average and less than neighboring countries (Figure 2.11). Current plans are for a doubling of organic area by 2030, a substantial improvement but below the Farm to Fork objective of 25%.

Figure 2.11. The share of organic agriculture in the Netherlands is much lower than in its regional peers

Organic area as a share of agricultural land in the Netherlands and its regional peers, 2008-2010 and 2018-2020



Source: FAO (2022) [Land Indicators], Accessed August 2022.

2.5. Farm consolidation and increased average farm size

The number of farms in the Netherlands has been on a downward trend in recent decades. There were 53 000 farms in 2020, 27% less than in 2010 and 46% less than 2000 (Table 2.4). Glasshouse horticulture and mushrooms saw the most significant consolidation since 2000, down by 68%. Grass-based livestock (sheep and cattle) farm numbers reduced by 47%, while arable farms reduced by a relatively modest 24%.

The reduction in farm numbers was more pronounced among smaller farms. A total of 52% of the farms under 5 hectares disappeared between 2005 and 2016, while farms between 5 hectares and 29.9 hectares declined by 34%. The number of larger farms (50 hectares or over) increased by 12% over the same period, which highlights the increasing concentration of the Dutch farming sector. In 2016, small farms (less than 5 hectares) made up only 20% of farms, a smaller share than in many other EU countries. The decrease in farm numbers has been matched with higher average farm sizes, up by 35% between 2005 and 2016, from 24 hectares to 32 hectares.

Table 2.4. Since 2000 the number of farms decreased by almost 50%

Changes in structural characteristics of farm holdings ('000) and farm type, 2000, 2010 and 2020

Indicator	2000	2010	2020	% change 2000-2020	% change 2010-2020
Area farmland (1 000 ha)	1975	1872	1814	-8%	-3%
Total number of holdings[3]	97	72	53	-46%	-27%
Arable farms	15	12	11	-24%	-7%
Glasshouse horticulture and mushroom holdings	9	5	3	-68%	-39%
Dairy farms	23	17	15	-38%	-17%
Other grassland based livestock farms	20	19	10	-50%	-47%
Intensive livestock farms	12	8	5	-55%	-31%
Mixed farms	8	4	3	-61%	-22%

Note: numbers rounded up to the nearest full number.
Source:https://www.clo.nl/indicatoren/nl2119-agrarisch-grondgebruik-;
https://opendata.cbs.nl/#/CBS/nl/dataset/81302ned/table?searchKeywords=aje;
https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232&sectorID=2243&themaID=2286&indicatorID=3049.

Overall numbers of livestock between 2000 and 2020 have been relatively stable. However, overall pig numbers have declined slightly in 2020 versus 2000 (Table 2.5). The decrease in the number of pigs is partly due to the Ammonia Livestock Farming Action Plan (*Actieplan Ammoniak Veehouderij*) and the Pig Farming Remediation Subsidy Scheme (Subsidieregeling sanering varkenshouderijen-SRV) (Chapter 3). The number of dairy goats has increased almost fourfold in the last two decades to 633 000 in 2021, while sheep numbers have dropped by almost a third since 2000. Dairy cow numbers have risen 6% since 2000, which is partially linked to the removal of EU milk quotas in 2015. Veal calf and broiler chicken numbers have increased significantly over the last decade.[2]

Table 2.5. Livestock numbers have been relatively stable since 2000

Number of farm animals in thousands, 2000-2020

Number of animals, 1 000 head	2000	2010	2020	2010-20 difference (%)	2000-20 difference (%)
Cattle, total	4 069	3 975	3 838	-3.5%	-5.7%
Dairy and calf cows (> = 2 years)	1 504	1 479	1 593	7.7%	5.9%
Young cattle for dairy farming	1 325	1 239	935	-24.5%	-29.4%
Young cattle for meat production	275	197	166	-15.7%	-39.6%
Veal calves	783	928	1 071	15.5%	36.9%
Other cows and bulls	182	133	72	-45.7%	-60.5%
Other grazing animals	1 601	1 625	1 613	-0.7%	0.8%
Sheep	1 305	1 130	890	-21.2%	-31.7%
Goats	179	353	633	79.3%	254.3%
Horses and ponies	117	143	90	-36.6%	-23.1%
Pigs, total	13 118	12 255	11 950	-2.5%	-8.9%
Piglets	5 102	5 124	5 414	5.7%	6.1%
Fattening pigs	6 505	5 904	5 446	-7.8%	-16.3%
Chickens, total	104 015	101 248	101 863	0.6%	-2.1%
Laying hens	32 573	35 310	31 999	-9.4%	-1.8%
Broiler chickens	50 937	44 748	49 229	10.0%	-3.4%

Source: CBS Agricultural CensusKey subsectors of primary production.

2.6. Employment

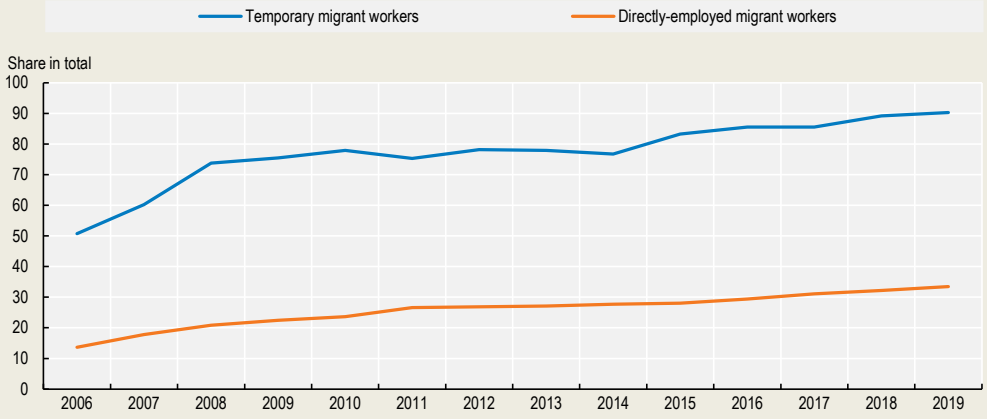
During peak periods in 2019, the Dutch agricultural workforce reached 329 000, of which 176 000 were full time workers and 153 000 were temporary or seasonal workers (van Hulle and Grotenhuis, 2020[17]). Almost half of the employment is related to greenhouse horticulture and dairy farms. During peak periods, large numbers of people may be working, but only for short periods (Box 2.1).

Box 2.1. Migrant workers in Dutch agriculture

The Dutch agricultural and horticultural sectors have increasingly become dependent on migrant labourers, the large majority of which come from Central and Eastern EU countries (particularly Poland, Bulgaria, and Romania). In recent years, the share of migrant workers in the total number of directly employed and temporary agricultural workers increased significantly (Figure 2.12). Between 2006 and 2019, the number of directly employed migrants in agriculture more than doubled to 58 000 people, a share of 33.5%. The importance of foreign labour is even more pronounced among temporary agricultural workers. Their number more than doubled between 2006 and 2019, reaching 107 000 foreign workers a share of 90% of all temporarily employed agricultural workers (compared to 51% in 2006). The majority of those temporary migrant workers are involved in the labour-intensive horticultural sector, particularly during the planting and harvesting seasons.

Figure 2.12. Migrant workers have become increasingly important for the agricultural sector

Share of temporary and directly-employed migrant workers among total agricultural workers, 2006-2019



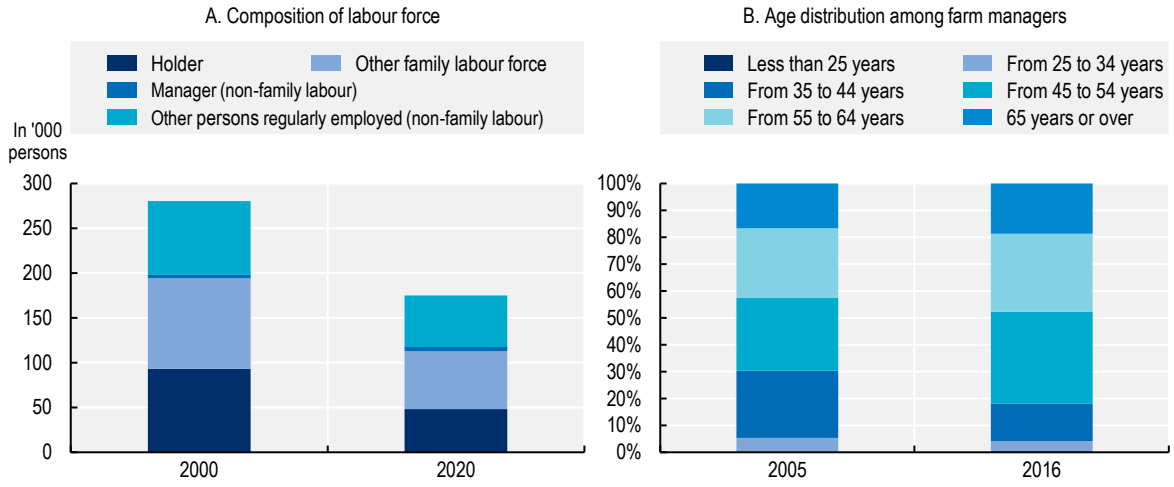
Note: Numbers on migrant workers are estimated, based on CBS microdata. The share of agency-employed migrants workers refers to migrants' share among all agency-employed workers in Dutch agriculture. Similar, the share of directly employed migrants refers to migrants' share among all directly-employed workers in Dutch agriculture.
Source: Heyma et al. (2020[18]), De economische waarde van arbeidsmigranten uit Midden- en Oost-Europa voor Nederland, (CBS, 2020[19]).

The Netherlands Labour Authority (NLA) listed agriculture as one of the sectors at highest risk for unfair work. Migrant workers face a high risk of exploitation, low incomes, and excessively long workdays. The COVID-19 crisis has highlighted those shortcomings, as migrants could not respect social distancing, had to stay in overcrowded accommodations or lost work, together with housing and health insurance. In addition, their access to training possibilities is low.

Source: Siegmann, Quaedvlieg and Williams (2020[20]).

The agricultural workforce has declined significantly since 2000 and the average working age is higher than that of the general workforce (Figure 2.13) (Eurostat, 2017[21]). In 2016, only 4.1% of farm holders were under the age of 35, compared to 5.3% in 2005. The proportion of farmers older than 65 years increased from 16.6% to 18.7% in that time.

Figure 2.13. Since 2000 the agricultural workforce has shrunk and aged



Source: Eurostat (2021), https://ec.europa.eu/eurostat/databrowser/view/EF_M_FARMLEG__custom_3271728/default/table?lang=en.

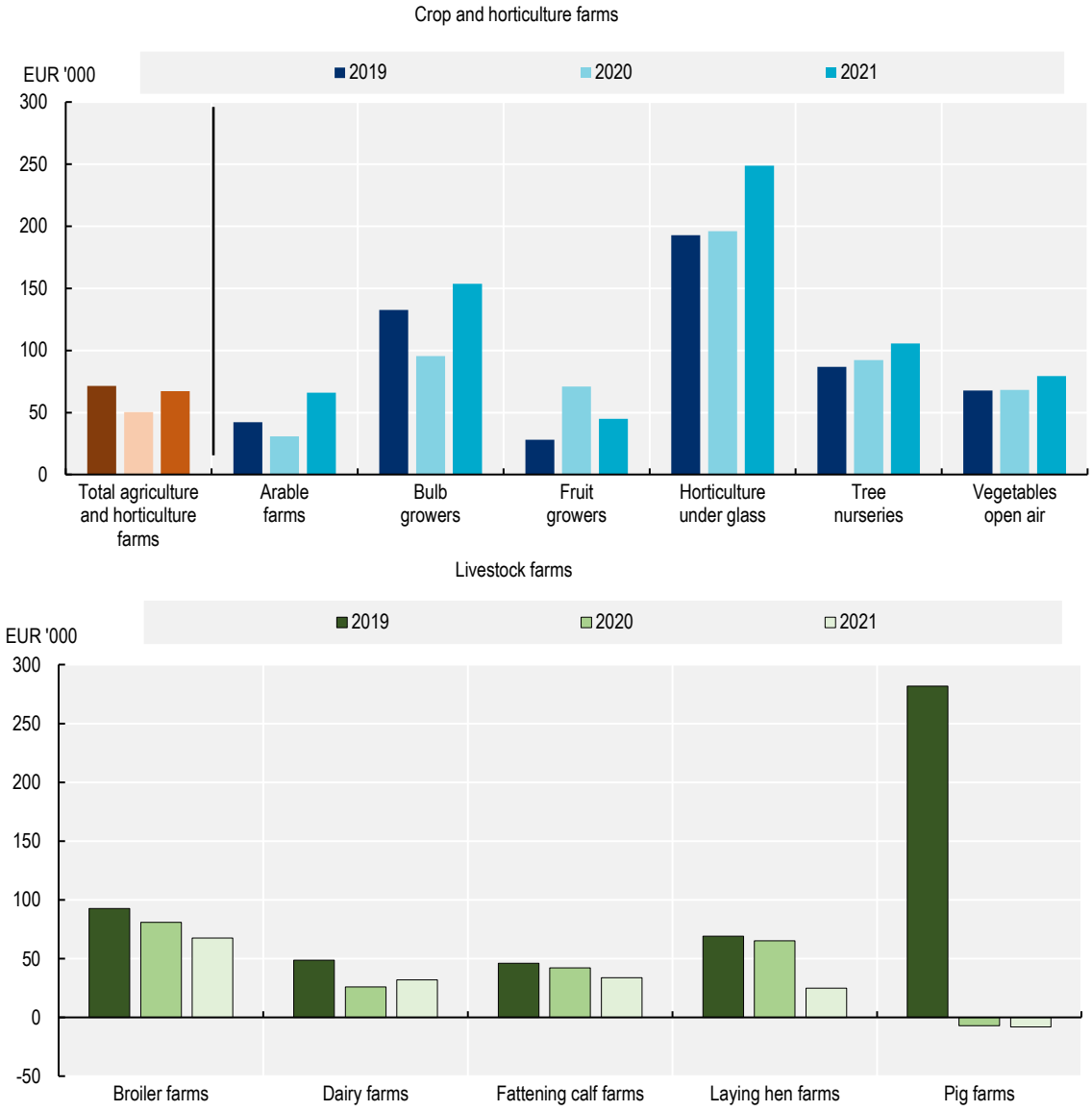
2.6.1. Farm incomes

Between 2001 and 2020 accounting profits per unpaid Annual Working Unit (AWU) increased by more than 60%.[3] The average profit per AWU was EUR 50 300 in 2020, one of the highest within the European Union (WUR, 2021[22]). However, there are wide differences in profits per AWU depending on the type of farming system.

The profits per AWU on livestock farms have been stable to declining in recent years (Figure 2.14). The exception is for pig farms which originally benefited greatly in 2019 from high world pig meat prices due to the impact of African Swine Fever (ASF).[4] Since 2019 international pig prices have slumped leading to negative profitability in 2020 and 2021. Intensive horticultural producers have highest profits per AWU (Figure 2.14).

Figure 2.14. In recent years, accounting profit per AWU has been stable to declining

Accounting profits per unpaid AWU by farm type, 2019-2021



Source: WUR (2022[23]), Estimation 2021 update: large differences between vegetable and animal farm types, https://www.agrofoodportal.com/SectorResultaat.aspx?themaID=2272&indicatorID=2046&subpubID=2232&sectorID=2243.

2.7. The Dutch domestic food market and dietary trends

In 2020, consumers spent about EUR 44 billion on food and non-alcoholic beverages, about 13% of all expenditure. This is slightly less than the EU average of 15%.[5] The share of food and non-alcoholic beverages in expenditure has stayed consistent over the last decade. This includes consumer spending in retail trade (including supermarkets, specialty stores, markets and internet shops and non-food shops) and direct sales. Online grocery deliveries, at 4% of the total, is modest relative to all retail spending (FSIN, 2021[24]). Between 2013 and 2020, the share of expenditure on sustainable food that is produced with stricter environmental, animal or social welfare regulations than legally required, increased from 3% in 2009 to 19% in 2021 (Berkhout, Van Der Meulen and Ramaekers, 2022[25]).

Overall meat consumption dropped from 79.1 kg per capita in 2009 to 75.9 kg in 2020, still above the EU average of 69.8 kg per capita (Dagevos et al., 2022[26]; European Commission, 2021[27]).In 2020 2.6% of Dutch adults reported eating fish but no meat, 1.7% reported being vegetarian and 0.4% reported eating a fully plant-based diet. Over 35% ate less meat than in previous years or stopped eating meat completely.[6] Milk consumption has also declined in recent years: between 2010 and 2021 national per person consumption dropped from 87 kg to 76 kg.[7]

The Dutch Government introduced a national protein strategy (*nationale eiwitstrategie*) to increase the share of protein consumed from plant sources. In 2017, the private sector through the Food Valley, launched the Protein Community in co-operation with the provinces of Gelderland, Overijssel and Oost NL, as a public-private partnership to develop and market plant-based protein sources.

The main channels of distribution of food to Dutch consumers are retail and food service. Retail includes traditional supermarkets and small retail outlets. Supermarkets are the most important sales channel for food, although this share is slowly declining in favor of the food service. The market share of the main supermarket chains has been relatively constant since 2013 (Table 2.6).

Table 2.6. Supermarkets remain the most important distribution channel for food

Key figures of main retailers, 2013 and 2021

Company	Store	2013 Market share (%)	2021 Market share (%)
Ahold	Albert Heijn (AH)	34.0	35
Jumbo Supermarkten	Jumbo Groep	20.1	21
Lidl Nederland	Lidl	9.0	11
Aldi Nederland	Aldi	7.4	5
Sperwer Groep	PLUS	5.8	7

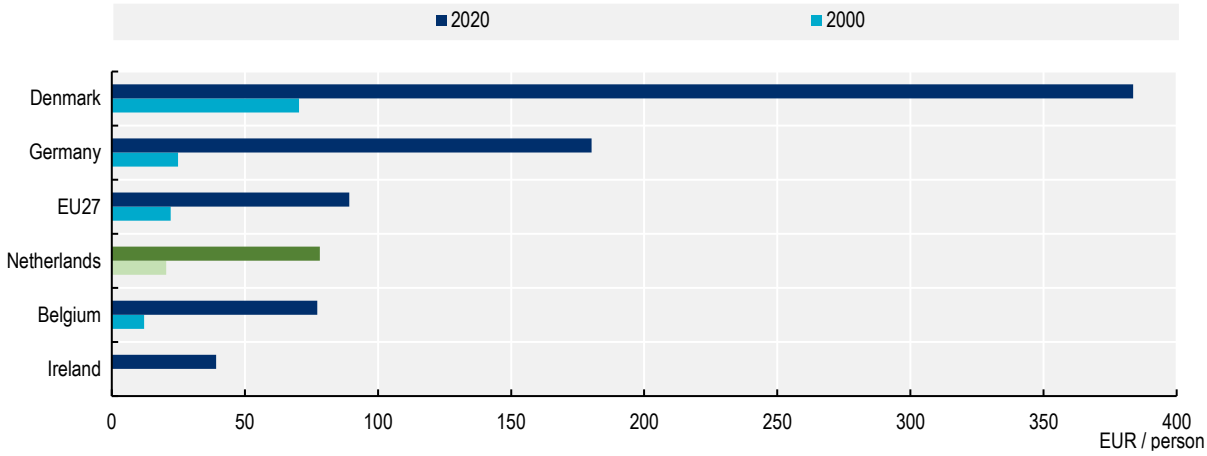
2.7.1. Organic market (production and consumption)

Dutch organic production is largely driven by demand in Germany and the Nordic countries, which absorb 80% of exports of organic products. The value of exports of organic products is estimated to be USD 1.6 billion. This includes organic products produced in the Netherlands such as potatoes, vegetables, eggs, cheese, and meat and imported organic products that are re-exported. Within the European Union, the Netherlands is the largest importer of organic products from third countries, though domestic demand is relatively low. In 2019 Dutch consumers spent EUR 71 per capita on organic food while Danish and Austrian consumers spent respectively EUR 344 and EUR 215 (FIBL, 2021[28]) (Figure 2.15). In practice most Dutch consumers are not prepared to pay a price premium for sustainable or organic products (Van Galen et al, 2021[29]). In 2021, Dutch overall food prices were below the EU average and those of neighbouring countries (Denmark, Belgium, and Germany).

Organic farmers expect to offset the revenue loss from lower yields with higher prices achieved for their products. While Dutch demand for organic products has grown in recent years, overall demand is still low. First experiences in other European market have indicated that inflation takes a toll on organic sales in particular as consumers try to save money on everyday expenditures. Increasing supply for instance through higher subsidies without addressing the demand lag leads to a disbalanced, unsustainable market structure. The Netherlands released an Organic Action Plan at the end of 2022 with an objective to increase market demand and production as well as strengthen knowledge and innovation (Chapter 3).

Figure 2.15. Organic food consumption in the Netherlands is below EU average

Organic food consumption in euros per capita in the Netherlands and peer countries, 2000 and 2020



Note: EU27 simple average.
Source: FiBL survey based on national data sources, data from certifiers, Eurostat. Accessed August 2022.

2.8. Policy context

The Netherlands is a decentralised unitary state. The Netherlands has twelve provinces that form the link between the municipalities and the national government. Provinces carry out national as well as regional policies. The provinces are responsible for construction of infrastructure, supervision of municipalities, regional water management boards and environmental compliance, the regional economy, fostering well-being and culture, and play a strong role in nature preservation (more on this in Chapter 3).

Provinces fund their own projects related to sustainable agriculture outside of the CAP. While small provinces such as Drenthe, Flevoland, and Zeeland have limited budgets, larger provinces like Gelderland and Noord-Brabant are able to establish relatively large-scale programmes.

There are a number of soil types, climatic conditions and farming systems in the various provinces. As part of the Dutch national CAP strategic planning process, a study was conducted to examine the relevance of creating regional or local policy within the CAP framework (Smit, 2020[30]). The study assesses whether regional differences in the Netherlands are relevant for an effective CSP and if so, to which extent, and how the CSP should include regional differences. It found that the CSP should allow for tailor-made regulations on a regional level to tackle specific problems by containing contain options that reflect regional differences.

2.8.1. EU policy framework

As an EU Member, Dutch agricultural producers operate in a policy setting shaped by European regulations, of which the Common Agricultural Policy (CAP) is the most important. Successive CAP reforms have reduced border protection and the importance of domestic market interventions.

For the 2014-20 period, the Netherlands received around EUR 6 billion from the CAP budget. The budget available for direct payments amounted to around EUR 5.2 billion and for rural development around EUR 0.8 billion. The Dutch share of CAP funding is relatively small compared to other countries with similar value added in the agricultural sector (European Parliament, 2022[31]). This is a consequence of the relative size of the horticulture sector, which is not eligible for CAP subsidies but represents a large share of the Dutch agricultural system.

The current CAP has been extended for the years 2021 and 2022. Starting in 2023 new rural development measures be established under the CAP 2023-27.[8] The CAP Strategic Plan (CSP) was approved in December 2022 and will be phased in during 2023 as final agreement was reached too late for it to be fully implemented as of 1 January 2023.

The Netherlands' total CAP budget for 2023-27 is EUR 4.8 billion. Of this, EUR 2.8 million is allocated to direct income support and market organisation under Pillar 1, while EUR 2 billion is directed at Rural Development Programs under Pillar 2. Pillar 2 financing is made up of an EU contribution of EUR 365 million, EUR 809 million in transfers from Pillar 1 funding and EUR 789 million cost-sharing from provinces, central government and water management bodies. EU funding is mainly provided through the European agricultural guarantee fund (EAGF) and the European agricultural fund for rural development (EAFRD) (Table 2.7)

Table 2.7. Direct support is the largest part of total CAP funding: Eco-schemes and ANLb are important environmental measures

Structure and budget of the Netherland's CAP Strategic Plan 2023-27

Component	Measures	Description	Budget (EUR million)
Direct payments	Basic income support	Direct support to active farmers, subject to enhanced conditionality	1 693
	Redistributive payment	Complementary direct payment based on farm size (hectares) subject to thresholds with a higher basic premium for the first 60 hectares; aims to benefit small and middle-sized farms	298
	Young farmers and horticulturists	Supports young farmers receive with start-up subsidies; Young farmers can receive additional funding for investments	23
	Eco-schemes	Compensates farmers for applying their choice of 26 eco-activities; applies entry criteria and a point system with regional weighing factors	964
	Coupled support	Payments for the production of a specific crop or for the maintenance of a specific type of livestock. The Netherlands does not apply coupled income support	0
Sectoral programmes	Continuation of sectoral interventions already in place for fruits and vegetables (payments to producers' organisations) and apiculture		433
Total Pillar 1			3 411
Pillar 2: Rural development programmes			
Area based co-operation	ANLb	Supports the management of nature reserves and habitats through agricultural collectives	560
	LEADER	Supports local actions groups (LAG) to draw up local development strategies (LOS) for rural development; increased focus on sustainability	68
Nitrogen, peatland and Natura 2000 co-operation		Supports farmers to establish management programs for transitional buffer zones around nitrogen sensitive Natura 2000 areas or peatland restoration	397
Set-up aid for young farmers		Supports young farmers receive start-up support to acquire land or a business	75
Productive investments young farmers		Supports young farmers to invest in farm modernisations which drive productivity and business revenue	34
Productive Investments		Supports investments aimed at farm modernisations that increase productivity and profitability, provided the investments also drives transformation towards circular agriculture	85
Non-productive investments		Farmers can receive subsidies for investments into non-productive farm improvements that target an increase in biodiversity, improved water quality or climate mitigation	244
Knowledge and innovation	Knowledge dissemination and innovation	Farmers can receive advice on their current business situation and draw up a business plan or attend trainings tailored to sustainability and management needs	43
	Cooperation for chains,	Supports entrepreneurial partnerships of operational groups within the	101

Component	Measures	Description	Budget (EUR million)
	sectors, more sustainable food, CAP pilots and innovation EIP	EIP network	
Weather insurance		Compensates farmers for a share of their insurance premium paid against damages through extreme weather	88
Total Pillar 2			1 796
Total Pillar 1 and 2			5 207

Note: The amount for rural development programmes includes EUR 365 million from the European Agricultural Fund for Rural Development (EAFRD), EUR 809 million of Pillar 1 transfers and EUR 789 million of co-financing from Dutch provinces, central government and water boards.
Source: LNV (2022), "NL - Nederlands Nationaal Strategisch Plan GLB 2023-2027".

Dutch CAP implementation has previously focused on supporting innovation, increasing productivity, and cutting costs. The CAP 2023-27 arrives in the context of a Dutch agricultural sector facing a large-scale transformation to address challenges of nature restoration, water and climate, and many farmers have to adapt new farming practices while preserving their competitiveness. The CSP has to strike a balance between ensuring that environmental objectives are met with ensuring a long-term perspective for the sector and must complement significant national spending to support the agriculture transition.

The CSP is managed by the Ministry of Agriculture, Nature and Food Quality (*Ministerie van Landbouw, Natuur en Voedselkwaliteit* – LNV). Provinces and regional water management boards, along with the Ministry for Infrastructure and Water management (*Minister van Infrastructuur en Waterstaat* – I&W) have been involved in developing the CSP. A midterm review is planned for 2025 to evaluate the efficacy of the CSP and make adjustments if necessary.

Under EU terminology, the *CAP green architecture* refers to the policy mix of enhanced conditionalities and voluntary eco-schemes under Pillar 1 and the Environment and Climate measures under Pillar 2 that are the main tools to ensure environmental sustainability in the new CAP. The Netherlands describes this framework as the *green-blue architecture* (*groenblauwe architectuur- GBA*). This terminology, along with the involvement of the I&W signals the importance the government places on water issues for the Dutch agricultural sector.

Member States tailor their CAP plans to their specific circumstances and needs. The CSP details their priorities, challenges and intended interventions and support programmes. This is done based on an analysis of their specific strengths, weaknesses, opportunities, and threats (SWOT analysis). The Dutch SWOT analysis finds biodiversity, climate and water quality to be the main challenges. Specific needs are to tackle nitrogen deposition on sensitive nature, restore of waterways, improve landscape diversity, mitigate GHG emissions and promote climate resilience. On top of this, generational renewal is a longstanding challenge for all countries in Europe.

Members States can transfer money from Pillar 1 to Rural Development interventions under Pillar 2 to adjust the CAP budget to better fit their individual needs. Under the 2014-20 CAP, around 8% of Pillar 1 funds were transferred to Pillar 2. The 2023-27 CAP increases that transfer to 15% and to 30% by 2027. This is the maximum amount within CAP rules to eco-schemes and environmental and sustainability interventions. Transfers to Pillar 2 do not affect eco-scheme funding, which will be held constant at EUR 152 million. The transfer of funds to Pillar 2 results in a smaller share of support provided as direct payments. While still around one-third of the budget, the share of direct payments is less than many other Member States and below that of past CAPs.

Additional funding for Rural Development projects under Pillar 2 is primarily directed at sustainability interventions, most notably EUR 397 million for the Nitrogen and Natura 2000 programme and EUR 560 million for the ANLb programme. These interventions are implemented by farm collectives,

whereby farmer organisations, sometimes in co-operation with civil society organisation, work on the issues within their area. The Netherlands has been a leader in the European Union in exploring collective action approaches (Chapter 3 has more on ANLb and the collective approach). EUR 360 million is dedicated for sustainable productive and non-productive investments in modernisation or environmental improvements.

Pillar 1

Under the basic income support scheme, farmers can receive subsidies based on hectares of eligible land, provided they meet certain conditions. Basic income support for farmers will be reduced from EUR 387 million in 2023 to EUR 290 million by 2028. To support the development of small and medium sized farms, the first 40 eligible hectares on a farm receive additional funding.

All farmers in the European Union must meet certain Statutory Management Requirements (SMR) which are legal obligations as well as additional Good Agricultural and Environmental Conditions (GAEC). Compliance with SMRs and GAECs apply to the basic income support, eco-schemes and the Agricultural Nature and Landscape Management Program (*Agrarisch Natuur- en Landschapsbeheer* – ANLb). The requirements for buffer strips, crop rotation, and unproductive land (GAEC 4,7 and 8) have been tightened, and there is a new requirement for buffer strips around dry ditches (GAEC 10). The Netherlands is making use of the option to postpone the implementation of stricter conditions on crop rotation and unproductive land until 2024 to mitigate the disruptions in global food supply caused by the Russian invasion of Ukraine.

The Netherlands is one of only five EU Member States introducing a multidimensional eco-scheme. Instead of giving farmers flat rate payments through multiple singular eco-schemes, all interventions are bundled into a single program. Farmers can earn points by participating in their choice of 24 eco-activities. These include measures such as introducing nitrogen-fixing crops, wet cultivation, or introducing buffer strips along arable land. Depending on the number of points, they earn a sustainability ranking and receive the corresponding payout between EUR 60 and EUR 200.

The SWOT analysis found that the biggest obstacles to young farmers are the high entry barriers caused by high land prices. To address this, the basic income support for young farmers under Pillar 1 will be replaced by multiple programmes under Pillar 2 that are designed to support farmers in the early phase of their business. Young farmers receive start-up support to acquire land or a business and additional support for investments to modernise the business and increase sustainability.

Pillar 2: Rural development programme

The Netherlands has introduced multiple area-based interventions that aim to move from farm-level interventions such as conditionalities and eco-schemes to community level action. Most importantly, the new CAP will expand the 2016 Agricultural Nature and Landscape Management Program (*Agrarisch Natuur- en Landschapsbeheer* – ANLb). Funding will increase from EUR 80 million in 2020 to EUR 120 million over the next CAP period. Farmers are encouraged to design collective action plans that tackle the unique challenges of their agricultural area regarding nitrogen depositions, soil, air, and biodiversity. More emphasis is placed on climate adaptation and building resilience to weather extremes.

A second collective approach is the EU LEADER programme. Municipalities, local businesses, organisation or individuals from the region organise in local actions groups (LAG) to draw up local development strategies (LOS) that are then supported through CAP funds. The LEADER is a long-running programme. In the past, the programme focused on rural development whereas in the new CSP it will increasingly emphasise sustainability projects around climate, biodiversity and the environment. To this end, funding will be expanded: while the Netherlands will continue to dedicate the minimum required 5% of Pillar 2 funding to LEADER, the increased transfers to Pillar 2 translates to a greater budget of around EUR 67 million for the entire CAP period.

A new development of the 2023-27 CAP is the prioritisation of peatland restoration and Natura 2000 protection. EUR 397 million are dedicated for schemes that allow farmers to introduce management plans that either raise water levels in peatlands or establish transition zones around nitrogen sensitive Natura 2000 areas which reduce nitrogen deposition in these critical zones. Farmers can be compensated for investments in drainage systems necessary to raise the water levels as well as the loss of yields through raised water levels and more extensive production.

Support is available to productive or non-productive investments. Productive investments aim at farm modernisation to increase productivity and profitability of the business while non-productive investments target increased biodiversity, improved water quality or climate mitigation. EUR 85 million is available for productive investments, with support available to reimburse farmers for up to 65% of investment costs, provided that these also help the transition towards circular agriculture. Funding for non-productive investments is around EUR 244 million.

Two schemes specifically target innovation and knowledge. The *knowledge dissemination and information* programme will allow farmers to receive advice on their current business situation and draw up a business plan or attend trainings on management methods. The programme is backed with EUR 43 million and will be deployed through the existing SABE voucher system.

EUR 101 million is dedicated to strengthening innovation in agriculture through co-operation for chains, sectors, more sustainable food, CAP pilots and the European Innovation Partnership (EIP). The programme provides subsidies to entrepreneurial partnerships which aim to develop and implement innovations in various key areas such as organic farming, animal welfare, green-blue architecture, or digitisation. Partnerships can be structured around an area, production chain, sector or other forms of cooperation that include at least one farmer and relate to CAP objectives. These operational groups (OG) are connected to the EIP network which further facilitates knowledges amongst farmers. Currently, around 40 operational groups with 15 000 farmers operate in the Netherlands.

Weather insurance is intended to contribute to climate change adaptation. Farmers can be reimbursed for a maximum of 64% of the insurance premium. An objective is to increase farmers' participation by 10% per year, from around 2 600 currently to 4 400 participants by 2027.

The Netherlands is currently far from the EU ambitions for organic production as expressed in the Farm to Fork strategy. The CAP 2023-27 aims to increase organic area from the current 3.8% to 6% by 2027, based on a separate SWOT analysis of the organic sector (Koopmans et al., 2021[32]). The new CSP provides greater incentive for organic production, primarily through higher premiums paid in the eco-schemes. Farmers transitioning to organic agricultural or other nature-inclusive practices will automatically receive the highest tier payment of EUR 200 per hectare. (de Wit and Koopmans, 2021[33]). Under the new CAP organic farms will no longer be exempted from applying GAECs (excluding GAEC 7, crop rotation). Despite this new requirement, the new CAP will likely have positive income effects for organic farmers,

2.9. Conclusions

The general picture of the agriculture and food sector is one of ongoing consolidation that reduces the number of farms while average farm size increases. The sector is shaped by its trade orientation to emphasise cost efficiency and has become one of the most productive agriculture sectors in Europe and the world. Trade has expanded fourfold in the past 20 years and the Netherlands is the second largest agricultural exporter in the world, in part due to its role as a major trading hub for Europe. The importance of the greenhouse and horticulture sector as a share of agricultural production value is unique in Europe. The horticulture sector operates on a different model than does the rest of Dutch agriculture; it uses relatively little land, receives a small amount of support from agricultural policy and is exposed to different risks than other forms of production.

Productivity growth has been a main driver of long term output growth. Trends in productivity are driven by the exit of labour from the sector (a common phenomenon in the OECD area), environmental limits and production quotas that influence capital spending, and structural changes in the sector such as economies of scale. Recent low productivity growth is concerning as it coincides with lower output growth. Environmental limits will make TFP growth an important factor for the future prospects of the sector.

Farm income as defined by accounting profits per unpaid Annual Working Unit (AWU) has grown strongly and is among the highest in the European Union, but it has increased only slightly in recent years. This is in part due to external factors such as the COVID-19 pandemic and the cyclical nature of pig markets.

Domestic consumption trends have shown a modest reduction in livestock-based products, though consumption of these is still above the EU average. Organic production is relatively small and dominated by exports. Domestic consumption of organic products is low compared with regional peers and the domestic market has not been able to support a large price premium for organic products.

Agricultural support policies are important, and the CAP is a major feature of the policy landscape, but the current structure of the sector is not dependant on support and the emphasis has been to use public funds for broader objectives and to support the agricultural knowledge and innovation system. The CSP emphasises sustainability objectives and provide good incentives for farmers to take action to improve the environmental performance of their farms. Over time, the importance of direct payments to farmers will continue to decline, though these will still be the largest CAP expenditure for the foreseeable future.

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Notes

[1] TFP is the ratio of an aggregate of the quantities of goods and services produced (outputs) to an aggregate of all the factors used to produce them (inputs) (Bureau and Antón, 2022[34]).

[2] The Netherlands imports a significant amount of veal calves from other EU Member States.

[3] Unpaid work is carried out at agricultural businesses by entrepreneurs and the members of their families. An Annual Working Unit is equivalent to a worker working 2 000 hours or more. Accounting profits per AWU can be used as a proxy for farm income for participating family members, which is difficult to observe directly.

[4] See https://food.ec.europa.eu/animals/animal-diseases/diseases-and-control-measures/african-swine-fever_en.

[5] See https://ec.europa.eu/eurostat/databrowser/view/NAMA_10_CO3_P3__custom_107542/bookmark/table?lang=en&bookmarkId=0a42eb21-a6f0-4f23-9556-58656ac77be3.

[6] See https://www.cbs.nl/nl-nl/longread/rapportages/2021/klimaatverandering-en-energietransitie-opvattingen-en-gedrag-van-nederlanders-in-2020/6-vleesconsumptie.

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3 Environmental sustainability

This chapter presents the status and trends in environmental quality in the Netherlands with respect to biodiversity, the effects of excess nutrients on the environment, water quality and climate change. It provides a timeline of environmental policy development and considers the current policy landscape with respect to environmental sustainability. Long-term trends generally follow a pattern of substantial improvement in the 1990s tapering off to slow or backward progress in the most recent decade. Agricultural emissions of nutrients and pesticides are an important factor in most cases where water bodies have failed to reach good status. The agricultural sector is currently not on track to meet its 2030 GHG emissions reductions commitments and biodiversity trends are worse on agricultural lands than on other land types. A court ruling on nitrogen deposition on sensitive landscapes accelerated action to address longstanding issues. Substantial spending to reduce related emissions most strongly affects dairy producers and relies on collaboration with regional governments in an “area-based approach”.

Key messages

- Long term trends in environmental indicators generally follow a pattern of substantial improvement in the 1990s tapering off to slow or backward progress in the most recent decade. The growing dairy herd starting in 2013 coincides with higher nutrient and GHG emissions.
  - Nutrient surpluses have reduced substantially over past decades but are still not at a sustainable level. Agricultural emissions of nutrients and pesticides are an important factor in most water bodies that have failed to reach good status according to the Water Framework Directive (WFD). Current plans will improve the situation but the 2027 objectives of the WFD will be missed.
  - The agricultural sector is currently not on track to meet its 2030 GHG emissions reductions commitments, though planned actions to reduce ammonia emissions are likely to also lead to lower GHG emissions.
  - Trends in biodiversity on agricultural lands are worse than that of other land types. The farmland bird index has continued to decline despite substantial spending to recover these species.
- The increasing emphasis on environmental sustainability in agricultural policy has not progressed quickly enough to resolve longstanding water quality and biodiversity challenges stemming from nutrient emissions.
- A court ruling on nitrogen deposition on sensitive landscapes accelerated action to address longstanding issues. Substantial spending to reduce related emissions by buying-out farm operations most strongly affects dairy producers and relies on collaboration with regional governments in an “area-based approach”.
- The Netherlands plans to use the maximum flexibility in the New CAP to transfer funds from income payments to Pillar 2 and eco-schemes. The use of payments to collective groups of farms for agri-environmental and climate measures is expected to increase.

This chapter covers policies and progress with respect to the environmental sustainability of the agricultural sector, including climate change, biodiversity and natural resource use (air, water, soils). It provides an assessment of the current status and trends and a description of the relevant policies in place. Section 3.1 starts with a general description of the government vision for sustainability that motivates policy design, the major environmental pressures and a short history of policy responses to them. Section 3.2 covers the overall environmental policy setting currently in place. Next, the chapter moves issue-by-issue in greater detail, with sub-sections on biodiversity (Section 3.3), manure and nutrients (Section 3.4), climate change (Section 3.5) and water (Section 3.6).

3.1. The Dutch policy perspective on agriculture and the environment

3.1.1. Government vision of circular agriculture and the nitrogen issue

The most recent vision statement of the Ministry of Agriculture, Nature and Food Quality was published in 2018 and puts environmental issues high on the agenda. It states, *"The Netherlands faces serious social and ecological challenges. We need to prevent depletion of soil, freshwater supplies and raw materials, halt the decline in biodiversity and fulfil our commitments to the Paris climate agreement."*[1] The solution, the vision proposes, is circular agriculture. *"This means closing cycles of minerals and other resources as far as possible, strengthening our focus on biodiversity and respecting the Earth's natural limits, preventing waste and ensuring farmers are paid a fair price for their hard work."*

The government vision statement of 2018 sees an agricultural model based on reducing raw inputs instead of costs, focused on circular principles that should bring about an ecologically and economically viable sector, in balance with nature and appreciated by society. In this circular system, arable farming, livestock farming and horticulture use raw materials from each other's supply chains along with waste flows from the food industry (LNV, 2018[1]).

In most parts of the Netherlands, the most pressing environmental issues for the sector have to do with the undesirable effects of emissions of nutrients (nitrogen and phosphorous) and greenhouse gasses (e.g. methane or CO_2) to air, water, soils and to biodiversity. Matching the quantity of nutrients entering the ecosystem to its absorptive capacity will likely be the most relevant aspect of circular thinking in agriculture.

The OECD PSR framework is designed to help policy makers achieve simultaneous goals of increased productivity, improved environmental sustainability and a more resilient sector. The trade-off between productivity and sustainability is particularly challenging in the Netherlands, a small and densely populated country with the highest agricultural animal density in Europe and with a long history of successful innovation and high productivity. Nitrogen deposition on sensitive landscapes is substantially above safe thresholds in most cases and has impaired the quality and recovery capacity of natural habitats (Adviescollege Stikstofproblematiek, 2020[2]). Increased production intensity has also reduced the amount of biodiversity on farm fields, such that many birds and insects that once cohabited with agricultural production are now found only on the margins of fields and pastures. Persistent nutrient surpluses are detrimental to surface and groundwater quality.

The Fertilizers Act and ammonia regulations from roughly 1990 onwards tried to solve the harmful consequences for nature and people caused by nitrate and ammonia while allowing for continued growth. The high levels of nutrient surpluses that existed in the 1980s and 1990s have been reduced, but the environmental problems surrounding animal manure have not yet been solved. With technology and through solutions such as the *Mineralen Indication System* (MINAS), the environmental impact of ammonia and nitrate decreased by more than half, and phosphorus surpluses have been nearly eliminated. However, surpluses have not further declined since 2010 and the situation is not yet sustainable (PBL, 2020[3]).

Further policy changes were introduced after the cancelling of the MINAS programme. In 2006 a new fertiliser policy based on application criteria for fertilisers was introduced. Nitrogen and phosphorus production derived from manure has also been restricted to 2002 levels as part of the terms of the Netherlands' derogation from the Nitrates directive. Since 2010, various policies were introduced to reduce effects of nitrogen and phosphorus on the environment. Nitrogen and phosphate use standards were introduced in 2006 (*gebruiksnormen*) and tightened over time. Phosphorus Rights (*Fosfaatrechten*) were introduced for the dairy sector after the abolishment of the European milk quota system in 2015 and the Program Approach Nitrogen (*Programma Aanpak Stikstof*, PAS) was implemented in 2015 to allocate nitrogen emission rights for all sectors (PBL, 2020[3]).

3.1.2. Court ruling accelerates action related to ammonia emissions

In 2019 the Council of State ruled that the PAS system in place at the time did not meet the requirements of the Birds and Habitats Directives (BHD) to ensure that threatened or important ecosystems (Natura 2000 sites) achieve good environmental status (Box 3.2 and Box 3.5). This ruling put a temporary halt to all new development activity requiring permits to emit nitrogen, affecting agriculture and construction most strongly but touching many parts of the Dutch economy and placing many projects in limbo. The ruling put in question the amount of available "space" for new nitrogen emissions from human activities and implied an acceleration of efforts to lower existing N emissions to the point where most Natura 2000 sites are no longer threatened by eutrophication. The ruling has made addressing ammonia emissions and resulting N deposition on sensitive habitats the most pressing near-term policy concern, but GHG emissions reductions, water quality and other concerns remain on the agenda with deadlines for improvements approaching.

Before the 2019 Appeals Court ruling, the idea that it was possible to have continued agricultural development along with environmental improvement was a central assumption behind policies. Today, there is new recognition that "not everything is possible" and that nutrient surpluses cannot be solved only with technical measures and increased efficiency, but only with an overall reduction in the quantities of nutrients entering the system (Adviescollege Stikstofproblematiek, 2020[2]). This realisation is bringing management of manure and ammonia into a new phase with plans to restructure the sector, a focus on circular agriculture and amendments to tighten the Fertilizers and Nitrogen Act.

The Environment and Planning Act was amended in December 2020 to provide the legal anchoring of a structural approach to the nitrogen problem. The amendment includes:

- An obligation for the government to achieve results in reducing nitrogen deposition on Natura 2000 areas by establishing three environmental values by law (for 2025, 2030 and 2035).
- An obligation for the Provincial Executive to draw up provincial area plans to implement the nationally required deposition reduction.
- An obligation for the Minister of Agriculture, Nature and Food Quality to establish a nitrogen reduction and nature improvement programme.
- An obligation for the Minister of Agriculture, Nature and Food Quality to establish an additional programme for the legalisation of previously unlicensed projects with low deposition rates.

The Nature Conservation Act of 2021 sets binding targets for the percentage of the hectares of nitrogen-sensitive habitats in Natura 2000 areas on which the nitrogen deposition must be brought below critical deposition values (KDW).[2] In 2025 this should apply to at least 40% of the hectares and 74% in 2030.[3] This represents an approximate 50% reduction in emissions by 2030. This overall target is transposed into provincial equivalents, where depending on their situation, some provinces will have to reduce emissions more than others. Provinces will translate these targets into area-specific objectives based on nitrogen loads (Adviescollege Stikstofproblematiek, 2020[2]). The targeted purchase of peak loader operations that originate an important share of total N deposition is currently the main policy tool to achieve these targets.

In 2020 the government made EUR 5 billion available in the period up to 2030, of which more than EUR 2 billion is for source measures and approximately EUR 3 billion for measures to reduce nitrogen emissions and precipitation and restore nature. From the budget for source measures, EUR 970 million has been reserved for the *National Termination Scheme for Livestock Farm Locations* (*Landelijke beëindigingsregeling veehouderij*, Lbv) and EUR 30 million for a pilot land purchase fund. The budget of the first tranche of the *Livestock Operation Purchase Scheme* (*Maatregel Gerichte Opkoop*, MGO) was EUR 483 million. Improved management measures have been allocated EUR 181 million and EUR 280 million is destined for animal housing measures (Schouten, 2021[4]).

A transition fund (*Transitiefonds landelijk gebied en natuur*) anticipates spending EUR 24.3 billion between 2022 and 2034 to reduce the negative environmental impacts of farming operations, focussed on ammonia emissions but also targeting other environmental concerns. The plans for this fund envision a reduction in the number of livestock in the Netherlands, which likely involves a reduction as well in the number of farm operations. This will especially affect farms that are adjacent to Natura 2000 sites that are sensitive to N deposition and where the current level of N deposition is above a threshold where there is a risk to the quality of nature. The funding will be managed according to an area-based approach where regional governments identify and implement local emissions reduction targets. Regional governments are to provide their plans to achieve emissions reduction goals by the end of 2022 and the legislation for this fund is expected in 2023. A dedicated organisation "Realisation Transition Rural Areas" has been established to manage this process in coordination with regional governments.

Multiple programmes were established in 2022 whose design is yet to be finalised.[4] This includes the following.

- A process to arrive at an agreement on agriculture (*Landbouwakkord*) based on recommendations by a report of mediator Johan Remkes (Box 3.1). Discussions are ongoing as of this writing. This agreement has two purposes:
  - Describe the position of agriculture as a strategically important economic sector, producer of sustainable food and raw materials and essential carrier of a vital countryside.
  - Describe how the agricultural sector will play its part in restoring nature, water and climate.
- The National Rural Area Programme (NPLG - *Nationaal Programma Landelijk Gebied*). It aims to translate country-wide policy objectives to the individual company level. The central government and the provinces are currently working on this, which was also recommended in the Remkes report. A first version is due July 2023, which will emphasise understanding the tasks in each area and making some major strategic choices. It will also select concrete measures for specific locations for the most urgent goals, such as in stream valleys, peat meadows and around nitrogen-sensitive Natura 2000 areas.
- The LBV plus scheme (*LBV plus-regeling*) is a modification of the LBV programme that targets peak loaders for early action (LBV is described in Section 3.4). This scheme is intended to give some 2 000 to 3 000 peak-loaders the opportunity to voluntarily terminate on more attractive terms than would otherwise be the case.

To allow some projects to continue subsequent to the court ruling, the Nature Conservation Act and the Environment Act were amended in April 2022 to create the Nature Compensation Bank (NCB).[5] This bank is designed to provide emissions offsets to compensate for the effects on Natura 2000 areas of nitrogen deposition caused by projects of major public importance. Under Article 6 of the Habitats Directive, the negative effects of such projects on N2000 sites can be compensated for by actions to protect an equivalent amount of nearby nature such that the overall environmental quality is maintained. The NCB does this compensation in advance by building up a stock of land for which additional measures have been taken to enhance natural values. Land in the NCB may subsequently be attached to a project to compensate for its negative effects.[6]

Box 3.1. *Wat Wel Kan* — the Remkes Report

Released in October of 2022, the Remkes Report is an attempt to restart the dialogue between the government and the sector after proposed nitrogen measures led to large farmers' protests in the second quarter of 2022. The report calls for an Agricultural Agreement between the sector and the government to move beyond the current impasse.

The Remkes report makes recommendations along three main lines of action:

- Prevent further deterioration of nature within a year via a targeted, short-term approach that reduces nitrogen deposition by buying out peak loaders. Create room for legalising those in uncertain situations (*PAS-melders*) and allow some new construction to begin.
- Provide a long-term perspective for the agricultural sector and the rural area. Reflecting that not everything is possible, everywhere, clear choices in spatial planning and zoning are needed. A long-term earning model for farmers must be clear and fair.
- Carry out an area-specific realisation of the transition to sustainable agriculture. This must be led by the regions but with a working structure in place at national level. This structure should be led by a person of authority and provide clear frameworks, organise activities and stimulate mutual discussion.

The release of the Remkes report received wide media coverage and is generally well regarded. The government has embraced the recommendations in the report.

Source: Remkes (2022[5]).

3.2. A steady policy evolution towards improved sustainability

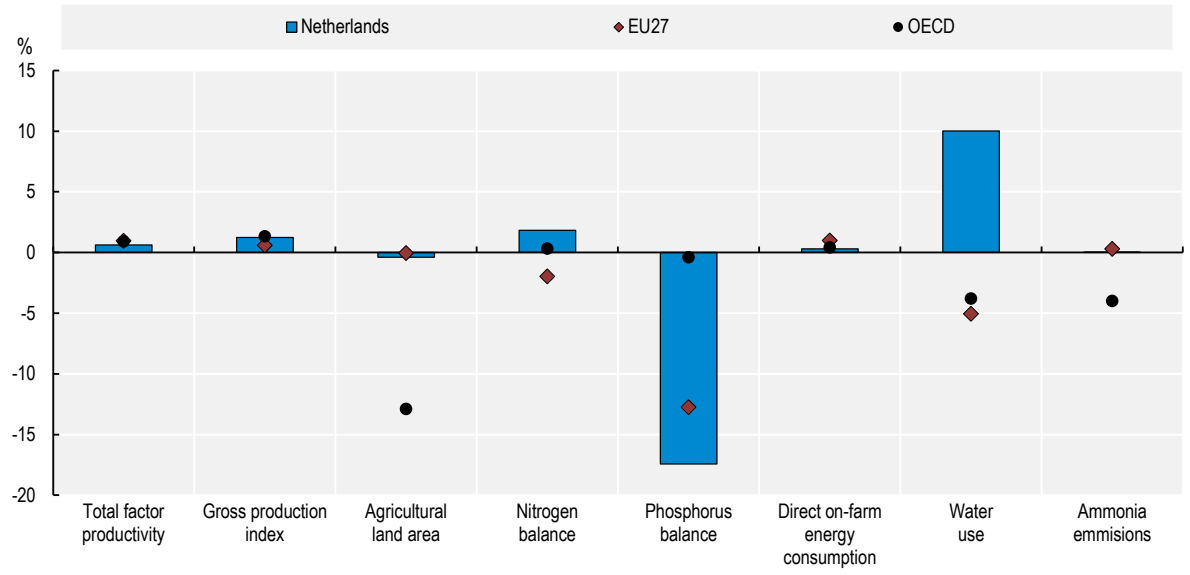
Progress has been made since the 1980s and 1990s in reducing the environmental impact of agriculture, but more remains to be done to put the sector on a sustainable footing. Much of the progress since the 1980s is due to both increased efficiency in the use of nutrients and trends in livestock numbers, themselves influenced by EU policy. The introduction of milk quotas in this period within the European Union caused the number of dairy and calf cows to fall by 42% between 1984 and 2011 to 1.47 million (CBS et al., 2022[6]). Between 1995 and 2020, real agricultural value added grew by 32% while use of inputs such as energy and raw materials decreased over the same period. This has lowered resource use and emissions as expressed per unit of output.

In 2015 milk quotas were abolished and the dairy herd subsequently increased by 19% to 1.75 million. As farmers anticipated the quota elimination, between 2012 and 2015 the number of dairy calves increased by 13% (CBS et al., 2022[6]). As a consequence, recent agri-environmental performance of Dutch agriculture has been relatively static (Figure 3.1), with the exception of a significant improvement in the phosphorus balance. Water usage has increased significantly, likely due to increased use of irrigation over this period, but is still low with respect to the EU average.

Livestock production plays a dominant role in Dutch agriculture and sustainability trends still often follow trends connected with livestock numbers. The State of Agriculture and Food report links short-term environmental trends mainly or significantly to changes in livestock numbers (Table 3.1).

Figure 3.1. Dutch agri-environmental performance, 2010-2019

Average annual percentage change, 2010-2019 or nearest available period



Note: Average annual percentage change, 2010-2019 or nearest available period
Source: Authors' calculations based on OECD (2022), OECD Agri-environmental Indicators database, USDA (2019), Economic Research Service, International Agricultural Productivity for total factor productivity.

Table 3.1. Livestock numbers are an important driver of many sustainability indicators

Drivers of changes in sustainability indicators

Indicator	Long-term trend	Main driver of changes	Other important drivers	Notes
GHG emissions	Stable (with reference to 1990)	Reduced application of fertilisers, manure	Fertiliser efficiency, gas consumption in horticulture	Methane from livestock stable, large share of total emissions
Acidifying substances	Improving	Stables, manure storage, spreading of manure	Livestock numbers, feed changes	Half of emissions are from cattle
Input use (materials, energy, water)	Improving	Energy efficiency in greenhouse horticulture	Livestock numbers	Livestock numbers have increased water consumption since 2012
Emissions of Nitrogen	Improving	Fewer grazing livestock	Less manure production	Netherlands among worst N surplus in EU
Emissions of Phosphorus	Stable	Livestock numbers	Feed changes	P surplus largely eliminated, but ground is saturated with P in many places
Emissions of ammonia	Improving	Low-emission application of manure	Livestock numbers	
Plant protection products	Improving	Favourable weather conditions	Introduction of cultivation-free zones, use of low-drift nozzles	Favourable weather conditions are transient phenomenon that were relevant in the most recent year
Fine dust	Improving	Technical improvement in poultry	Livestock numbers, air scrubbers in pig barns	Fine dust from cattle farming tracks livestock numbers
Antibiotic use	Improving	Reduced use for growth promotion	Better monitoring	Use still high in pigs, broilers and veal calves
Biodiversity	Declining	Agricultural intensification	Eutrophication, desiccation, fragmentation, pollution	Positive effects of nature policy measures compensating for the negative effects of environmental pressure

Note: Drivers mentioned here can be part of a longer-term trend or they can explain year-on-year variation in the indicator.
Source: Adapted from Berkhout, Petra, Harold van der Meulen, Pascal Ramaekers (2022) *Staat van Landbouw en Voedsel*, Wageningen Econoimic Research, Wageningen.

Policies and regulations regarding sustainable practices have been evolving at a steady pace. Common Agricultural Policy (CAP) spending has been increasingly targeted towards environmental outcomes (Chapter 1). The regulatory framework is frequently revised (Fertiliser and Nitrogen Act, Environment and Planning Act) and a number of new programmes have been put in place since 2018 to reduce livestock numbers and improve environmental performance (see Manure and Nutrients section for more on these programmes) (Schrijver and Uetake, 2015[7]).

There are three predominant regulatory measures in use. In order of importance, these are regulatory requirements, environmental cross-compliance (which partly incorporates regulatory requirements) and environmental taxes and charges. National regulatory measures (permits or licenses to produce) are used to maintain landscape features such as wooded areas and hedgerows, water quality, water availability, soil quality and air quality, while EU environmental regulations mainly address biodiversity and water quality (Box 3.2).

Box 3.2. EU directives play a strong role in the sustainability of the agricultural sector in the Netherlands

The following directives require that the government of the Netherlands achieve certain results and have been transposed to corresponding Dutch regulation. They are also part of cross compliance component of the CAP.

- The Birds and Habitats Directives (BHD) calls for protecting nature and restoring good status to important habitats and ecosystems. Achieving these aims has led to a substantial amount of planned spending to reduce ammonia emissions leading to deposition on Natura 2000 sites and provoked changes in how permits are approved in the nitrogen accounting system (PAS). Meeting the requirements of the BHD is the most challenging agricultural issue in the Netherlands today.
- The Nitrogen Directive is highly relevant to the Netherlands, as the country has significant nitrogen surpluses. The Netherlands (along with Ireland and Belgium) is one of three countries with a derogation that allows application of manure N in excess of the 170kg/ha allowed by the directive. One condition of the derogation is that total N and P application to soils remain below 2002 levels, a constraint that has been binding or close to binding in many years, but less so recently.
- The Water Framework Directive (WFD) requires counties to return surface waters to “good” status. The WFD works at the river basin level, requiring each to have a plan to restore good status, with associated monitoring and reporting responsibilities. There are four river basins in the Netherlands (the Rhine, Meuse, Scheldt and Ems). The Netherlands has a National Water Plan to help meet the objectives of the WFD. The government objective is to meet WFD requirements by 2027, but significant progress will need to be made to realise this as many water bodies do not yet have good quantitative or qualitative status.

3.2.1. Strategic Environmental Assessment (SEA) is missing in the policy development cycle

While the Netherlands Environmental Agency (PBL) carries out regular analysis of the agricultural sector, the Ministry of Agriculture, Nature and Food Quality (LNV) does not itself make systematic use of strategic environmental assessment (SEA) as part of is policy development cycle. This risks having policies become reactive to short-term issues at the cost of long-term objectives. Strategic planning may have helped avoid the current situation with ammonia emissions, where a court ruling acted as a strong motivator of policy

change. The relatively static progress (and some reversals) in environmental performance in the last decade should be seen as a missed opportunity to put the sector on a sustainable footing earlier, with less disruption, and at lower cost. Implementing the lessons of this experience in policy will help ensure that agriculture in the Netherlands is future-proof and ready for any shocks that might come. One such lesson seems clear: a gradual tightening of requirements that does not achieve clear progress towards sustainability in the near term is not a successful strategy.

The current situation, where livestock numbers must be adjusted at substantial cost to the taxpayer, points to the value of preparedness and foresight in policy making. SEA is one tool for this, but it is also important to ensure that all stages of the policy development cycle are reinforced, starting from risk assessment and objective setting through policy design, implementation, review and revision.

Monitoring and enforcement can be strengthened with data

All farmers, whether or not they receive CAP support, must comply with statutory management requirements (SMRs). In the Netherlands there are several enforcement services that check this. Municipalities, provinces, water boards and the police share responsibility for enforcement of different statutory and regulatory requirements relevant to farmers.

Of all farms that apply for CAP support, 1% are selected for an annual check. This is in line with the CAP regulation requirements. In 2021 and 2020, this percentage was reduced to 0.5% as a result of COVID-19. In 2020, 243 farms were inspected with respect to SMR 1 (Nitrates Directive) and 82 were inspected with respect to SMRs 2 and 3 (Birds and Habitats Directives). Of these, seven farms were found in non-compliance in at least one aspect SMR 1 (2% of inspections) (National Administration, 2021[8]).

OECD best practice on regulatory enforcement and inspection emphasises the importance of proportionality; the allocation of resources proportional to the level of risk, and enforcement actions proportional to the seriousness of the violation. This includes criteria to assess the risk of individual businesses and rank them according to assessed risk level; data on all (or at least most) businesses allowing to effectively assess their individual risk level; and planning and resource allocation mechanisms so that inspection visits are effectively planned based on the risk level, and resources are rationally allocated (OECD, 2014[9]). Evidence of significant non-compliance has previously been noted in the context of the Netherlands' derogation under the Nitrates Directive, which also calls for further reinforcement of controls to provide additional safeguards and reassurances of the effectiveness of measures (EC, 2020[10]).

A joint monitoring strategy between LNV, environmental agencies and regional and local authorities can help ensure rapid identification and follow-up of risks, uniform practices through good routines, tools and clear job descriptions, and better and faster communication of inspection results. A systematic approach to inspection can help identify weaknesses in self-reporting systems and help close the "implementation gap" between regulations and outcomes.

The Netherland's new CAP Strategic Plan uses maximum flexibility to strengthen sustainability

The Netherlands will make maximum use of the flexibilities in the CAP 2023-27. Fifteen per cent of Pillar 1 funds will be transferred to EAFRD (Pillar 2) in 2023, gradually increasing to 30% by 2027 (see Chapter 1 for more detail on the new CAP and the CSP).

Twenty-five per cent of the amount remaining in Pillar 1 will be dedicated to eco-schemes. These are new ways to support farmers who wish to contribute to transition to sustainable agriculture. Through eco-schemes, a farmer can choose from a list of eco-activities that fit their business as well as climate and environmental goals. The payment they receive depends on the number of eco-activities they choose, according to three levels of participation.

The Netherlands has taken an innovative approach in the CAP with respect to collective and results-based approaches to protection of farmland birds in the form of the Agricultural nature and Landscape management programme (*Agrarisch Natuur- en Landschapsbeheer, ANLb*) (Box 3.3). While addressing many of the weaknesses of this kind of scheme, it has not yet produced substantial improvements in the farm birds index (Figure 3.4). This approach has been extended to include climate and water issues in the CAP 2023-27.

Box 3.3. Agricultural nature and landscape management programme: A co-operative-based approach

The previous CAP reform (2014-2020) gave the option to organise agri-environmental schemes with a cooperative-based approach, through collective agreements with groups of farmers. The Dutch Government, which had lobbied for this possibility in Brussels, wanted to introduce this approach to management agreements aimed at creating good habitat conditions in habitats for rare species. Agricultural collectives can apply for a subsidy from the province within the *Agrarisch Natuur- en Landschapsbeheer* (ANLb) system. Collectives are the final beneficiaries of the subsidies and are responsible for the implementation of agricultural nature management in their area.

In 2020 there were 40 agricultural collectives. The collectives managed an area of approximately 92 000 hectares in 2019, about 81% of which is for meadow birds. Funding for this programme was EUR 71 million in 2019. Payments are based on the extra costs and the loss of income resulting from the area agreement, plus up to an additional 20% to cover implementation and transaction costs.

The collectives create a multi-year plan for the management of the area and the strategy for the conservation of biodiversity. This focuses mainly on 68 target species of the Birds and Habitats Directives (BHD) that are highly dependent on agricultural area, but also includes fish, amphibians and insects. The collective then contracts individual farmers or land users for various activities to achieve its overall objectives as agreed with the provinces and water boards. That is, agricultural collectives make agreements with provinces and water boards about the performance to be delivered and with farmers and other agricultural land users about the actions to be taken.

The collectives approach offers more flexibility and scope for customisation that takes local circumstances into account. They have the potential for a more effective local mutual monitoring. By co-ordinating the actions of farmers, the different needs of species can be met efficiently at a landscape level. This approach passes many responsibilities from government administrators to farm collectives, which can reduce administrative burden while increasing engagement and ownership on the part of the farming community.

Source: Berkhout, van der Meulen and Ramaekers (2021[11]), *Staat van Landbouw en Voedsel Editie 2021* (State of Agriculture and Food 2021) Wageningen Economic Research, Wageningen.

Organic Action Plan

The Organic Action Plan, released in 2022, is the Dutch implementation of the EU Organic Action Plan, which in turn gives substance to the European Green Deal and the Farm to Fork strategy. The action plan aims to accelerate the growth of the organic agricultural area from 4% (in 2021), to 15% in 2030 (LNV, 2022[12]). That translates to moving from approximately 80 000 hectares to 300 000 acres. Growth will come primarily from dairy farming and arable farming, sectors with a lot of acreage that are land-bound and with conversion can contribute to the major challenges that exist in terms of nature, nitrogen, water, biodiversity and animal welfare. This can also boost circular agriculture and nature-inclusive agriculture, as organic includes some similar concepts and practices (Box 3.4).

Box 3.4. Approaches and practices to produce food in an environmentally friendly way

Since the early 20th century, several approaches have emerged to promote environmentally friendly agricultural practices as part of production systems that are more environmentally sustainable. The concepts and the movements that originated them are strongly intertwined, and the terms are sometimes used synonymously. In fact, a wide set of terms to describe environmentally superior agricultural techniques coexist in public discourse. Alongside organic, circular and regenerative agriculture are terms such as "agroecological farming" "alternative agriculture," "biodynamic agriculture," "carbon farming," "nature inclusive farming," "conservation agriculture," "green agriculture," "organic regenerative agriculture," and "sustainable agriculture" (Newton et al., 2020[13]).

Organic agriculture

Organic agriculture is the most successful example and has been encouraged for a long time by policies in many countries. 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[14]). The main characteristics of organic production are the prohibition of most synthetic inputs, and mandatory crop rotations (FAO Committee on agriculture, 1999[15]).

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[16]). 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.

Organic agricultural practices have environmental benefits including lower pesticide residues, a richer biodiversity and greater resilience to drought. However, 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 (OECD, 2003[17]).

Circular agriculture

Circular agriculture focuses on using minimal amounts of external inputs, closing nutrients 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 intensive application of raw inputs such as fertiliser and chemicals leads to harmful outflows of waste and degraded soil quality in the farm system.

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 optimise the interactions between plants, animals, humans and the environment while also

addressing the need for socially equitable food systems" (FAO, n.d.[18]). While the concept emerged decades earlier, it gained prominence in the 1990s, in the United States and in Latin America to express a new way of viewing agriculture and its relationship with society (Wezel et al., 2009[19]). It is seen simultaneously as a science, a set of agricultural practices and a social movement (GIZ, 2020[20]).

There are no national or international agro-ecology standards, 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 CAP eco-schemes. In 15 case studies across Europe, agroecological farms were found to enhance biodiversity and water quality compared to non-agroecological farms (Landert, J et al., 2020[21]). However, no clear patterns were found regarding soil quality or economic performance. The results also suggested that agro-ecological practices could have higher greenhouse gas emissions and fuel consumption.

Regenerative agriculture

Regenerative agriculture encompasses a range of practices (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 use of the term has surged since 2015, which suggests that it is gaining more attention from scholars and practitioners. Regenerative agriculture stresses soil restoration and the interplay of crops and farm animals. The concept of regenerative agriculture is broader and less prescriptive than agro-ecology and organic agriculture, as it accepts a targeted use of modern plant and animal breeding technology, tilling, and inorganic fertilisers or pesticides (EASAC, 2022[22]).

The Special Report on Climate Change and Land by the UN Intergovernmental Panel on Climate Change 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 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[23]). While there are no standards 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.

The action plan is based on the recognition that both sides of the market are important for success. Farmers will supply more organic products if the demand is there at the right price. Therefore, the whole food value chain needs to be involved in a successful action plan. The action plan is built along the following three goals.

- More organic consumption and a larger market for organic products via
  - Helping ensure consumers and chain actors are familiar with organic products and the European organic label
  - Ensuring there is an increased supply of organic products in various marketing channels
  - Ensuring that organic products are accessible and affordable.
- More organic production via
  - Encouraging conversion to organic farming
  - Continuing existing organic production
  - Facilitating co-operation and commitment of chain parties
  - Gaining access to suitable and affordable land

    - Having a distinct sustainability brand by having organic take additional steps in the area of sustainability.
- More knowledge and innovation.
    - Establishing a knowledge agenda for organic production and consumption (*Kennisagenda Biologisch*)
    - Knowledge dissemination and education, especially via *GroenKennisnet* (Chapter 4)
    - Keep innovating by making use of field labs, living labs and experimental gardens.

Organic dairy farming might be a solution for dairy farms located near nature reserves, the ammonia emissions from organic dairy can be significantly less than for conventional production. Organic production does not automatically lead to improvements in all environmental factors; organic pig and poultry farming potentially have higher N emissions than conventional farms (Plomp and Migchels, 2021[24]).

Farmers practicing organic farming are younger and more diverse which makes them particularly able to adopt innovative practices and transform the agricultural sector. Younger farmers tend to run more modernised and profitable farms (Zagata and Sutherland, 2015[25]). Moreover, the attractiveness of the agricultural sector as a viable career path is an important concern in the Netherlands, where outside career options are strong. Organic agriculture might have less issues concerning generational renewal and attracting new entrants to the sector.

While the switch to organic agricultural might decrease the environmental pressure per hectare, lower yields associated with organic production can increase pressure per kg of product. Organic potato farms for instance deliver 20-40% lower yields than conventional farms. The lower productivity per hectare can complicate profitability, as land is already amongst the most expensive in the European Union. Converting non-farmland into land for organic agriculture to mitigate the productivity decline can address the yield gap, but at some risk to biodiversity (Berkhout et al., 2021[26]; Koopmans et al., 2021[27]).

Advances in research and education could overcome current drawbacks associated with organic agriculture. Organic agriculture still plays a relatively minor role in these areas. The overall knowledge and innovation system for organic agriculture lags other sectors (Berkhout et al., 2021[26]; Koopmans et al., 2021[27]).

Other programmes

The Sustainable Animal Products (VDP) market programme financially supports parties in the chain with pilot projects and research to accelerate sustainability. This includes setting up new sustainable chains or expanding eco-labelling schemes. For example, the Royal Dutch Butchers' plan to increase awareness about sustainability and increase the use of a quality mark. The market programme is also intended to facilitate the transition to one star *Better Life* for broiler farmers. All supermarkets and others in the value chain have committed to sell only chicken rated at least one star in the *Better Life* label as of 2023. The market programme is facilitated and co-ordinated for at least three years by the *Alliantie Verduurzaming Voeding* foundation (Schouten, 2021[28]).

Certain banks and green funds can apply for a green certificate under the Green Projects Scheme. This allows them to finance sustainable projects at a lower interest rate along with some additional income tax benefits for citizens. The interest and tax benefits together amount to approximately 3% of the value invested.[7]

The Subsidy Module Agricultural Business Advice and Education (Sabe) is part of a broader framework related to farm-level innovation. In order to help market sustainable products, a component has been added to Sabe that provides EUR 1 million to support collaborative projects focussing on the development of more sustainable animal market concepts. To be eligible for a subsidy, at least one farmer and a processor or trading company in the animal chain must work together. This scheme began on 1 November 2021.The

Sabe scheme also provides vouchers for advice and business planning services (see Chapter 4 for more on Sabe).

Since the beginning of 2020, the Advancing Sustainable Animal Products (ASAP) project has been part of the Sustainable Livestock Farming Programme. This project is aimed at removing international obstacles to sustainability and making the European market for animal products more sustainable. This has resulted in the establishment of a broad group of stakeholders (governments, NGOs and market parties) from Denmark, Germany, Belgium, and France exploring how voluntary harmonisation of sustainability information in the market for animal products could take shape. Under the heading of ASAP, work is being done on a system to harmonise existing animal welfare labels from different countries and clearly organise them. In addition, a sustainability dashboard is being developed that provides insight into how sustainably animal products are produced.

Investors may deduct up to 45% of the cost of environmentally related investments from their taxes via the Environmental Investment Allowance (*Milieu-investeringsaftrek*, MIA). This is to put environmentally friendly alternatives on a more equal cost footing with conventional technologies. A related tax benefit, The Arbitrary depreciation of environmental investments (*Willekeurige afschrijving milieu-investeringen*, Vamil) allows farmers to depreciate up to 75% of eligible investment costs as quickly as they like (the entire amount may be taken in the first year if desired).[8]

While there are many qualifying investments for MIA and Vamil, these are most relevant for investments in buildings such as sustainable barns that are certified under the Sustainable Livestock Farming Measures (*Maatlat Duurzame Veehouderij,* MDV). An MDV barn is a livestock barn with design features that lower its environmental impact and provides for improved animal health and welfare. For example, the investment in a certified MDV dairy barn is eligible for a maximum of EUR 6 250 per animal place under MIA and the owner may depreciate the value of the barn by a maximum of EUR 4 million under Vamil.[9]

The development of agroforestry is considered part of the transition to circular agriculture. Agroforestry combines trees as multipurpose natural elements with agricultural activities. Siting of agroforestry locations in proximity to the Nature Network and Natura 2000 areas can increase connectedness between natural areas and strengthen landscape identity and biodiversity. In this regard it can help synergistically with planned reduction of peak loader farms near Natura 2000 areas. This practice is in its early stages in the Netherlands, but a ten-year strategy for agroforestry has been developed as part of the Dutch Forestry Strategy (LNV, 2020[29]). This strategy is three-fold:

- creating a supporting (policy) environment in the coming years
- stimulating innovative practices (financially)
- stimulating knowledge development and exchange, after which there will be a focus on upscaling.

Part of developing a supporting policy environment for agroforestry is inclusion of this production system in the CAP. Such agroforestry activities may be supported from both Pillar 1 and Pillar 2. This is part of the CAP Strategic Plan for the Netherlands. Agroforestry Nederland is a network of researchers, companies and organisations involved in the development of agroforestry in the Netherlands.[10] This network connects all agroforestry initiatives in the Netherlands to promote knowledge development and exchange. Agroforestry Nederland is a member of the European Agroforestry Federation (EURAF).

3.3. Biodiversity and ecosystem management

3.3.1. Assessment of status and trends

Land reclamation, agricultural intensification and urban development have reduced the size of natural ecosystems. The average ecological quality of all types of terrestrial ecosystems has declined since 1994 but has stabilised in recent years. Major contributors are eutrophication, acidification, lowered water tables

leading to drying out of soils, poor water quality and a lack of spatial connectivity, though their effects differ according to the type of ecosystem and between regions. Since 1990, the pressures on the environment in terms of emissions and deposition have declined and land use conditions have improved due to habitat creation in the national ecological network (NEN). However, the situation is not yet sustainable. Suboptimal environmental and land use conditions lead to low and declining ecosystem quality. Local factors are important; ecosystems on nutrient-poor sandy soils are much more sensitive to eutrophication and acidification than those on clay soils (CBS et al., 2021[30]).

The current ecological quality of freshwater ecosystems is on average low. Among the causes of this are the delayed release of nutrients from sediment, run-off and leaching of nutrients from farmland, pollution with sources outside the Netherlands, and the presence of invasive species. About 60% of the nutrient load of regional waters comes from agricultural land (PBL, 2020[3])

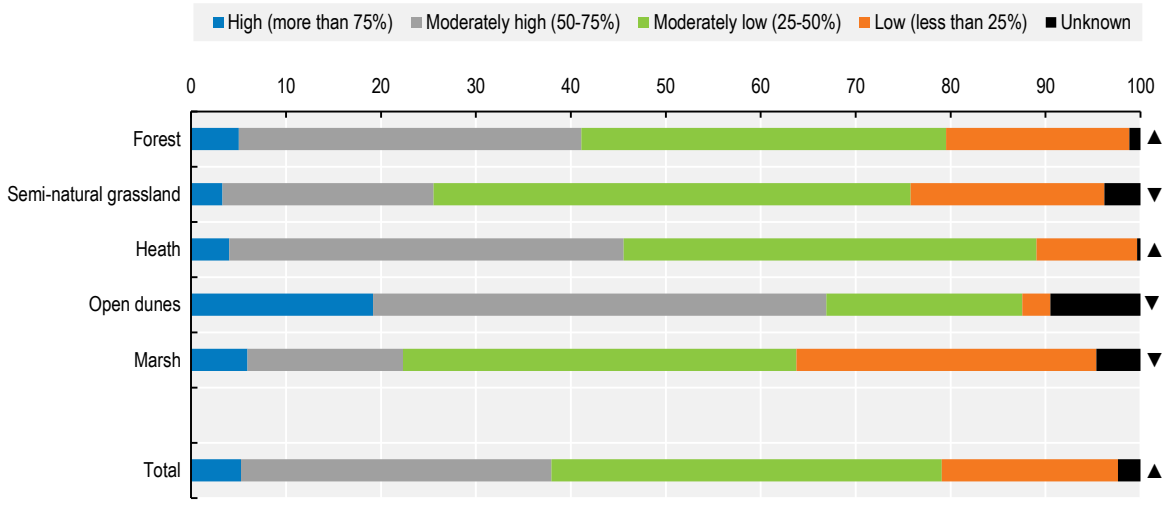
Almost 40% of the area of terrestrial ecosystems has a moderately high to high ecological quality, measured by the presence of qualifying species of breeding birds, vascular plants and butterflies (Figure 3.2). The index shows that semi-natural grasslands and marshes, which are often affected by agricultural activities, are in relatively poor condition and declining, while the condition of forests is improving (CBS et al., 2021[30]). While ecological quality is improving on average, this is due mainly to improvements in forest area; the overall quality of other ecosystems has not improved since the 1994-2001 reference period.

In natural areas, the average numbers of target species of vascular plants and summer birds increased between 1990 and 2005, compared with the 1975-1989 period, but these decreased in agricultural areas (Figure 3.3). An increase in the average number of target species in natural areas does not mean that every species is doing well. Species that make the highest demands on their habitats are becoming increasingly rare. Long term species decline is even more substantial. Since 1900, plants on arable fields have declined by 35%; grassland butterflies by 80%, and characteristic birds of open farmland by 85% (CBS, 2020[31]). Since 1990, the number of farmland birds as measured by the OECD agri-environmental indicator has declined by 54% (Figure 3.4).

In recent decades, spatial and environmental conditions have improved for the target species in natural areas, and their average numbers have improved. This is because of an expansion of natural areas as well as an improvement in their quality subsequent to reduced nitrogen deposition and restoration efforts. In agricultural areas, the number of target species is decreasing because of the increasing optimisation of land for production and harvest efficiency. As a result, fewer species have the space they need to survive (CBS et al., 2014[32]).

Figure 3.2. Semi-natural grassland has the smallest share of high-quality area

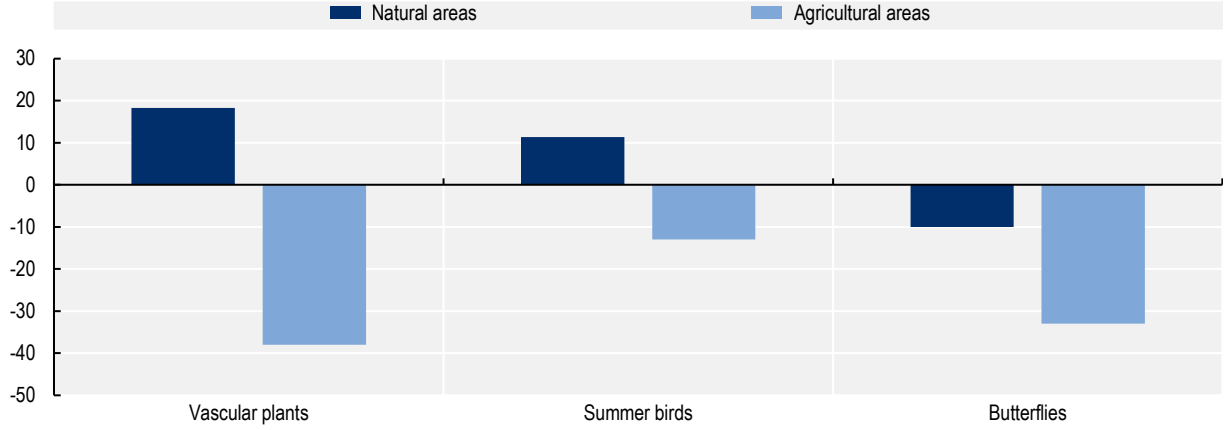
Ecosystem Quality Index, 2010-17, percentage of area



Note: Ecological quality is determined from the number of qualifying species (a selection of butterflies, vascular plants and breeding birds indicative of an ecosystem in a good condition) present in the area. Arrow indicates average improvement or decline since 1994-2001.
Source: CBS, PBL, RIVM, WUR (2021). Ecosystem quality (area) 1994-2017 (indicator 1518, version 03, 10 November 2021), www.clo.nl. Centraal Bureau voor de Statistiek (CBS), Den Haag; PBL Planbureau voor de Leefomgeving, Den Haag; RIVM Rijksinstituut voor Volksgezondheid en Milieu, Bilthoven; Wageningen University and Research, Wageningen.

Figure 3.3. Target species doing worse in agricultural areas compared to natural areas

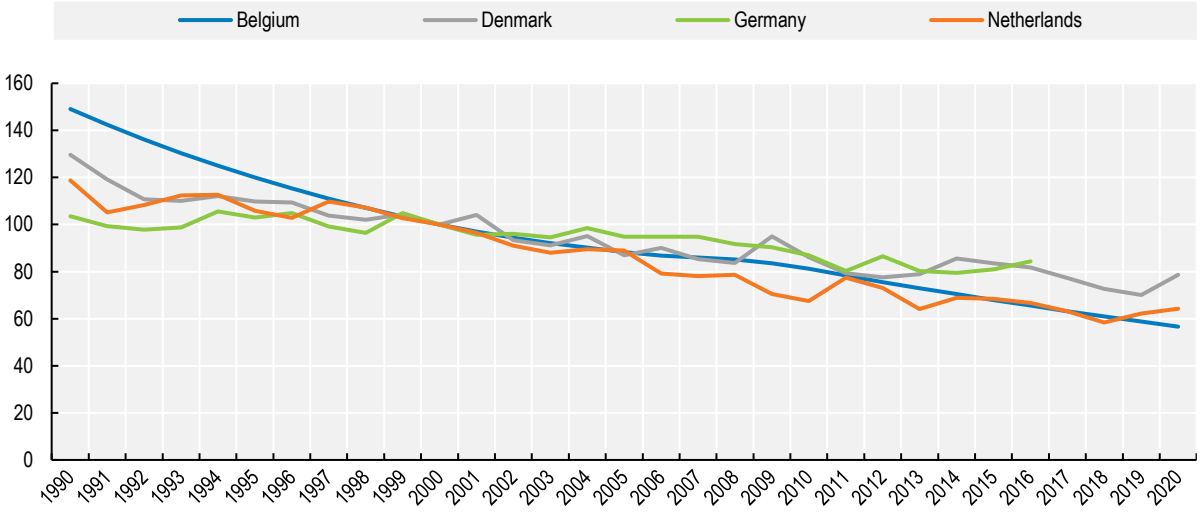
Numbers of target species, 1990–2005 compared with 1975–1989 for natural areas larger than 100 ha



Source: CBS, PBL, RIVM, WUR (2014). Change in species numbers in natural and agricultural areas, 1975-2005 (indicator 1543, version 01, 20 May 2014) www.environmentaldata.nl. Statistics Netherlands (CBS), The Hague; PBL Netherlands Environmental Assessment Agency, The Hague; RIVM National Institute for Public Health and the Environment, Bilthoven; and Wageningen University and Research, Wageningen.

Figure 3.4. The number of farmland birds has been declining

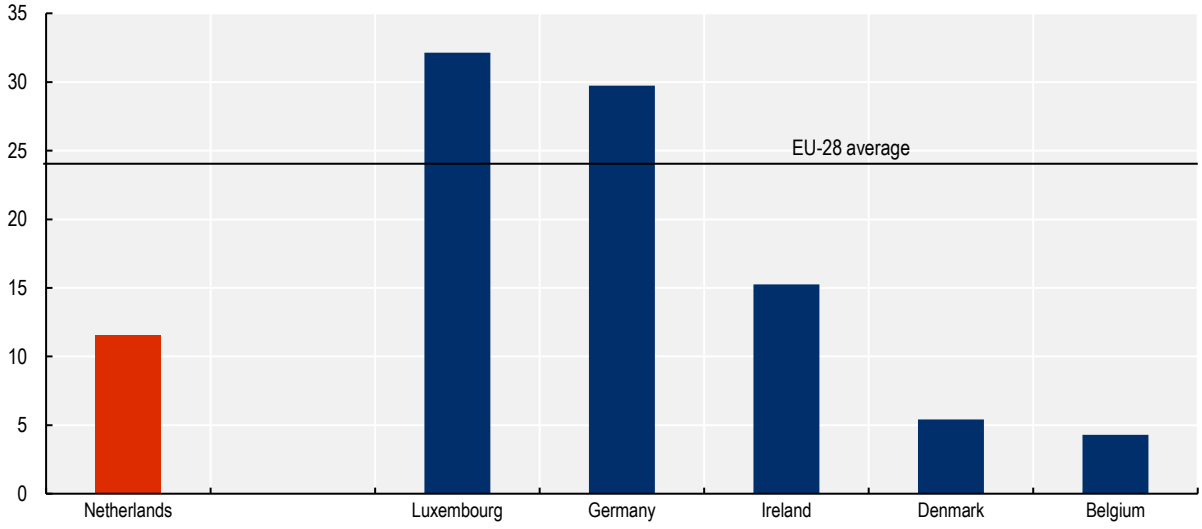
OECD Farmland Birds Index, year 2000=100, 1990-2021



Note: There are 23 species: European Turtle Dove (Streptopelia turtur), Northern Lapwing (Vanellus vanellus), Eurasian Wryneck (Jynx torquilla), Common Kestrel (Falco tinnunculus), Red-backed Shrike (Lanius collurio), Woodlark (Lullula arborea), Eurasian Skylark (Alauda arvensis), Marsh Warbler (Acrocephalus palustris), Common Whitethroat (Curruca communis), Common Starling (Sturnus vulgaris), Fieldfare (Turdus pilaris), Whinchat (Saxicola rubetra), European Stonechat (Saxicola rubicola), Northern Wheatear (Oenanthe oenanthe), Eurasian Tree Sparrow (Passer montanus), Tree Pipit (Anthus trivialis), Water Pipit (Anthus spinoletta), Common Linnet (Linaria cannabina), European Goldfinch (Carduelis carduelis), European Serin (Serinus serinus), Corn Bunting (Emberiza calandra), Yellowhammer (Emberiza citrinella)
Source: OECD (2022), OECD Agri-environmental Indicators database.

Figure 3.5. The number of habitat types with a favourable conservation status is below the EU average, but similar to some regional peers

Conservation status of habitat types relative to EU and regional peers, 2013-18, % habitat types with favourable status



Source: CBS, PBL, RIVM, WUR (2021). Conservation status and trends in species and habitat types under the Birds and Habitats Directives, 2013-2018 (indicator 1483, version 05, 9 November 2021) www.environmentaldata.nl. Statistics Netherlands (CBS), The Hague; PBL Netherlands Environmental Assessment Agency, The Hague; RIVM National Institute for Public Health and the Environment, Bilthoven; and Wageningen University and Research, Wageningen.

About 10% of the habitat types in the Netherlands have a favourable conservation status. About a quarter of the Habitats Directive species have a favourable conservation status. The number of species and habitat types with a favourable conservation status is lower than the EU average but higher than in Belgium and Denmark, where the situation is close to that of the Netherlands (Figure 3.5). The trends in habitat types and population sizes of species with an unfavourable conservation status in the Netherlands show a strong improvement compared with other EU Member States. However, more species show worsening trends than those showing improvement (CBS et al., 2021[33]).

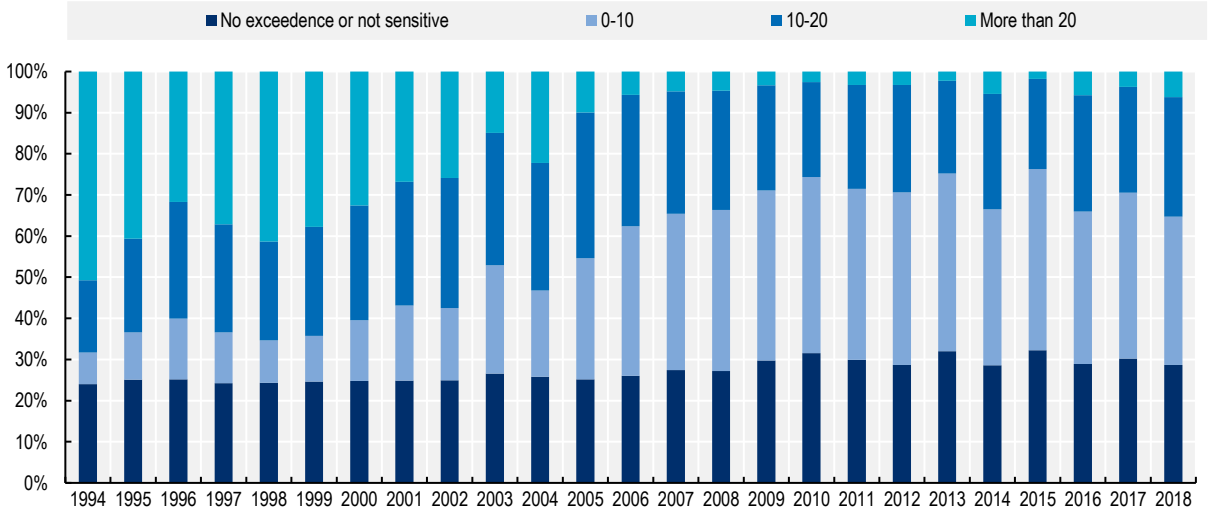
The Netherlands is currently far from the Birds and Habitats Directives (BHD) target to achieve and maintain a favourable conservation status for all BHD species and habitat types and to restore bird populations. Indeed, reaching the European Commission's interim target of 30% in the EU Biodiversity Strategy would require considerable improvement. Across all the EU28 Member States, 24% of the habitat types and 31% of the Habitats Directive species have a favourable conservation status. In the Netherlands just 12% of the habitat types have a favourable conservation status. Of the Habitats Directive species in the Netherlands, 26% have a favourable conservation status (CBS et al., 2021[33]).

Of the 161 Dutch Natura 2000 areas, 130 are sensitive to an excess of nitrogen precipitation from the air, or nitrogen deposition, which is caused by nitrogen emissions from, for example, agriculture, traffic, industry or sources abroad (PBL, 2020[34]). Nitrogen deposition causes eutrophication (excess nutrients), and also makes soil more acidic When nitrogen deposition exceeds the critical load, vulnerable species will disappear. The higher the exceedance and the longer the period of exceedance, the greater the impacts. Nutrient-poor ecosystems are especially sensitive to nitrogen deposition.

The area with no exceedance of nitrogen deposition has doubled but remains relatively small at about 10% of land area (Figure 3.6). In many ecosystems the environmental pressure from nitrogen deposition is still too high and has not decreased in recent years. In forest, open dune, and heath ecosystems in particular, nitrogen deposition is responsible for moderate to bad conditions throughout almost the entire area. Considerable progress has been made in reducing the worst cases of excessive N deposition, but progress has been slow after the mid-2000s.

Figure 3.6. About 70% of land area has some level of excessive N deposition

Exceedance rate of critical deposition of N by percentage of land area, kg per ha1994-2018

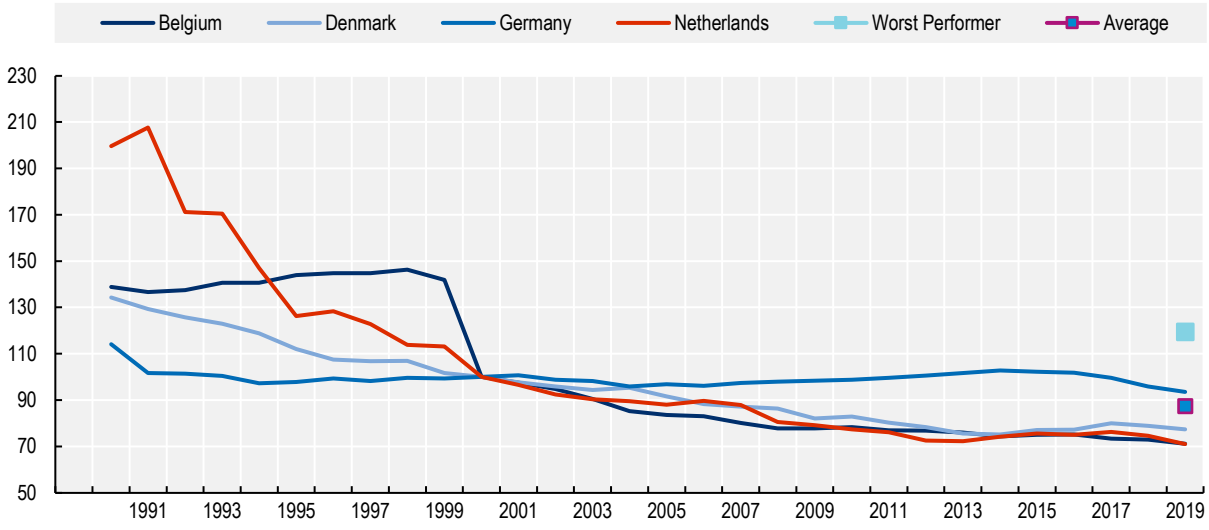


Source: CBS, PBL, RIVM, WUR (2021), *Ecosystem quality and trends in nitrogen availability, 2018*, (indicator 1592, version 03, 9 November 2021), www.environmentaldata.nl. Statistics Netherlands (CBS), The Hague; PBL Netherlands Environmental Assessment Agency, The Hague; RIVM National Institute for Public Health and the Environment, Bilthoven; and Wageningen University and Research, Wageningen.

The environmental pressure from nitrogen deposition has reduced since the 1990s and the Netherlands has had the most rapid ammonia emissions reductions in the OECD (Figure 3.7). The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol) sets national ceilings for 2010/2020 for ammonia and three other pollutants. The ceilings were negotiated and agreed to on the basis of scientific assessments of pollution effects and abatement options. Under the Protocol, the Netherlands has committed to reducing ammonia emissions by 14% by 2020 relative to 2005. This commitment is less than recently set domestic targets for reductions.

Figure 3.7. Substantial reduction in ammonia emissions since 1990 but not yet sustainable

Ammonia trends in the Netherlands and peers, 1990-2019 Index 2000=100

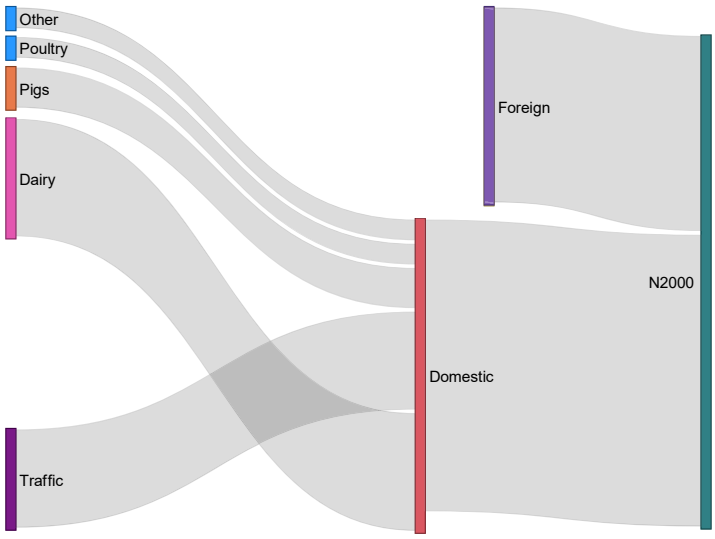


Note: Worst performer and OECD average shown only in 2019 to aid clarity. The Netherlands is the best performer in ammonia reduction over the time period.
Source: OECD AEI database.

Atmospheric deposition of nitrogen comes from sources outside the country, domestic transport, and agriculture. The national contribution to nitrogen deposition in Nature 2000 areas is around 60%. Of this, around 20% comes from traffic, industry, and consumers. The other 40% comes from livestock farming. Nitrogen deposition from livestock farming is around 65% from cattle farming, 20% from pig farming and 10% from poultry farming (Figure 3.8).

Figure 3.8. About 40% of N deposition on N2000 sites is from domestic agriculture

Nitrogen flows onto Natura 2000 sites



Source: https://www.wur.nl/en/Dossiers/file/Nitrogen.htm.

3.3.2. Policies and regulations

The Netherlands has made international commitments to meeting the goals of the Convention on Biological Diversity, the Birds and Habitats Directives (Natura 2000) and the EU Biodiversity Strategy. Policies cover reducing emissions of nutrients and acidifying substances, nature restoration, expansion of the protected area network, and farmland bird protection. Nature restoration projects for natural areas have been carried out since 1989, initially under the *Subsidy scheme for effect-oriented measures (Effectgerichte Maatregelen, EGM)* and in recent years under the *Quality initiative for nature and landscape (Kwaliteitsimpuls natuur en landschap, SKNL)* and the PAS.

The national government is responsible for setting policy with respect to biodiversity and ecosystems. Since 2007, the Dutch provinces are responsible for most landscape and biodiversity policies, including land acquisition for new nature reserves within the ecological network (Schrijver and Uetake, 2015[7]). The division of responsibilities are described in the *Agreement on decentralization of nature policy* of 2011 and the *Pact for Nature* of 2013. Since 2014, the transformation of the National Ecological Network (EHS) into the Netherlands Nature Network (*Natuurnetwerk Nederland*) is the responsibility of regional governments. Current plans are to improve the size and connectivity of natural areas and add 80 000 hectares to the Network by 2027.

In the *Pact for Nature*, the national and provincial governments have agreed to maintain ecological quality within the national ecological network through conservation management and to raise ecological quality by intensifying efforts for temporary or permanent restoration measures aimed at improving water quality and environmental conditions (EZ and provinces, 2013[35]). Many restoration measures are designed to remove nutrients and combat acidification and reduced groundwater levels. (CBS et al., 2021[30]).

To prevent the effects of eutrophication and acidification, policy focuses on reducing emissions of eutrophying and acidifying substances in the Netherlands and surrounding countries. In 2015 the government introduced the Integrated Approach to Nitrogen (PAS) with the aim of reducing nitrogen deposition, improving ecological quality in natural areas and at the same time permitting economic development. This system however did not meet the requirements of the Habitats Directive, and has since been amended (Box 3.5).

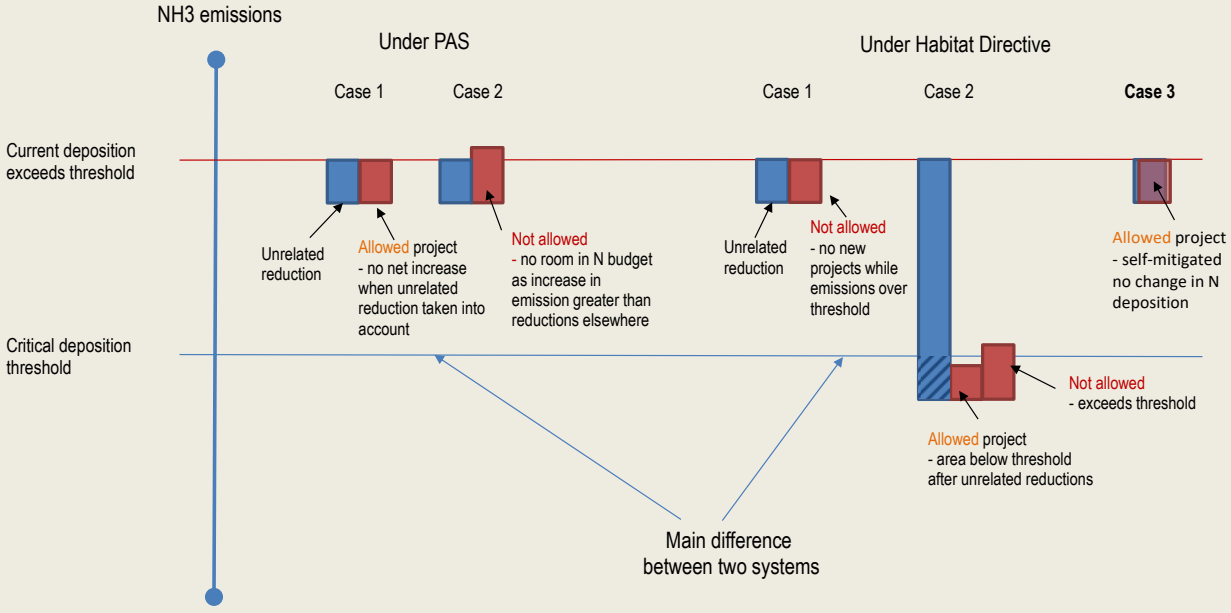
Box 3.5. The court ruling regarding the Habitats Directive and the PAS

In 2019 the Council of State ruled that the PAS system does not meet the requirements of the Habitats Directive to ensure that threatened or important ecosystems (Natura 2000 sites) achieve good environmental status. The PAS allows the new N emission permits when N emissions are forecasted to be reduced elsewhere, perhaps from unrelated activities (thereby "creating space" for new activities that emit nitrogen). In this way, new projects could perpetuate emissions at a level that exceeds critical deposition thresholds and thus prevent achieving good conservation status of relevant landscapes.

There are three problems with this:

- Emissions reductions were counted in PAS even when they are expected, not confirmed
- Unrelated emissions reductions could offset a new project's emissions
- A project with new emissions could be approved when the critical threshold is already exceeded.

Figure 3.9. Project approval under PAS versus rules of Habitats Directive



Note: Amber bars represent potential projects that increase emissions, blue bars are projects or other outcomes that reduce emissions.

Under the Habitats Directive, new projects must not pose a threat to sensitive landscapes. That means in practice that when the threshold is exceeded in an area, no project with net new emissions can be allowed. Indeed, it is necessary to reduce emissions below the critical threshold above which they can harm landscapes. A project can still be approved if it also includes mitigation actions that result in the project as a whole having no net emissions. That is, a project can self-mitigate but cannot benefit from unrelated N reductions, unless those reductions bring emissions below the critical threshold

Source: Adviescollege Stikstofproblematiek (2020[2]).

The BHD imposes obligations on the Member States with the aim of maintaining or restoring bird populations to sufficient levels and maintaining or restoring a favourable conservation status of habitat types and other species. The national ecological network is an important part of this. Most Natura 2000 sites are part of this network which is also essential for achieving the required favourable conservation

status for the protected plant and animal species and habitat types listed in the Birds and Habitats Directives (CBS et al., 2021[33]).

Since 2014, the Netherlands uses an innovative cooperative-based approach to farmland bird conservation and commits significant funding to improving the conditions for birds on working farmland (Box 3.3). While this approach has been more effective than past measures, bird populations have done better in protected areas despite higher expenditures on conservation in farmland areas (Batáry et al., 2015[36]). Furthermore, birds show positive trends in protected areas but negative trends in agricultural areas (Figure 3.3). This suggests that, for some species, protected areas are more effective than agri-environmental schemes that make payments to farmers to improve conditions for biodiversity on their land.

Dutch policy for restoration of Natura 2000 sites has concentrated on emissions of eutrophying substances from agriculture, transport and industry. Among these, reducing ammonia emissions from agriculture are usually less costly than reducing NOx emissions from other sectors, and agriculture accounts for the largest share of deposition (40%) on Natura 2000 sites. However, the large amount of deposition originating from outside the country (30%) means that even if agricultural emissions were to be completely eliminated, some areas would still have deposition rates above critical thresholds. Restoration efforts are likely to be ineffective or even counterproductive while deposition exceeds critical thresholds. Tightening emission limits under the NEC Directive can help with cross-border NOx, but it is uncertain whether anticipated eventual international emission reductions will be sufficient to bring deposition below critical thresholds.

Nature Implementation Programme

The Nature Implementation Programme (*Uitvoeringsprogramma Natuur*) of 2021 aims to make natural areas more robust and resilient helping to meet the objectives of the BHD and promote general biodiversity recovery. The central government and the provinces, in co-operation with other organisations, form joint plans for nature restoration up to 2030. The Nature Programme is an integral part of the structural approach to nitrogen (described above). This programme allocates EUR 3 billion to restore and strengthen vulnerable nature areas. The programme includes measures for the restoration of natural areas as well as source reduction of pollutants with a negative impact on those areas.

The Nature Implementation Programme elaborates on the joint ambition document *Netherlands Nature Positive (Nederland Natuurpositief)*[11] and on the existing agreements between the provinces and the national government in the Nature Pact (2013). The programme targets an improved state of conservation through the coherent deployment of measures aimed at reducing nitrogen emissions, improving nature and increasing nature-inclusive acreage.

The programme unrolls in phases. The first phase started in 2021 and focuses on projects that can be implemented quickly while at the same time carrying out analysis and evaluation of approaches to support the second phase, which runs from 2023 to 2030. Measures funded under the programme are evaluated according to a set of criteria designed to elicit maximum cost-efficiency and timeliness (LNV, 2020[37]).

Provinces also set out their nature conservation objectives for the size and quality of nature types over a timeframe of five to ten years. Funding for these objectives is available under the 'quality initiative for nature and landscape' (*Kwaliteitsimpuls natuur en landschap* or *SKNL*) and the subsidy scheme for converting agricultural land to nature and improving the ecological quality of existing natural or semi-natural areas (*inrichtingssubsidie*) (CBS et al., 2021[38]).

3.4. Manure and nutrients

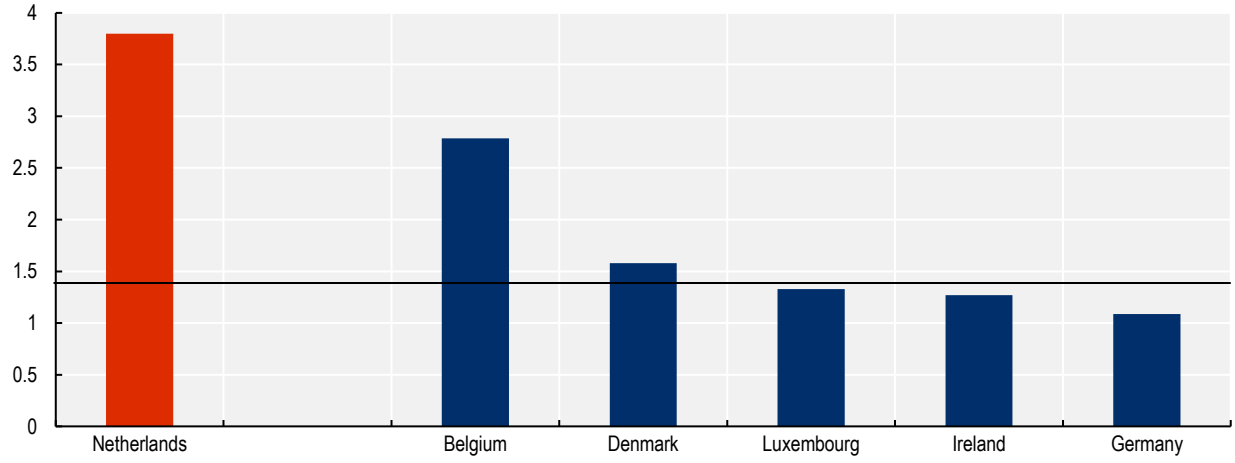
3.4.1. Assessment of status and trends

The Netherlands has the highest livestock density in the European Union in terms of animal units per hectare (Figure 3.10). At the NUTS2 region level, five of the ten highest density regions in Europe are located in the Netherlands.[12] With a total land area of 41 543 km^2 including water bodies, there were an average of 14 goats, 93 cattle, 298 pigs and 2 372 poultry and 414 persons per km^2 in 2018. Managing the resulting manure is perhaps the most important challenge facing policy makers. The Netherlands is one of four EU countries with a derogation from the requirements of the Nitrates Directive. The Directive normally restricts N application from livestock manure to a rate of 17 0kg/ha but this derogation allows Dutch farmers with grassland farms (>80% grassland) to apply up to 230 or 250 kg N/ha from manure, depending on soil type. For the period 2022-25 the Netherlands received a renewed derogation that gradually reduces the level N-application from livestock manure to the generic rate of 170 kg N/ha.

The nitrogen surplus reached a maximum in 1986 and has been trending downward since that time, though increases are seen after 2014 (Figure 3.11). In 2019, nitrogen use efficiency on cropland was 62%, an increase from 47% in the 1990s (CBS et al., 2021[39]). The application of inorganic fertilisers and manure production have been reduced considerably from peak levels.

Figure 3.10. The Netherlands has a high livestock density compared with its regional peers

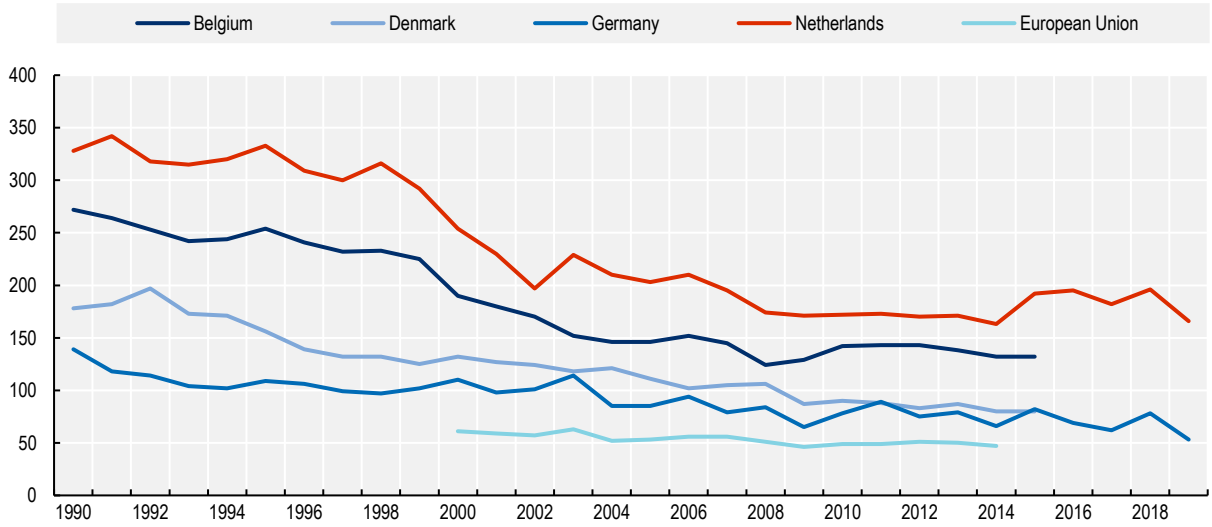
Livestock units per hectare UAA



Note: Horizontal bar indicates EU average.
Source: Eurostat (online data codes: ef_lsk_main, ef_lus_main).

Figure 3.11. Nitrogen surpluses stable after a period of decline

Kg N surplus per hectare 1990-2019



Source: OECD (2021) "Nitrogen Balance" OECD Agri-Environmental Indicators (database), https://stats-2.oecd.org/Index.aspx?DataSetCode=AEI_NUTRIENTS.

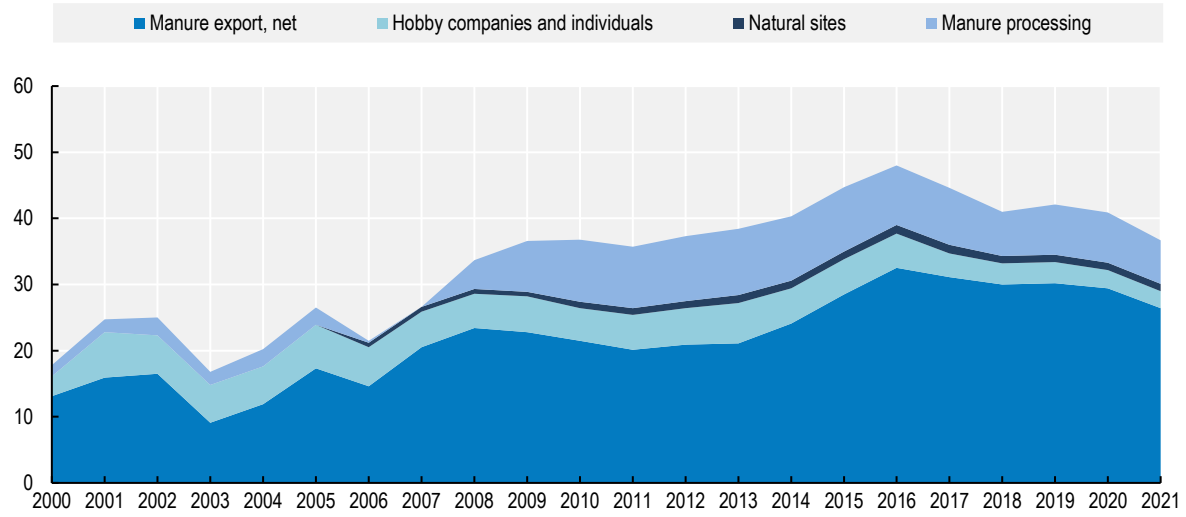
Around 80% of the feed requirement (measured in calories) for cattle production in the Netherlands comes from domestic sources, but only about 15% for pigs and 5% for chickens. Most feed grains (wheat and barley) for pig production are imported from Germany, France, and Belgium, with about 10% supplied domestically (mainly wheat). Soy is mainly imported from North and South America (CBS et al., 2022[40]).

The nutrients in imported feed not retained in the animal or lost to the atmosphere will remain in the manure. Excess nutrients above the carrying capacity of Dutch farmland must be disposed of by other means. About 18 million kg of phosphate in pig manure is exported to Germany, France, and Belgium, each year, 35-45% of the manure produced. Some of this manure is also sold in retail garden markets or applied to natural areas (Figure 3.12).

The load of nutrients from agriculture on surface waters is monitored by the Nutrient Monitoring Network for Agricultural Specific Surface Waters (MNLSO). The results of the MNLSO show that the water quality in agriculture-specific waters is improving, but that in the period from 2014 to 2017 approximately 40-60% of the measuring locations did not yet comply with the water authority standard for total N or total P. This suggests that current agricultural practice of fertilisation according to agricultural advice and economically optimal crop choices is not sufficient to achieve WFD targets for water quality (Berkhout et al., 2019[41]).

Figure 3.12. Most surplus phosphate in manure is exported

Million kg P_2O_5



Note: Only a small amount of manure from cattle is exported. On a phosphorus basis, exports are about equally divided between pig and poultry sources.
Source: CBS, PBL, RIVM, WUR (2022). Manure disposal outside agriculture, 2000-2020 (indicator 0403, version 21, 9 March 2022), www.clo.nl. Central Bureau of Statistics (CBS), The Hague; PBL Netherlands Environmental Assessment Agency, The Hague; RIVM National Institute for Public Health and the Environment, Bilthoven; and Wageningen University and Research, Wageningen.

3.4.2. Policies and regulations

There are four major policy thresholds to be achieved with respect to manure and nutrient use. These are:

- Ammonia (NH_3) emissions should remain below the level that would lead to N deposition above critical thresholds (overall target of -50% by 2030).
- Nitrate (N_3^-) emissions should remain below the level that would lead to degradation of surface and groundwater quality (WFD directive targets, 50 mg/l).
- N and P application within the Good Agricultural Practice, and N from livestock manure should remain below the limit set in Nitrates Directive (170, 230 or 250 kg N/ha, total N and P manure-production below 2002 quantities).
- Methane (CH_4) emissions should be below GHG targets (total GHG emissions of sector to be reduced by 49% by 2030).

All of these thresholds are closely related to livestock production, specific animal husbandry or other farming practices. Success requires meeting all four of these thresholds sustainably over time. Effective policy packages for manure and nutrients would ideally take a holistic view of how to jointly meet these thresholds. In principle, one threshold will be binding with respect to livestock numbers and the others met either as a consequence of that binding limit or with some additional management changes.

These thresholds have a strong local element, except for total N and P application limits and GHG emissions. Therefore, which threshold binds on animal numbers and the degree of adjustment required to meet thresholds will likely differ by region. To what extent local factors are taken into account will depend on local capacity to measure and monitor effects, and the point at which increasing administrative and transactions costs outweigh the benefits of a more precise local optimisation.

The Netherlands has an extensive policy on the use of fertilisers. The Nitrate Action Plan requires farms to develop and follow nutrient management plans. Other requirements of the plan include restricting

fertiliser use to the growing season (1 February – 15 September), animal manure must be spread on fields using low-emission application techniques and cover and catch crops are promoted (National Administration, 2021[8]) and in some cases required.

Current polices to reduce the number of livestock operations create significant policy uncertainty. The Council for the Environment and Infrastructure suggests that one way to give future prospects to farmers who wish to operate sustainably is to clarify the sustainability criteria for farms on the basis of measurable and enforced standards that are sufficient to meet targets (RLI, 2021[42]). This would reduce policy uncertainty faced by farmers, which is an important component of perceived risk.

The Environment and Planning Act will come into effect in 2022, as a result of which municipalities will have to deal with new procedures, requirements and work processes when assessing applications from livestock farmers to withdraw or change their environmental permit and to change the destination of their production location.

The EU Nitrates Directive aims to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution.[13] The Netherlands has designated the entire territory as a vulnerable zone and implemented the Nitrates Directive through:

- The Fertilizers Act, its Implementing Decree (*Uitvoeringsbesluit Meststoffenwet*, Ubm) and its Implementing Regulations (*Uitvoeringsregeling Meststoffenwet*, Urm). This covers, among other things, ceilings for the production of animal manure, animal and phosphate rights and application standards for fertilisers.
- The Activities Decree (*Activiteitenbesluit*, Ab) based on the Environmental Management Act and the Water Act, which includes cultivation and manure-free zones, among other things.
- The Decree on the Use of Fertilizers (*Besluit gebruik meststoffen*, Bgm) based on the Soil Protection Act, which provides regulations for the use of manure, including when manure may not be spread and how manure must be used to reduce ammonia emissions into the air.
- The Nitrate Action Plans, the 7th of which covers 2022-25.

7th Nitrate Action Plan

The measures in the action plan also contribute to the objectives of the Water Framework Directive (WFD) insofar as agricultural practice is responsible for emissions of nitrogen and phosphorus to ground and surface waters (including coastal and transitional waters) that affect WFD targets. The 7th Action Plan sharpens the focus on problem areas and problem crops with regard to nutrient leaching. The action programme is built on five pillars and contains a mix of mandatory and supporting measures that are either nationally applicable or area-specific. These pillars are:

- *Sustainable construction plans* to improve water quality and soil quality, for both livestock and arable farms. The focus is on a clear transition from a growth path to sustainable path. The transition is facilitated with support from the Common Agricultural Policy and the Delta Plan for Agrarian Water Management.
- An *area-specific approach* in areas where the water quality of groundwater or surface water is less than good. The basic principle is that the entrepreneur takes the initiative and responsibility for the immediate vicinity of their operation.
- *Other regulatory measures* as needed to achieve the necessary improvement in water quality. This includes wider integrated buffer strips and an update of the nitrogen application standards and measures that broaden the options for applying manure and organic matter-rich fertilisers.
- *Knowledge, communication and pilots*. Knowledge development emphasises on manure policy as a means of achieving good water quality.

- *Control and enforcement*. The Reinforced Enforcement Strategy will be pursued in co-operation with local authorities. A process with the sector will be undertaken to gain more insight into the use of artificial fertilisers, with tighter enforcement for misapplication of fertilisers (LNV, 2021[43]).

In addition to these five pillars, the existing regulations from the 6th Action Plan will be continued.[14]

Programmes to terminate livestock activities

The Livestock Operation Purchase Scheme (*Maatregel Gerichte Opkoop*, MGO) was established in 2020 with a budget of EUR 483 million and targets livestock farms that cause a deposition of at least 2 mol N/ha/year on average on nitrogen-sensitive hectares on which the critical deposition value is exceeded, located within a distance of 10 km. According to the RIVM, there are more than 800 livestock farms that can be classified as peak loaders under these conditions. Together, these companies emit approximately 5 kilotons of ammonia. This is approximately 4% of the total ammonia emissions in the Netherlands (Kamerstuk 35334 no. 170).

To implement this programme, the central government provides funds to the provinces that can be used to purchase livestock farms based on their market value. These purchases are also subject to cost-effectiveness ceilings for reducing nitrogen deposition. In the second and third tranche of the MGO, provinces will buy out those peak loaders in a targeted way to create space for housing and MIRT trajectories and legalising activities, in addition to nature conservation, restoration and improvement.

In addition to the MGO which is focused on reducing deposition in sensitive areas, the National Termination Scheme for Livestock Farm Locations (*Landelijke beëindigingsregeling veehouderij*, LBV) is designed to achieve maximum nitrogen reduction. Both schemes complement each other. LBV is a voluntary subsidy scheme for livestock farmers who want to discontinue their business or a location of their business. Eligible farmers keep animals requiring production rights; dairy cattle, pigs or poultry and whose nitrogen emissions exceed a threshold value. The programme budget is EUR 970 million. If the full subsidy amount is used, a nitrogen reduction of 16 to 35 mol is expected.[15] The LBV focuses on reducing nitrogen precipitation as efficiently as possible and applications are ranked according to cost-effectiveness.

Uptake of these programmes by farmers has been less than anticipated, and the parameters of the schemes. A version of LBV, called LBV+ will be available for a limited time to farmers with high ammonia emissions near sensitive areas. LBV+ provides a higher payment and is designed in part to increase early uptake and achieve significant progress in reducing ammonia emissions in 2023. This concept of higher payments available for a limited duration was proposed in the Remkes report, with the additional incentive that measures would be increasingly mandatory in nature over time and if objectives were not met through voluntary measures (Remkes, 2022[5]).

An important question is what happens to the land once a livestock operation is terminated. A pilot project has allocated EUR 100 million for purchasing land from participants in the LBV. This is intended to help address challenges in rural areas. For example, purchased land can be used to enhance nature or to extensify agricultural land. The land fund will come into effect as soon as the first tranche of the LBV goes into operation.

The Subsidy Scheme for the Remediation of Pig Farms (*Subsidieregeling sanering varkenshouderijen*, Srv) programme provides a subsidy for the irreversible closure of a pig farming location if the odour from the location is above a certain level and it is located within an area with a high concentration of farms. The programme payment compensates for the value of the production rights (100%) and the value of the loss of production capacity as result of the closure of the location (65%). The budget for the programme is EUR 450 million, but some of this has been transferred to the MGO due to low uptake.

On-farm improvements to reduce ammonia emissions

In addition to the purchase scheme, a number of technical adaptations are to be put in place as part of the overall plan for ammonia emissions reductions. The most important of these are:

- The crude protein content in the dairy feed ration is to be gradually reduced at sector level to a maximum of 160 gr RE/kg ds in 2025. This should reduce ammonia emission by 3.5 kilotons per year in 2025.
- Increase in the average number of grazing hours by 180, calculated for all dairy cows in the Netherlands (grazing and non-grazing), compared with 2018. This will be done in steps, with an increase of 90 extra hours by 2022 and 180 hours from 2023. This should reduce ammonia emissions by 0.7 kilotons per year.
- By 2025, half of the manure that is applied to sandy soil with a sod injector in grassland should be diluted in a 2:1 ratio (2 parts manure to 1 part water). This should reduce ammonia emissions by 0.4 to 1 kiloton per year.

3.5. Climate change

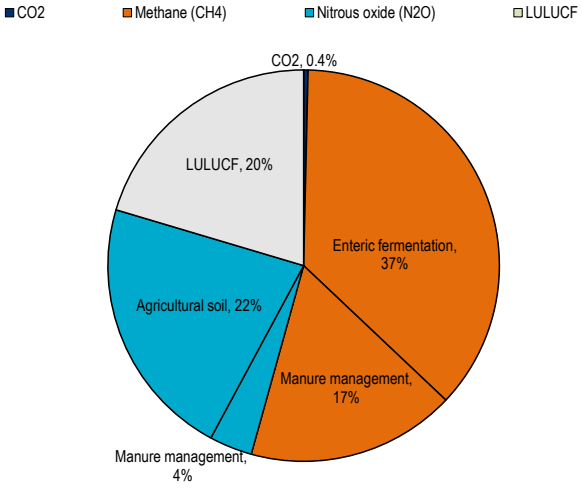
3.5.1. Assessment of status and trends

In 2021, agriculture contributed 16.1% of the national GHG emissions in comparison with 14.9% in 1990.[16] However, this sector is a major contributor to both national total Methane (CH_4) and Nitrous Oxide (N_2O) emissions. In 2019 agriculture accounts for 76% of the total CH_4 emissions and for 73% of the total N_2O emissions. The main source of agricultural GHG emissions is enteric fermentation, followed by manure management and agricultural soils (Figure 3.13). A trivial amount comes from liming of soils to adjust acidity.

Since 1990, the agricultural and horticultural sector has reduced greenhouse gas emissions by roughly 17%. However, GHG emissions from agriculture have stabilised in the last ten years. GHG emissions intensity as a share of value of production has improved and this is expected to continue with the application of new technologies and growth in total output. However, the reduction in intensity has slowed down from -2.54% per year in 1991-2000 to -0.65% in 2011-19 (Chapter 1). The Netherlands has the highest GHG emissions (CH_4 and N_2O) per hectare of agricultural area in the European Union, more than four times the EU-27 average. This reflects the intensive nature of Dutch agriculture (EC, 2020[44]). Horticultural production processes in greenhouses account for more than 10% of total natural gas consumption in the Netherlands, but the related CO_2 emissions are not included in reporting for agriculture.[17] Progress in agricultural GHG emissions reductions is nevertheless in line with OECD and EU averages, if less than that in Belgium and Denmark (Figure 3.14). Nitrous oxide emissions have shown the greatest reduction, with methane reductions relatively flat. The sector will need to draw on many different mitigation measures such as carbon capture in soils, forests and materials, production of biomass and generation of renewable energy to reach its emissions reductions objectives (Government of the Netherlands, 2019[45]).

Figure 3.13. Methane from enteric fermentation or manure management is the largest source of agricultural GHGs

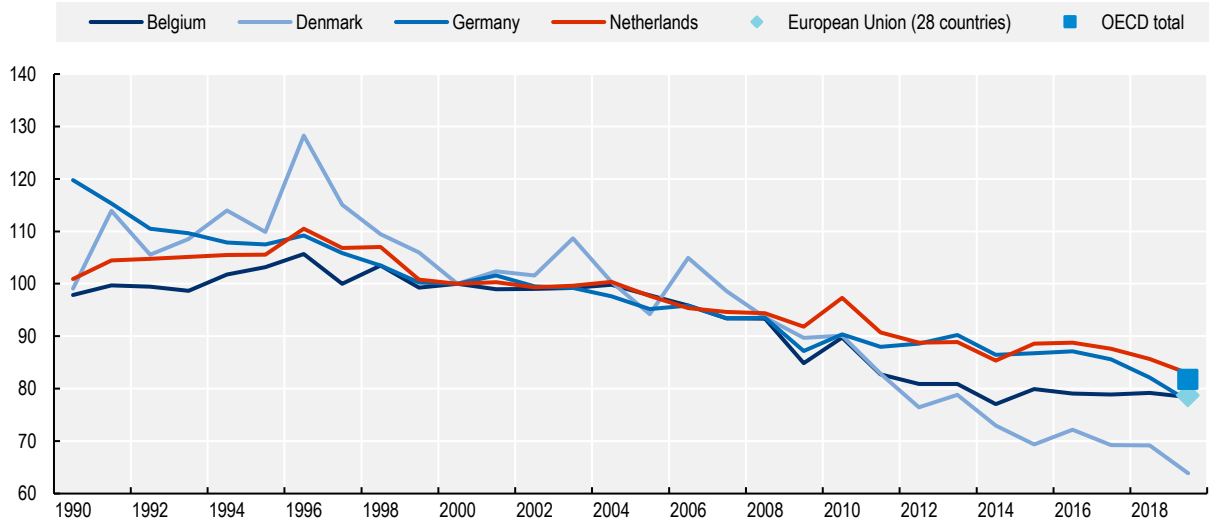
Total greenhouse gas emissions by source, 2019



Note: $C0_2$ emissions from liming of soils and application of urea are too small to see clearly on this chart.
Source: OECD AEI Database.

Figure 3.14. Agricultural GHG emissions have declined by 17% since 1990

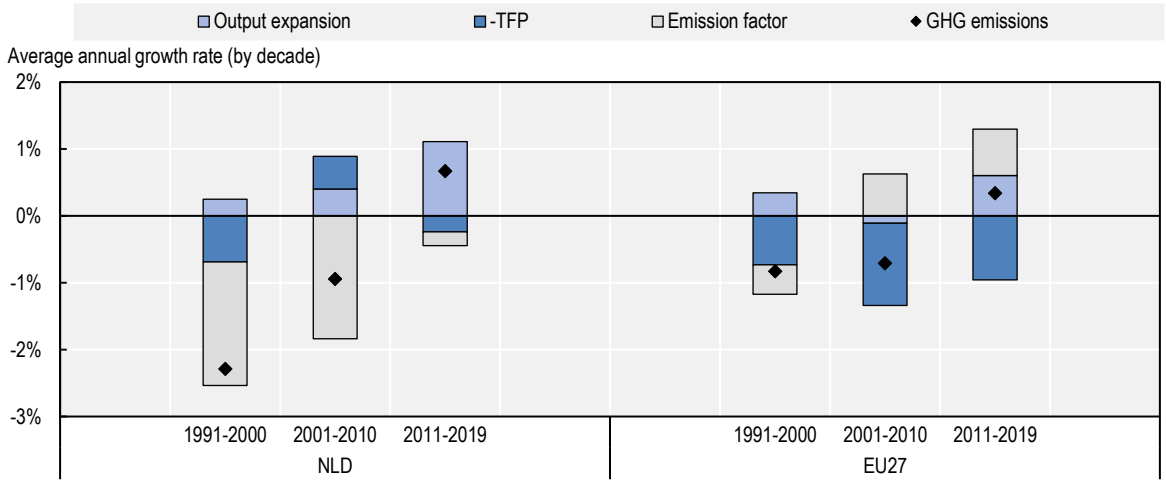
Agricultural GHG emissions, 1990-2019, $C0_2$eq, index year 2000=100



Note: For clarity, only last year values for EU-28 and OECD average are shown. Excludes emissions from LULUCF.
Source: OECD AEI Database.

The main contributor to the reduction of emissions has been the improvement in the emission intensity of production factors, which has been more pronounced than in EU27 (Figure 3.15). That is, production technology has shifted towards less emitting inputs. In the most recent decade, expanding output was not counteracted by the effects of improved productivity and emission factor, resulting in higher GHG emissions.

Figure 3.15. Evolution of changes in GHG emission intensity in the Netherlands, EU and OECD (1991-2019)



Source: Authors calculations based on USDA ERS (2021), International Agricultural Productivity database.

Emissions from enteric fermentation, and to a lesser extent manure management are driven by livestock numbers. CH_4 emissions from enteric fermentation decreased from 9.2 Mton CO_2eq. to 8.1 Mton (-12%) between 1990 and 2019, which is almost entirely explained by the decrease in CH_4 emissions from cattle. Cattle accounted for the majority (89%) of CH_4 emissions from enteric fermentation in 2019 (RIVM, 2021[46]).

The majority of emissions from manure management is CH_4, mainly related to cattle and swine. Emissions from swine manure have been declining steadily, while emissions from cattle manure have been increasing since the mid-2000s. With an increasing percentage of cattle kept indoors, a larger proportion of the manure is excreted inside animal housing facilities. This has a higher emission factor than excretion on pasture.

Inorganic fertilisers are the main source of emissions from agricultural soils, and these emissions have been steady over the last decade. Emissions from organic nitrogen have been increasing in recent years, but emissions from urea and manure from grazing are lower.

Net emissions from land use, land-use change and forestry (LULUCF) including sources and sinks was 4.5 Mt CO_2eq in 2019. Land use in the Netherlands is dominated by agriculture (approximately 55%), followed by settlements (15%) and forestry (9%); 3% comprises dunes, nature reserves, wildlife areas, heather and reed swamp. The remaining area (18%) is open water. Since 1990, agricultural land area has decreased by about 5%, mainly because of conversion to urban or natural functions. Organic soils (peat) have received increasing attention Because emissions of CO_2 from the decrease in carbon stored in peat soils were the major source in the LULUCF sector and total 5.5 Mt CO_2 in 2017 (7.6 Mt CO_2 in 1990). This peat oxidation is due to agricultural and water management. The major sink is the storage of carbon in forests, which was -1.8 Mt CO_2 including forest land and land converted to forest land.

3.5.2. Reducing GHG emissions

The Dutch Government targets GHG emissions reductions of 49% by 2030, compared to 1990 levels, and a 95% reduction by 2050. These goals are set out in the Climate Act of 28 May 2019. The Climate Plan,[18] the National Energy and Climate Plan (NECP) and the National Climate Agreement contain the policy and measures to achieve these climate goals. The Climate Act provides a framework for the development of policies on greenhouse gas emission reductions. The national government plans to allocate

EUR 970 million between 2020 and 2030 to realise the 6 Mt ambition, of which EUR 330 million will come from the Climate Budget. (Government of the Netherlands, 2019[45]).

The National Climate Agreement, which was concluded in June 2019, specifies what the agricultural sector will do to help achieve the climate goals. Targets are set for different sub-sectors: livestock farming, greenhouse horticulture, peatlands, agricultural soils and forests and nature areas. To increase the sense of ownership, the execution of the agreed measures is assigned to working groups for each sub-sector, consisting of representatives of the sub-sectors and LNV (National Administration, 2021[8]). For the agriculture and land use sector as a whole, the emissions reduction target has been set at -3.5 $MtCO_2$-eq by 2030, on top of existing policy which called for -1 $MtCO_2$-eq in methane emissions and -1 $MtCO_2$-eq from reduced energy demand in greenhouses. Land use does not count towards the 49% reduction target in the Climate Agreement, but actions in land use change and forestry (LUCF) are expected to reduce GHG emissions by 1.5 Mt by 2030.

The current efforts to reduce ammonia emissions below critical thresholds for nature restoration is expected to also help reduce GHG emissions by as much as 5 Mt CO_2-eq, easing somewhat the path to emissions reductions to 2030 and beyond. That is, the investment subsidy for low-emission animal housing and corresponding tightening of standards, along with the national cessation scheme for livestock farms (see section on manure and nutrients) will be major contributors to the reduction targets for agriculture. There are other potential synergies between climate policy and other environmental objectives. Reducing emissions from peatlands are also likely to improve biodiversity values on those landscapes, for example. Actions that have multiple benefits can be more cost-effective, a point for consideration when designing and evaluating policy choices. Many of the investment policies mentioned in the section on Sustainable production, below, are relevant for GHG emissions reductions with some being adapted to focus more on climate.

The national climate agreement contains a goal of emissions reductions of 1 Mt CO_2eq from peatlands. The Peatland programme brings together national and regional governments as well as nature and agricultural organisations. The initial phase of the programme is focused on research, pilots, monitoring, awareness, area-oriented planning and specific measures for regions with opportunities for higher ground water levels.

The Stimulation of Sustainable Energy Production and Climate Transition (*Stimulering Duurzame Energieproductie en Klimaattransitie*, SDE++) scheme focuses on the large-scale roll-out of technologies for renewable energy production and other technologies that reduce carbon dioxide (CO_2) emissions. For agriculture, this includes production and combustion of bioenergy, such as from manure. The SDE++ is an operating subsidy that makes payments during the operating period of the project. An SDE++ subsidy compensates for the difference between the cost price of the sustainable energy or the reduction in CO_2 emissions and the revenue (if any) (RVO, 2021[47]).

The *Integrated approach methane and ammoni*a is a research programme, with its accompanying network of companies, helps to identify and evaluate the effectiveness of measures to reduce emissions of methane and ammonia. Differences in effectiveness between different soil types is taken into consideration. Measures which have proven to be effective will be implemented on a larger scale. The main challenge is that the majority of livestock farmers is not aware of the methane emissions of their farms and that measures to reduce methane emission are relatively costly (National Administration, 2021[8]).

The Netherlands is part of the Global Research Alliance (GRA) on agricultural GHG emissions, which provides an international framework for voluntary action to increase co-operation and investment in research activities to help reduce the emissions intensity of agricultural production systems. Members of the GRA aim to deepen and broaden mitigation research efforts and to co-ordinate cross-cutting activities, including promoting synergies between adaptation and mitigation efforts. Research Groups address these areas of work, through work plans that bring countries and partners together in research collaborations, knowledge sharing, use of best practices, and capacity building among scientists and other practitioners.

The Dutch contribution to the GRA is co-ordinated by the Ministry of Economic Affairs which links these contributions to other actions concerning food security, sustainability and climate change. Given that Dutch farmers work with limited space and expensive resources, the Netherlands has developed experience in "sustainable intensification" in agriculture and food chains. The framework of the GRA enables the sharing of this experience and offers an opportunity to learn from others.

3.6. Water

3.6.1. Assessment of status and trends

About one-third of the Dutch land area lies below sea level. This unique geographical delta location is particularly vulnerable to ocean and weather. The Dutch relationship with its coastline and catastrophic storm surges in the past has led the Netherlands to develop one of the world's most sophisticated water management systems. Climate change will likely put these systems under pressure with rising sea levels and a higher frequency of extreme weather events.[19] Subsequently, rising sea levels and intruding ocean water could also lead to an increasing salinisation of ground water which not only endangers drinking water supply and industrial production but sets new challenges to the agricultural sector as well. Agriculture will need to become more resilient to longer droughts during the summer months, and adapt to flooding rivers during the remaining seasons. (Baptist et al., 2019[48])

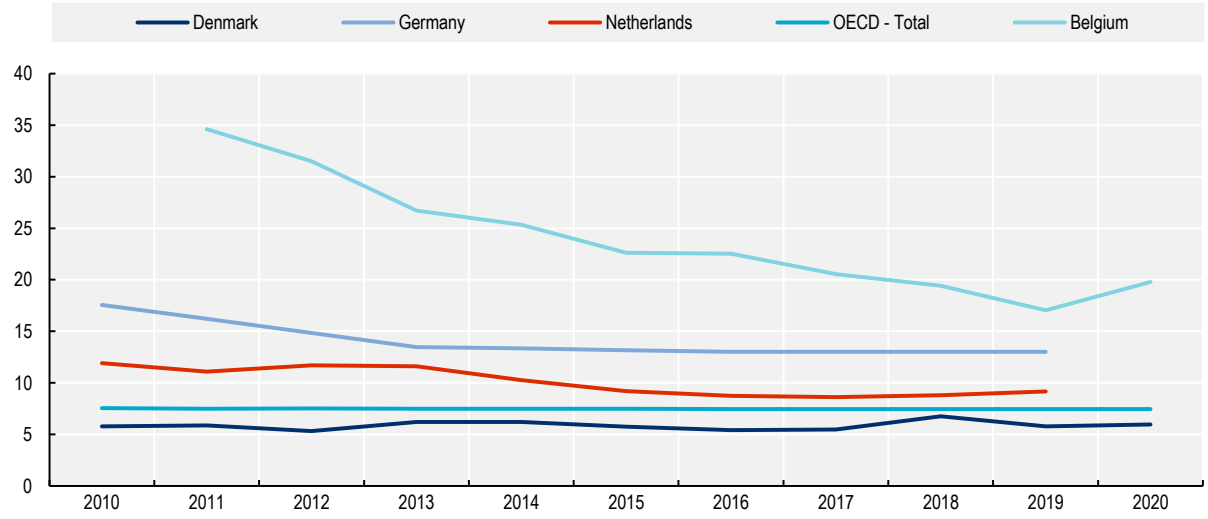
While all groundwater bodies are in good quantitative status, 13% of groundwater bodies do not have good chemical status. The situation is worse for surface waters where all surface water bodies were in less than good ecological status and 52% of surface waters do not have good chemical status. Diffuse pollution from agriculture is the most significant pressure on surface waters and second most significant pressure on groundwater. The average nitrogen surplus in the Netherlands, at 200 kg N per hectare per year, is four times the EU average (EC, 2020[44]). The chemical quality in most water bodies is insufficient and the ecological quality ranges from moderate to poor (CBS et al., 2021[49]). Water quality objectives are set at the EU level with respect to both drinking water quality and the status of water bodies.

In many areas the water table has been lowered for agricultural and residential land uses or is drawn down by drinking water abstraction, which can lead to lower groundwater levels in natural areas as well, resulting in desiccation. Reduced groundwater levels in the spring is a major reason for the loss of rare species in ecosystems, and impairs the water-buffering capacity of land to store and slow excess rainfall.

Gross abstractions of freshwater taken from ground or surface waters is about 12% of total available renewable freshwater resources. Water stress in the Netherlands is above the OECD average, but low in absolute terms (Figure 3.16). While average water stress has been improving in the Netherlands, climate change is expected to increase risk of drought and may become a driver of increased water stress in the future.

Figure 3.16. Water stress in the Netherlands is low but above OECD average

Freshwater abstraction as % of renewable supply



Note: Missing values for Germany interpolated.
Source: OECD Environment Database – Freshwater abstractions (million m3).

3.6.2. Policies and regulations

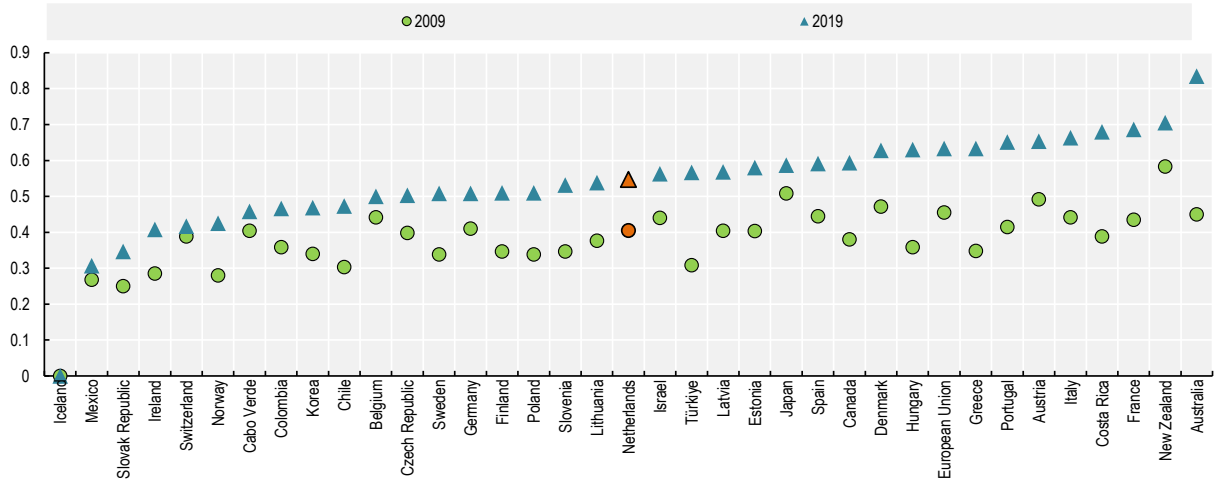
The load of nutrients and plant protection products on surface water in the Netherlands has improved in recent years, but this improvement has not been enough to achieve the goals of the WFD and policies will have to be strengthened if WFD goals are to be achieved. Level-controlled drainage, buffer strips, catch crops and soil improvement, improved manure management and integrated pest management are all measures that could potentially improve the situation (ten Brinke et al., 2021[50]).

The effects of policies on water bodies will manifest only after a certain period of time. The age of groundwater at different depths and in different soil types can vary significantly, as can the amount of time for nutrient-rich water to enter surface waters. Increased frequency of severe drought or excessive rainfall can also affect N concentration and the rate of transport of nutrients into in the water system. The effects of excess nutrients are difficult to reverse in the near term. This is also true for persistent chemicals, which may affect water quality for decades.

Water policies in the Netherlands are only partially aligned with the OECD Council Recommendation on water (Figure 3.17). The most progress in water policy has been with respect to the recommendations of Chapter 3 on water quantity, and policies in this area are most aligned with the recommendation (Gruère, Shigemitsu and Crawford, 2020[51]).

Figure 3.17. Water policies are increasingly aligned with OECD recommendations, more progress possible

Average alignment of agriculture and water policies with the Council Recommendation on Water by country, 2009 and 2019



Note: Average indices have been adjusted to cope with the heterogeneity in response rates for each chapter. Chapter 8 indices of alignments were adjusted to account for text caveats, but they remain imperfect and should be subject to cautious interpretation. The EU score is based on partial data as policies are primarily defined at member state level.
Source: Gruère, Shigemitsu and Crawford (2020[51]), "Agriculture and water policy changes: Stocktaking and alignment with OECD and G20 recommendations", http://dx.doi.org/10.1787/f35e64af-en.

Water Management and the National Water Program 2022-2027

Responsibility for water management in the Netherlands lies with the executive branch of the Ministry of Infrastructure and Water Management (*Rijkswaterstaat, RWS*) and the regional water management boards. Their duties are:

- RWS is responsible for the management of the major waters, such as the sea and the rivers. It ensures that the government authorities responsible are alerted in good time to floods or stormy seas. In addition to maintaining dykes, dams, weirs, and storm surge barriers, RWS protects the coast and river navigation, for example, by deepening floodplains and constructing secondary channels.
- District water boards are responsible for regional waters, such as canals and polder waterways. They ensure that the water quality does not harm fish stocks. The district water boards also protect the country from flooding and ensure that farmers have sufficient water for their crops. Furthermore, they are responsible for wastewater purification.[20]

The National Water Program 2022-2027 (NWP) was adopted on 18 March 2022. The NWP describes the main features of national water policy and its implementation in national waters and waterways. The NWP has three main components: river basin management plans (RBMPs), Flood risk management plans (FRMPs) and the North Sea programme, which all take the form of annexes to the NWP. Of these three elements, the RBMPs are most relevant to agriculture, which is an important non-point source of nutrient and chemical pollution.

Under the EU Water Framework Directive (WFD), RBMPs are produced every six years, the latest covering 2022-27. They RMBPs identify increasing concentrations of nitrates from agricultural sources as a cause for concern amid otherwise generally improving water quality status and anticipate continued improvements in status as the effects implemented programmes are felt over time. The current RBMPs

aim to put in place by 2027 a final set of measures sufficient to restore water bodies to good status as per the WFD, but these measures are expected to need some extra time beyond 2027 to fully meet their objectives (Ministerie van Infrastructuur en Waterstaat, 2022[52]). As a rule, measures are often part of projects that serve multiple purposes and are often jointly financed.

Regarding plant protection products, RBMPs are aligned with the 2030 Vision for Crop Protection. The Environmental Management Activities Decree contains rules for farmers to reduce surface water pollution. In addition, there are non-statutory emission reduction plans that are drawn up and implemented by the sector if measurements show that water quality requirements for pesticides are exceeded.

The EU Floods Directive requires that Member States produce flood risk management plans (FRMPs) every six years, following an approach similar to the WFD. FRMPs evaluate flood risks, identify areas most at risk, map the consequences of flooding in at-risk areas and define goals and measures to manage flood risks in the designated areas. The 2016-21 FRMP set out seven objectives and 17 measures, almost all of which have been implemented. Nevertheless, flood risk management is a continuing process; many goals require ongoing attention and many measures have a cyclical character (Ministerie van Infrastructuur en Waterstaat, 2022[53]).

Partnership programmes for water quality

In 2013 the Dutch agricultural and horticultural organisation (LTO Nederland) and the Dutch regional water authorities began a collaboration to reduce emissions from farms to water: the Delta plan for agricultural water management (*Deltaplan Agrarisch Waterbeheer*–DAW). In addition to the water boards, the provinces and drinking water companies have joined this initiative over the years, as well as the Ministry of Infrastructure and Water Management (*IenW)*, and the LNV. The ambitions of the Delta plan were to:

- Solve 80% of the remaining water quality problems in a motivating and stimulating manner by 2021 and 100% by 2027.
- Use water sparingly at company level, conserve water at area level and use smarter distribution and buffering at national level to make the agricultural water supply sustainable by 2021.
- Increase the agricultural production potential at regional level by 2% per year through area processes, new spatial instruments and innovative techniques (Ministerie van Infrastructuur en Waterstaat, 2022[52]).

Since 2014, the number of farmers participating has grown to 15 000 taking part in nearly 500 projects across the country. The Delta programme focuses on impacts of increased rainfall, droughts, sea level rise and heat. To address these risks, the programme targets restoration of the water-retention capacity of natural areas and agricultural land, improved agricultural practices such as grassland management to enhance carbon sequestration and appropriate use of lowland peatland/wetland and the of risk salinisation of delta areas due to sea level rise, to be addressed through the development or enlargement of fresh water lenses (EC, 2020[44]).

IenW and LNV jointly operate the Programmatic Approach Large Waters (Programmatische Aanpak Grote Wateren, PAGW) investment programme. The aim of this programme is to improve water quality and nature in large water bodies by expanding and connecting them as well as improving their habitat values. Projects under the PAGW are carried out with companies, social organisations and other government levels. A national programme team supports partners in preparation, planning and implementation of projects. PAGW supports targets for ecological water quality and nature in large waters stemming from the WFD and BHDs. The measures are intended to provide space for natural processes and flows of water, sand and silt where former hydraulic works impede them (Rijkswaterstaat, 2017[54]).

3.7. Conclusions

Putting the agricultural sector on a sustainable footing has become an urgent task since the 2019 Court of Auditors ruling with respect to the PAS and the BHD. While the ammonia crisis is a strong impetus for action, the sector has many longstanding sustainability issues that require attention. These too will become more urgent over time, due to international commitments such as with respect to the EU Green Deal, GHG emissions and the WFD, and also because environmental problems such as declining farmland biodiversity are becoming more serious and costly to reverse.

Past progress in reducing emissions from agriculture and putting production on a more sustainable footing has slowed in the last decade. While environmental programmes and regulations have been continually strengthened, the pace of improvement has been insufficient to fully address environmental problems. The result is a stagnating situation with respect to environmental quality. The pressure on Dutch ecosystems increased after EU dairy quotas were eliminated in 2015 and the size of the dairy herd subsequently increased considerably. In fact, the agriculture sector was allowed to grow beyond the carrying-capacity of the environment, which precipitated the current situation with excessive ammonia emission that now must be reduced at great cost. EUR 24.3 billion has been allocated for a transition fund for the sector by 2030, in addition to EUR 5 billion already in place for emissions reductions measures (mainly restructuring through buy-outs). Current objectives are to reduce nitrogen deposition on 74% of sensitive habitats in Natura 2000 areas below critical thresholds by 2030.

Current problems have their root in past policy assumptions that it was possible to have continued agricultural development along with environmental improvement driven by higher productivity and nutrient efficiency. Long-term strategic planning was either absent or failed to identify the risks of continued missed objectives with respect to nutrient emissions and water quality.

This model is changing, and 2018 saw the introduction of the Circular Agriculture Vision which set out long term objectives of a sector more in balance with nature. While the Vision provides guidance regarding the future shape of the sector, it is not specific enough to inform strategic planning processes. A more elaborated vision combined with a more strategic approach to sector development that takes into account environmental limits can help ensure that undesirable consequences are avoided and objectives are met.

The CSP (described in Chapter 1) shows potential to increase the effectiveness of policies aimed at improving the environmental performance of agriculture. The multi-dimensional eco-scheme, where farmers gain higher payments for taking on more and more challenging actions on farm, can help improve the quality of implementation by giving producers incentives to choose more effective actions. AES in Pillar 2 extends the application of objective-based and community-based approaches to include climate and water issues.

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Notes

[1] See https://www.government.nl/ministries/ministry-of-agriculture-nature-and-food-quality/vision-anf.

[2] Enacted 1 July 2021.

[3] In 2022 the government agreed to bring forward the 74% objective to 2030 from 2035. The prior goal was 50% by 2030.

[4] These were laid out in a series of three letters to parliament (*Kamerbrief*) released simultaneously on 25 November 2022.

[5] The future of this programme is uncertain as a letter to Parliament mentions it may be eliminated and funding transferred to other programmes. See the Kamerbrief LGS / 22558512 of 22/11/2022 on the Porthos ruling.

[6] In a recent development, it has been proposed to cancel the NCB and redirect the allocated funds elsewhere.

[7] See https://zoek.officielebekendmakingen.nl/stcrt-2017-169.html.

[8] See https://www.rvo.nl/subsidies-financiering/mia-vamil/milieulijst/wijzigingen-milieulijst.

[9] See https://www.maatlatduurzameveehouderij.nl/over-mdv/.

[10] See https://www.agro-forestry.nl/.

[11] The Netherlands Nature Positive document was presented at the 2019 Nature Summit. https://www.rijksoverheid.nl/actueel/nieuws/2019/10/02/nederland-natuurpositief.

[12] Eurostat (online data code: ef_lsk_main for LSU, ef_m_farmleg for UAA total).

[13] See https://www.eea.europa.eu/archived/archived-content-water-topic/water-pollution/prevention-strategies/nitrate-directive.

[14] See 7th Action Plan at this link: https://www.rijksoverheid.nl/documenten/publicaties/2021/11/26/7e-nederlandse-actieprogramma-betreffende-de-nitraatrichtlijn 6th action plan at this link: https://www.tweedekamer.nl/kamerstukken/detail?id=2017Z18918&did=2017D38906

[15] A mol is a measure of nitrogen deposition. 500 mol represents deposition of approximately 7 kg N/ha/year. The national average nitrogen deposition is about 1 500 mol.

[16] Comprehensive data on GHG emissions in the Netherlands available here: https://www.emissieregistratie.nl/data/overzichtstabellen-lucht/broeikasgassen.

[17] Horticulture producers use natural gas to generate electricity, using co-produced waste heat and CO_2 to heat and enrich greenhouses.

[18] The draft climate policy programme produced in June 2021 proposes to raise the target to a 55% reduction in 2030 and to reduce the net greenhouse gas emissions to zero in 2050. This also contained a

revised estimate of the reduction of emissions from peatland to 0.7 MtCO2-eq from the current anticipated 1 Mt.

[19] See https://www.knmi.nl/klimaat.

[20] See https://www.government.nl/topics/water-management/water-management-in-the-netherlands.

4 Innovation for sustainability

The Dutch Agricultural Knowledge and Innovation System (AKIS) is highly developed, with active private sector and public support. The system has successfully brought a high standard of productivity and international competitiveness. The challenge is to use this powerful AKIS to better address environmental pressures. This chapter examines the Dutch AKIS, presenting its main actors, institutions and governance, the sources and flows of its funding, and the interactions between actors, such as via the tripartite “Top Sector” approach. It describes policies in place to facilitate innovation in the agri-food sector including the role of institutions like Wageningen University Research (WUR) and the linkages with education created by the Groenpact initiative. The chapter also assesses how well the skills of Dutch agricultural workers are matched to their roles. In the final section, examples of Dutch initiatives to promote innovation for environmental sustainability are presented.

Key messages

- The Dutch Agricultural Knowledge and Innovation System (AKIS) is highly developed, with active private sector and public support. The system has successfully brought a high standard of productivity and international competitiveness. The next challenge is to use this powerful AKIS to further address environmental pressures.
- Some of the strengths of the system are:
  - The Netherlands has a world-class agricultural education system with many highly rated training institutes and universities and Dutch farmers are relatively well educated. Wageningen University is consistently listed as one of the top universities in the world for agricultural education and research. The *Groenpact* initiative also complements this system.
  - The Netherlands Top Sector approach has created successful partnerships between government, companies and research institutions to deploy private research funding to improve the performance and competitiveness of the sector.
  - The "innovation on the farm" initiative helps provide independent agricultural advice without the expense of traditional public extension services. Peer-to-Peer learning systems, field labs and demonstration farms play an important role in technology transfer to and between farms.
  - International collaboration and partnerships on R&D raise the profile of Dutch researchers and their outputs and helps strengthen access to EU Horizon funds. The Dutch Government and agri-food research sector play an important role in global and bilateral co-operation initiatives.
- While some areas for further improvements are:
  - Data sharing, portability, and trust are still bottlenecks to achieving the full potential of digitisation for agriculture.
  - More needs to be done to ensure that workers have the right skills, particularly for temporary and seasonal workers.
  - The strategic priorities for the Top Sector system regarding the provision of public goods and environmental externalities need to be sharpened to address urgent environmental issues.

This chapter covers policies and progress with respect to innovation in the agricultural sector, including the structure of the innovation system, areas of focus, participants, partners, spending and results. It provides an assessment of the current state of the innovation system and a description of the relevant policies in place. Section 4.1 starts with a general description of the innovation system in the country as a whole, Section 4.2 covers general policies and approaches to research and development and Section 4.3 covers intellectual property. Next, the chapter turns its focus to the agricultural sector, covering the agricultural innovation system (Section 4.4), international co-operation (Section 4.5), human capital and skills (Section 4.6), digitisation (Section 4.7) and sustainability (Section 4.8). Section 4.9 provides some examples of innovation in practice with examples from arable and livestock farming, the horticultural sector and food processing.

4.1. General innovation profile and governance

The Netherlands is a world leader in the field of R&D in agribusiness. Fifteen of the twenty largest agri-food companies have established production or R&D centres in the Netherlands.[1] An abundance of large, globally networked and efficient research and development (R&D) spenders drives high rates of patenting activity (OECD, 2015[1]). The Netherlands places highly in many science, technology, innovation and competitiveness rankings.[2] The country ranked fourth on the overall European Innovation Scoreboard in 2022 (EC, 2022[2]), and fourth in Europe and sixth in the world on the Global Innovation index for 2021 (WIPO, 2021[3]).

The Dutch research system co-operates with partners from abroad and its researchers are well networked at international level. According to the European Commission (EC), the Netherlands' strengths are in *Attractive research systems*, *Linkages* and *Use of information technologies*. The Netherlands' top relative strengths are public-private co-publications, foreign doctorate students, lifelong learning (EC, 2022[2]).

Responsibility for Research and Innovation policy in the Netherlands, is covered by the Ministry of Economic Affairs and Climate Policy (EZK) and the Ministry of Education, Culture and Science (OCW), with OCW co-ordinating the national science policy agenda and public-sector education and research. The Dutch Research Council (NWO) has a mission "to promote scientific research with science and societal impact".

The National Growth Fund**,** launched in 2020, earmarked EUR 20 billion to support projects in the areas of knowledge development, research and development, innovation, and infrastructure across all sectors in the economy.[3] The fund is intended for investments that contribute to economic growth, such as knowledge development, infrastructure, research and innovation.

Agricultural Innovation policy falls under the responsibility of several ministries in the Netherlands; however, the Ministry of Agriculture, Nature and Food Quality (LNV) oversees defining and implementing national agricultural policies, including the EU Common Agricultural Policy (CAP), and finances research, innovation and knowledge transfer projects within the field, particularly through the two green "Top Sectors" (horticulture and agriculture). Furthermore, LNV is responsible for the applied research organisation of Wageningen Research (WR).[4]

4.1.1. Public private sector collaboration

The AKIS system, also called the "Triple Helix" or "golden triangle", works through co-operation between knowledge institutions, businesses and the government. The system is divided into nine leading export sectors as the "Top Sector" policy (*topsectorenbeleid*), which account for 80% of Dutch R&D. Two of the nine top-sectors are agri-food sectors: Agri-food and Horticulture & Starting Materials (Box 4.1). This has proven to be an effective model for driving innovation and has greatly improved the contacts between universities and the business community.[5] The Innovation Agenda of each Top Sector provides strategic

orientation to Dutch research and innovation activities. The strategic policy was created in the aftermath of the 2011 financial crisis to strengthen the collaboration between actors and to guarantee that R&D activities are channelled towards innovation and improve economic performance.[6]

Box 4.1. The agriculture and horticulture top sectors

Top Sector Agri & Food

The Top Sector Agri & Food has the ambition to be a world leader in successful solutions for global challenges in the fields of agriculture and food (for example, climate change or biodiversity). It aims to stimulate new knowledge and innovations, first and foremost by creating and financing research and innovation projects. This includes both fundamental and applied research and valorising the research outputs.

Top Sector Horticulture & Starting Materials

The goal of the Top Sector for Horticulture & Starting Materials is to be the world leader in successful solutions for global societal challenges in the areas of horticulture, food and a green environment. The Horticulture & Starting Materials sector is a strong, innovative and highly productive sector that has highly efficient logistics and processing systems at its disposal. It has among the best research institutions in the world, and public-private co-operation between industry, academia and the government is an intrinsic part of its make-up. By joining forces, it aims to tackle societal challenges while concurrently strengthening the economic clout of the sector. It does this at both national and international level.

Sources: https://topsectoragrifood.nl/en/over/ and https://topsectortu.nl/en/.

4.1.2. The new mission-oriented approach

In 2019 a new mission-driven approach was applied to the Top Sector innovation policy (Ministry of Economic Affairs, 2019[4]). The aim of mission-oriented innovation policy is to tackle societal challenges. The overarching mission is to achieve GHG emission reduction targets by 2050 through a cross-sectoral energy transition and improved sustainability. It also matches the mission-oriented innovation policy approach the European Union is following in the Horizon Europe framework programme for 2021-27 and in line with the OECD approach (Larrue, 2021[5]).

During 2019, Dutch ministries put forward a total of 25 missions, under four central themes. In their latest Knowledge and Innovation Agendas, the Top Sectors have specified how they plan to contribute to the development of innovations that address these missions. In addition, by signing the Knowledge and Innovation Covenants 2020-23 in November 2019, around 30 stakeholders committed budgetary funding totalling EUR 4.9 billion in 2020 to supporting these development efforts. The relevant missions for the two agri-food Top-sectors under the new mission approach include several environmental aspects such as a general reference to use of all residuals (circular agriculture), GHG emissions and ecological capacity and water management (Table 4.1).

Table 4.1. Overview of agriculture, water and food missions

Themes	Missions
Agriculture, water and food	• Reduction of the use of raw and auxiliary materials in agriculture and horticulture by 2030 and creating the maximum possible value from all end products and residuals by utilising them as fully as possible (circular agriculture). • By 2050, the agricultural and nature system will be net carbon-neutral. • The Netherlands will be climate-proof and water-resilient by 2050. • By 2030, [the Netherlands] will produce and consume healthy, safe and sustainable food, while supply chain partners and farmers get a fair price for their produce. • A sustainable balance between ecological capacity and water management vs. renewable energy, food, fishing and other economic activities, where this balance must be achieved by 2030 for marine waters and by 2050 for rivers, lakes and estuaries. • The Netherlands is and will remain the best-protected and most viable delta in the world, with timely future-proof measures implemented at a manageable cost.

Source: Ministry of EZK 2019 https://www.rijksoverheid.nl/documenten/publicaties/2019/04/26/missies.

4.2. Investments in R&D

4.2.1. Public and private investments in R&D in the whole economy

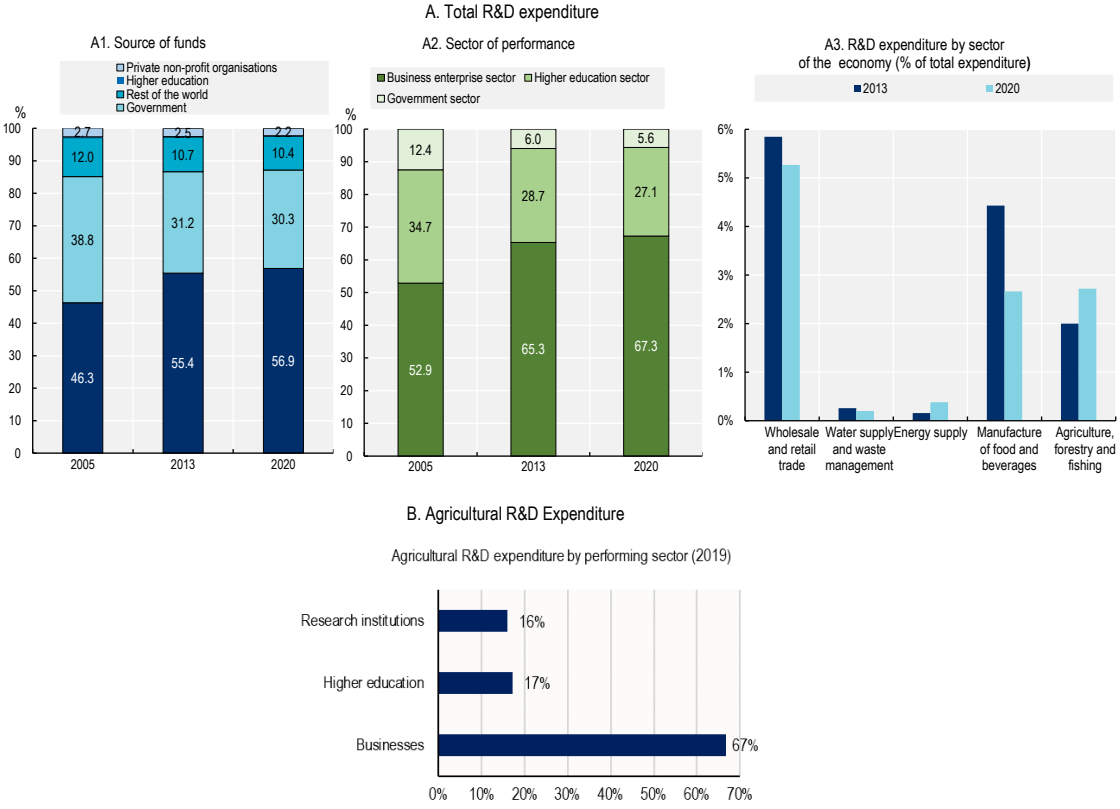
The Netherlands set a R&D intensity target to increase combined public and private investment in R&D to 2.5% of GDP by 2020 (Rakic and et al., 2021[6]). While this was not reached, actual expenditures may be undercounted due to the relatively large proportion of R&D of Dutch multinationals that is carried out abroad (Teurlink and Donselaar, 2021[7]).

The Dutch Government supports R&D through direct financing and indirectly through tax measures. The most important R&D tax measure is the Research and Development Work Promotion Act (WBSO), which has been in existence since 1994. Through the WBSO, companies can reduce their payroll tax and national insurance contributions on personnel that work in the field of research and development (OECD, 2021[8]). The scheme is implemented by the Netherlands Enterprise Agency (RVO) and only companies that conduct their own research are eligible to use this tax measure. As a percentage of GDP, tax support increased in importance from 0.06% of GDP in 2000 to 0.15% in 2019 (OECD, 2021[9]).

The private sector is the main and growing source of R&D funding, accounting for 57% of the gross domestic expenditure on research and development (GERD), which is just slightly below the EU27 average of 59% (Figure 4.1, Panel A1). The government provides about 30%, while financing from foreign business enterprises accounts for 10%. The role of higher education and private non-profit sectors remains modest (0.2% and 2% respectively). R&D activities are mainly carried out by the business sector, accounting for two-thirds of the GERD, which is comparable to the EU27 average (Figure 4.1, Panel A2). The higher education sector was responsible for 27% of the total, while the government carries out 6%.

Figure 4.1. Businesses are the largest source of R&D spending

Gross domestic expenditure on R&D in the Netherlands



Notes: Gross domestic expenditure on R&D (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.
Rest of the world includes foreign business enterprise sector, European Commission and Other abroad.
Numbers may not add up to 100 due to rounding.
Source: Authors' calculation based on Eurostat (2022), GERD by sector of performance and source of funds (database) [RD_E_GERDFUND], https://ec.europa.eu/eurostat/data/database (accessed September 2022); Research and development; expenditure and funding per implementation sector, https://opendata.cbs.nl/ (accessed September 2022). A3. Research and development; personnel, expenditure, company size, branch. SIC2008 sector classification. https://opendata.cbs.nl/ (accessed September 2022).

4.2.2. Public and private investments in R&D in agriculture

Agriculture gross domestic spending on R&D in 2020, was 2.75%, which has increased from approximately 2% in 2013 (Figure 4.1, Panel A3). The vast majority of agricultural R&D is carried out by the private sector (Figure 4.1, Panel B).

The government budget allocation for R&D in 2019 as a percentage of the sector's value added was 3%, a small decline from 2013 (Table 4.2). However, business expenditure as a percentage of the sector's value added increased significantly from 1.2% to 1.9% in 2019, which is over four times greater than the EU27 and much larger than its comparison countries. In the food and beverages sector, business investment in R&D is high by international standards at 2.1% of the sector's value added, a decline from the 2.9% seen in 2013.

Table 4.2. R&D expenditure is increasing, led by higher business expenditure

Gross domestic expenditure on R&D in the Netherlands

Field of R&D	All		Agriculture		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 sectors value added		GBARD[3] total as a % of GDP		GBARD on Agriculture[4] as a % of sectors value added		BERD[5] total as a % of GDP		Agriculture BERD[6] as a % of sectors value added		Food and beverage BERD[7] as a % of sectors value added	
	2013	2020	2013	2019	2013	2020	2013	2020	2013	2020	2013	2019	2013	2019
Netherlands	2.16	2.29	3.26	2.96	0.73	0.79	1.26	1.72	1.41	1.54	1.19	1.94	2.91	2.07
Belgium	2.33	3.48	9.40	8.90	0.64	0.74	1.30	2.01	1.62	2.53	0.62	0.33	..	2.45
Denmark	2.97	2.96	4.41	3.76	1.02	0.91	2.72	5.13	1.88	1.82	0.21	0.15	1.71	2.18
France	2.24	2.35		0.50	0.71	0.74	0.99	0.93	1.44	1.56	0.58	0.59	0.87	0.85
Germany	2.84	3.14	3.41	4.96	0.90	1.10	2.71	4.15	1.91	2.11	0.54	0.68	0.79	0.61
Spain	1.28	1.36	1.58	1.21	0.56	0.62	1.40	1.34	0.68	0.78	0.20	0.31	0.76	0.90
United Kingdom	1.61	1.66	3.34	2.65	0.56	0.58	3.54	2.77	1.03	1.25	0.09	0.10	1.16	1.06
Sweden	3.26	3.40	2.07	3.00	0.82	0.76	0.82	0.75	2.25	2.55	..	..	1.02	0.99
Japan	3.28	3.27	5.50	5.19	0.71	1.71	1.83	4.28	2.49	2.58	0.04	0.05	1.96	2.19
Korea	3.95	4.81	2.56	3.22	1.14	1.25	2.93	3.29	3.10	3.81	0.08	0.25	..	..
New Zealand	1.15	1.41			0.47	0.52	1.32	1.66	0.54	0.84	0.56	0.53	1.05	1.05
Canada	1.71	1.70			0.53	0.49	1.73	2.04	0.87	0.86	0.25	0.38	..	0.49
United States	2.70	2.81		1.87	0.65	0.81	0.97	1.38	1.91	2.60	..	..	2.88	2.36
EU27	1.98	2.20	...	...	0.69	0.77	1.28	1.33	1.25	1.44	0.31	0.43	0.96	0.95

Note: 2013, 2018 and 2019, or the nearest available year.
Source: Authors' calculation based on OECD (2022), 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 August 2022); Eurostat (2021), BERD by NACE Rev. 2 activity (database), [RD_E_BERDINDR2_], GBARD by socioeconomic objectives (NABS 2007) (database), [GBA_NABSFIN07], GDP and main components (database) [NAMA_10_GDP], National accounts aggregates by industry (up to NACE A*64) (database) [NAMA_10_A64], http://ec.europa.eu/eurostat/data/database (accessed August 2022); and USDA (2017), Agricultural Research Funding in the Public and Private Sectors, https://www.ers.usda.gov/data-products/.

4.2.3. EU funding

The European Union (EU) is an increasingly important financier of R&D in the Netherlands. The European Framework Programme for research and innovation is the main source of this funding. The eighth framework programme, Horizon 2020**,** ran from 2014-2020 and had a total budget of EUR 77 billion.[7] The new framework programme, Horizon Europe has an increased budget of EUR 95.5 billion and runs from 2021-2027.[8]

The Netherlands is one of its biggest recipients per capita, with researchers affiliated with Dutch knowledge and research institutions and companies received an average of EUR 760 million per year (Rathenau Institute, 2022[10]). Only five countries have a larger share of the funding. Dutch researchers are particularly successful in the field of science and research for societal challenges, with EUR 1.9 billion received to date (Rathenau Institute, 2022[10]).

The agri-food sector has been equally successful in obtaining Horizon 2020 funding. In the field of food security and sustainable agriculture the Netherlands received EUR 292 million or 9% of the total EU budget (Rathenau Institute, 2022[10]). Wageningen University and Research (WUR) was involved in more than 430 EU research projects, representing a total European contribution of EUR 256 million for research.[9]

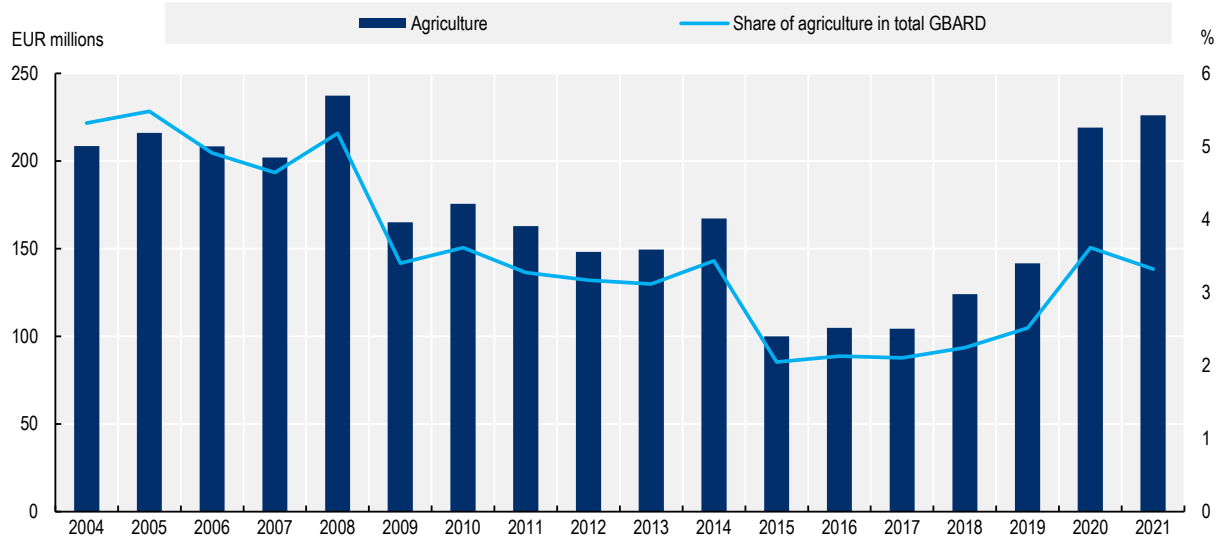
In the new Horizon Europe framework programme, which started in 2021, the most recent call awarded 52 WUR projects (and EUR 37.5 million) of the 128 submitted projects in cluster 6, "Food, Bioeconomy, Natural Resources, Agriculture and Environment". In addition, the success rate of WUR projects in this call was greater than 40% compared to an average of 20-25% for other applicants.

4.2.4. Agriculture and food research funding

In 2021, the Dutch Government, allocated 2.7% of the R&D budget to agriculture R&D (below the EU27 average of 3%). Direct government support for agricultural R&D has risen significantly since 2015, both in absolute terms and as a percentage of total National R&D expenditure (Figure 4.2). The Netherlands allocates a relatively large share of Pillar 2 funding under the CAP to knowledge and innovation, 8.3% in 2021 versus the EU average of 2.3%.[10] That said, CAP funding makes up a relatively small share of the total; in the OECD PSE, funding from national payments made up 91% of the transfers in the category "Agricultural knowledge and innovation system" (GSSE H) with the balance coming from the CAP (OECD, 2022[11]).

Figure 4.2. Direct government support for agricultural R&D has risen significantly since 2015

Government budget allocation for R&D in the Netherlands



Note: 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 enables linking these budget lines to policy considerations through classification by socioeconomic objectives. However, it provides only a partial indicator of investment in public agricultural research, since it refers to research funding instruments dedicated specifically to agriculture.
Source: Authors' calculation based on Eurostat (2022), [Joint OECD-Eurostat international data collection on resources devoted to RD] GBARD by socioeconomic objectives (NABS 2007) (database), [GBA_NABSFIN07], http://ec.europa.eu/eurostat/data/database (accessed August 2022).

Private sector expenditure on R&D has also increased significantly in recent years (Table 4.3). The number of R&D researchers has fallen slightly compared to 2013 yet the number of working years has increased, suggesting more full-time researchers working in this area. The number of companies doing R&D research has fallen significantly since 2013, with fewer small companies participating.

Table 4.3. Fewer companies with their own R&D, but more spending overall

Agriculture, forestry and fisheries private sector R&D: Personnel, expenses and company size (2013-20)

	2013	2014	2015	2016	2017	2018	2019	2020	2020 vs 2013
Number of R&D researchers	4 770	4 367	5 260	5 191	5 587	5 079	4 639	4 552	-5%
Working years	2 277	2 158	2 226	2 580	2 914	2 643	2 652	2 862	26%
Expenditure (millions)	186	200	216	249	276	271	337	335	80%
Number of companies with their own R&D activities	985	785	885	820	820	740	620	610	-38%

Source: CBS Statline 2022. Accessed October 2022.

4.2.5. R&D outcomes

With 9% of the total patents originating from the agri-food sector, the Netherlands is highly specialised in the sector, well above the EU average (4.9%) and the OECD average (4%), but below that of some peers such as Belgium (11.2%) and Denmark (11.8%) (Table 4.4). 18.4% of Dutch research publications are in the top 10% of most cited publications in agri-food in the world, significantly above both the European Union (12.7%) and OECD (11.9%) averages. This is an indicator of the quality of the scientific output from the sector.

The contribution of the Netherlands to global agri-food patents and publications is relatively small (3% and 1%, respectively), which is related to the relatively small size of the country. With 52.2%, the Dutch research community is above the averages of the European Union (38.9%) and the OECD (33.8%) in collaboration in research publications. However, on collaboration on patents (23.8%), it is considerably lower than neighbours Belgium (41.3%) and Denmark (35%).

Table 4.4. Dutch agricultural research has high importance and visibility

Agriculture and food science R&D outcomes

	Specialisation Agri-food science outputs as a share of country's total (%)		Contribution: Country's share of world agri-food science output (%)		Collaboration Agri-food outputs with foreign partners as a share of country's total agri-food outputs (%)		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]	Patents[1]	Publications[2]	Publications[2] (top 10% most cited)[3]
Netherlands	9.1	4.0	3.0	1.0	23.8	52.2	18.4
Belgium	11.2	5.4	1.7	0.7	41.3	53.8	14.5
Denmark	11.8	5.3	1.5	0.6	35.0	52.9	16.5
Germany	3.9	3.8	10.4	3.3	21.2	43.4	14.2
Ireland	5.3	4.8	0.2	0.3		43.4	16.0
Canada	5.9	5.2	2.4	2.6	23.1	35.4	11.9
Sweden	3.5	4.1	1.0	0.7	29.9	51.6	14.2

	Specialisation Agri-food science outputs as a share of country's total (%)		Contribution: Country's share of world agri-food science output (%)		Collaboration Agri-food outputs with foreign partners as a share of country's total agri-food outputs (%)		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]	Patents[1]	Publications[2]	Publications[2] (top 10% most cited)[3]
New Zealand	11.3	10.7	0.3	0.8		39.0	10.3
EU27[4]	4.9	5.0	28.2	22.2	14.3	38.9	12.7
OECD[5]	4.0	4.7	87.5	57.5	10.7	33.8	11.9

Note: Shares for economies having less than 100 patents in a given period are shown.
1. Patents field 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.
2. Publications in the field of agricultural and biological science refer to the SCOPUS 2-digit All Science Journals Classification (ASJC) 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 the fractional counts.
3. Top 10% of the world's most cited publications in the field of the agricultural and biological science.
4. EU27 values are the averages of EU Member States, except in the case of Collaboration, where the figures represent collaboration between EU countries and non-EU countries only.
5. OECD values are the averages of OECD countries.
Source: Authors' calculation based on OECD (2022), STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats (accessed August 2022); and OECD (2022), OECD STI calculations based on Scopus Custom Data, Elsevier, Version 1.2018; and 2018 Scimago Journal Rank from the Scopus journal title list (accessed August 2022).

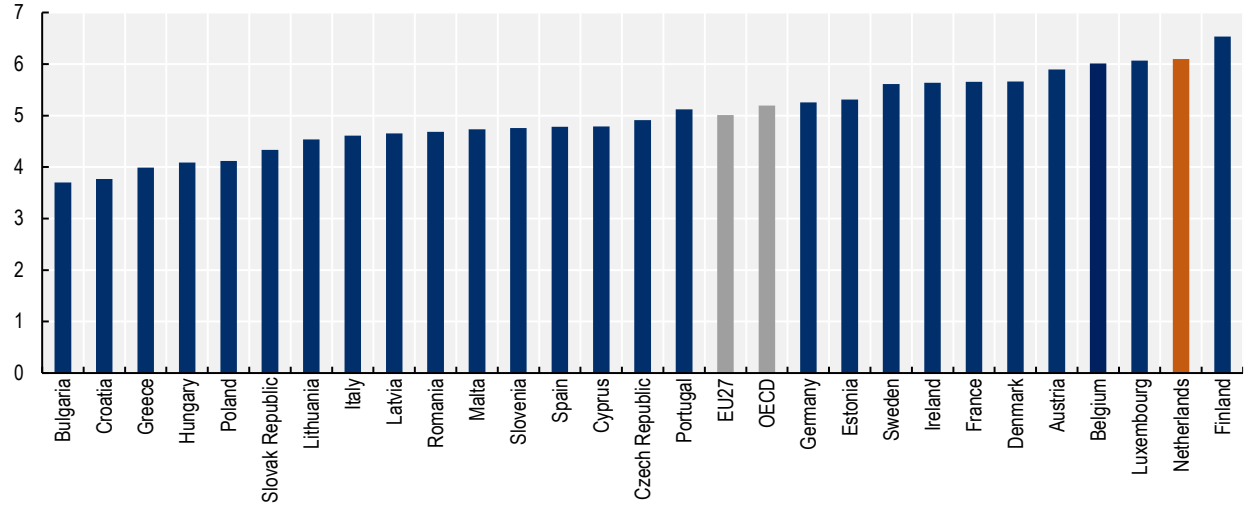
4.3. Protection of intellectual property rights

Intellectual property rights (IPRs), knowledge networks, and knowledge markets are of growing importance in fostering innovation, which increasingly requires collaboration and exchanges.

Although the European Union has a common framework and supranational institutions governing the protection of intellectual property rights (IPRs), each Member has its own national intellectual property protection system. The Netherlands has one of the highest levels of intellectual property rights (IPRs) protection among European Union Members, according to the latest index of patent protection of the World Economic Forum (Figure 4.3).[11] In 2019, the index score for the Netherlands was 6.20 which was above the mean of the European Union (5.04).

Figure 4.3. Intellectual property is well protected

Intellectual Property Protection index 2019, scale from lowest (1) to highest (7) protection



Note by the Republic of Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: Authors' calculation based on WEF (2019[12]).

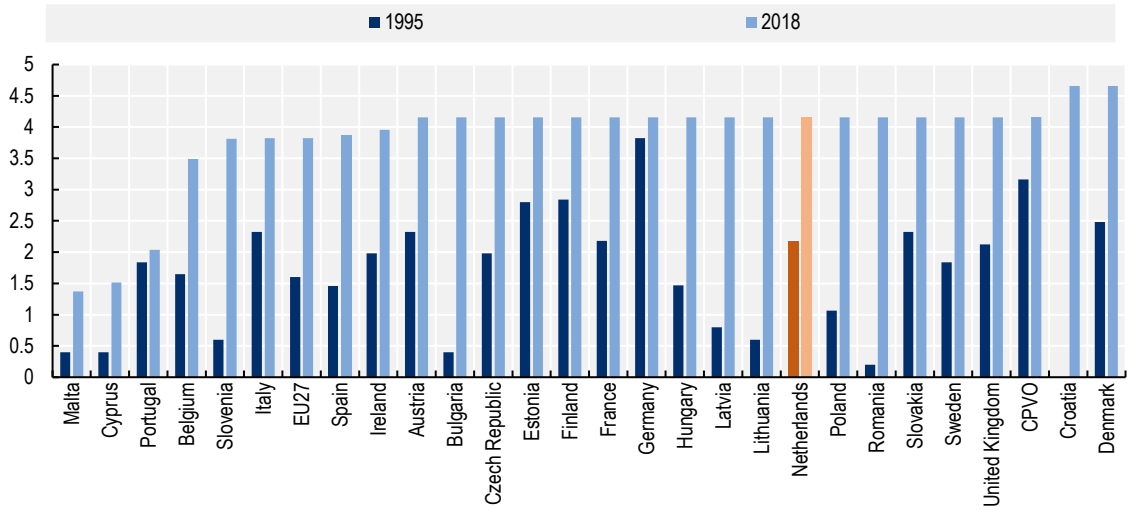
4.3.1. Plant breeding rights

In the Netherlands, plant breeder's rights are applied for at the Board for Plant Varieties (*Raad voor plantenrassen*).[12] The Community Plant Variety Office (CPVO) implements the European legislation. The Netherlands as a founding member of the International Union for the Protection of New Varieties of Plants (UPOV), offers intellectual property protection for plant varieties since at least 1961 and has adhered to all the UPOV conventions (also 1978 and 1991) reforming its plant variety protection accordingly. The level of IP protection has increased significantly from 1995 to 2018, and now ranks among the highest in the European Union countries (4.16 in 2018 above the 3.82 average level of the European Union) (Figure 4.4).

Plant breeders seeking intellectual property protection in the Netherlands can apply for plant breeders' rights (PBR) at the Dutch national office or, since 1995, at the CPVO, which provides protection in the whole European Union. PBR applications at the Dutch plant variety protection national office of residents and non-residents decreased with the creation of CPVO in 1995, although those made by non-residents decreased more (Figure 4.5). Applications at the Dutch national office made by residents were higher than those of non-residents, which might relate to the fact the Netherlands has a substantial plant breeding industry, which is not the case for many other European countries. Applications from Dutch firms at the European CPVO have been increasing.

Figure 4.4. IP protection has increased significantly

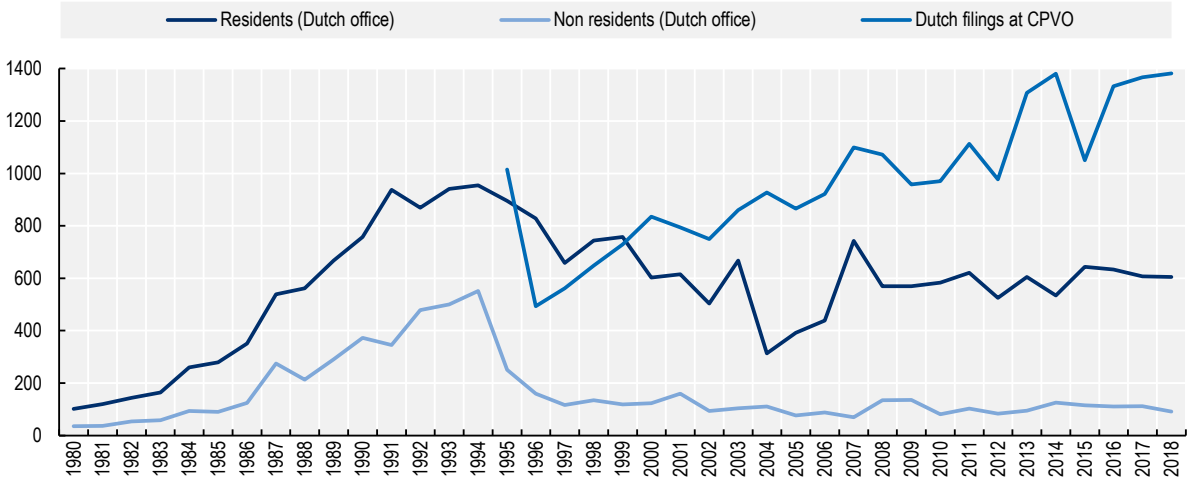
Index of legal IPRs protection for plant varieties (by EU Member States) 1995 vs. 2018
Score from lowest (0) to highest (5) protection



Note: The score goes from lowest (0) to highest (5) protection. EU27 is the simple average of member-countries indices, which are built using national legislation. CPVO is the Community Plant Variety Office.
Source: Campi and Nuvolari (2021[13]). Data are available at www.openicpsr.org/openicpsr/project/121001/version/V1/view.

Figure 4.5. IP protection at EU scale is growing in importance

Number of Plant Breeding Rights applications at the Dutch national office and from Dutch applicants at CPVO



Source: Data from UPOV's PLUTO: Plant Variety Database (https://www.upov.int/pluto/en/) and CPVO plant varieties database (https://cpvoextranet.cpvo.europa.eu/mypvr/#!/en/publicsearch).

4.3.2. Communicating science

In 2020 the LNV set up a scheme (*kennisopmaat*) that allows SME's and educational institutions to request capacity support from Wageningen Research for knowledge dissemination. Depending on the request, Wageningen Research may produce knowledge products such as factsheets, videos and course material,

create knowledge networks or participate in practice-based research of universities of applied sciences. LNV also supports the other governmental bodies in various programmes working on access to and availability of open data, for example via the Data Agenda Government and the EU Open Data Directive.

Since 2018, NWO has funded research through the Dutch Research Agenda on encouraging science communication and outreach. Parallel to funding science communication project, NWO is working together with the Impactlab of Leiden University and Utrecht University.[13] The Impactlab investigates the effects of science communication and develops instruments and a toolbox that researchers can use to measure impact. Impactlab contributes to the development of science communication. Several Dutch initiatives have emerged in various quarters aimed at making "knowledge" more transparent for companies and others; examples include the "Science Finder" or "knowledge transfer offices" via ScoutinScience (this helps the knowledge transfer offices to find potentially usable knowledge among the whole body of research output).[14]

4.4. The Agricultural Innovation System

The Dutch AKIS is a powerful combination of many small knowledge systems in sectors or regions that function well to address the knowledge needs of farmers, making the Netherlands a global frontrunner in the agri-food sector (Knierim and Prager, 2015[14]). In recent decades, the number and diversity of actors involved in innovation policy has steadily increased, which has led to a complex system with many parts (Dortmans, Van Geel and Van der Velde, 2020[15]).

4.4.1. Main actors and institutions

The government (in particular LNV), has a key role to define and fund national agricultural innovation policies within the EU framework. It steers research and education to respond to the knowledge and skills needs for sustainable innovation and incentivises the private sector's active participation in the process (Geerling-Eiff, Linderhof and Poppe, 2014[16]). The government co-ordinates agricultural research and innovation predominantly through the Top Sector Agri & Food, and the Top Sector Horticulture & Propagation Materials. The Top Consortia for Knowledge and Innovation (TKI), a legal entity resulting from this trilateral co-operation, co-ordinates the creation of the Knowledge and Innovation Agenda (KIA), specifying the research programming and financial resources for the Agri-food sector (and for the Horticulture Sector) and fostering innovation with its own financing schemes. The TKI is under the responsibility of the Agri-food Top Team, which is made up of representatives from government, business, and academia (OECD, 2015[1]). The government shares responsibility with business and academia to define strategic action plans for innovation. The twelve provinces also carry out national and regional policies and have their own innovation funding schemes.

The educational system for agriculture is comprehensive and considered to be among the best worldwide (Mulder and Biemans, 2018[17]). Educational institutions play an important role to generate and transmit practical expertise relevant to sustainable innovation on the farm. There are twelve vocational schools for agriculture, four agricultural Universities of Applied Sciences, twelve non-specific universities working on green subjects as well as three relevant technological universities, offering opportunities for lifelong learning in agriculture. Educational institutes operate on all levels and collaborate closely among each other and with other AKIS actors to facilitate joint initiatives in Centres of Expertise (and centres for innovative craftmanship) (Dortmans, Van Geel and Van der Velde, 2020[15]). Educational institutions are actively involved with research, mainly through WUR and the universities of applied science with practice-oriented research. In addition, they offer opportunities for "peer-to-peer learning" through demonstrations on farms, enabling farmers to learn from other farmers (WUR, 2022[18]).

WUR is a key player within the Dutch agricultural knowledge system (Box 4.2) and has a central role in agricultural education and research (OECD, 2015[1]). It is a collaboration between Wageningen University and the Wageningen Research foundation, an association of nine specialised research institutes for applied agricultural research (formerly known as the Agricultural Research Service, DLO). WUR is a hub of knowledge that extends beyond the Dutch borders and, thanks to the European Union's single European research area (ERA), is a European and international innovation leader. It is the main actor providing evidence and knowledge into the AKIS and helps transmit the relevant skills for agricultural innovation. A particular strength of WUR is its close co-operation with the businesses that finance a large part of its research, other national and international research and education institutes and the agricultural working population, as well as with the government. Wageningen has its own strategic plan outside of the Top Sector Team.

Box 4.2. Wageningen University and Research Centre (WUR)

WUR was created in 1997 by merging the Wageningen Agricultural University and the Research Institutes of the Dutch Organization for Agricultural Research. The research institutes are commissioned by the government, business, and non-profit organisations. They mostly work collaboratively with each other as well as national and international external knowledge institutes. With a total of about 6 500 staff (split approximately 50:50 between research and training) and 13 000 students from over 100 countries studying for Bachelors, Masters and PhD degrees, it has become one of the largest centres in the world for research and education in agriculture and food-related sciences. Its mission is "to explore the potential of nature to improve the quality of life".

WUR's domain of healthy food and living environment consists of three interrelated core areas with partial overlap:

- society and well-being
- food, feed and biobased production, and
- natural resources and living environment.

The University has been ranked as the best in the Netherlands for 17 consecutive years and is one of the top agriculture and forestry universities in the world, having been voted number 1 in the world for the last seven years. Wageningen also has an excellent reputation in environmental science, placing 5th in the world in 2021. It also scores very well on development studies ranking 10-12 worldwide in the Quacquarelli Symonds (QS) rankings.

One of the important research centres WUR hosts is the Top Institute Food and Nutrition (TiFN), a public-private research partnership between scientists of multiple disciplines, also since 2021 the World Economic Forum-European Food innovation Hub in Wageningen.

Several leading private companies in the sector have research centre in the Wageningen Campus. This includes, for example, Unilever, FrieslandCampina, Nutrileads or SAIA Agrobotics.

Source: https://www.wur.nl/en/wageningen-university.htm.

There are many research institutes for agriculture and a wide range of further research-performing actors that provide evidence and generate knowledge to facilitate sustainable agricultural innovation on the farm. These collaborate through public-private partnerships such as the TiFN and are also involved with international partners (OECD, 2015[1]). Dutch researchers often take a leadership role in EU and other international collaborations such as the European Research Project on the sustainable management of land and soil in Europe, LANDMARK (Box 4.3), which is co-coordinated at WUR.

Box 4.3. LANDMARK

LANDMARK is a European Research Project on sustainable land and soil management in Europe, funded under the Horizon 2020 framework. LANDMARK aims to answer "How can we make the most of our land? How can we ensure that our soils deliver on the many expectations we have of our land?". These expectations (or "demands") include:

- primary productivity (agriculture and forestry)
- water purification and regulation
- carbon sequestration, cycling and regulation
- provision of functional and intrinsic biodiversity, and
- provision and cycling of nutrients.

LANDMARK is a pan-European multi-actor consortium of 22 partner institutes from 14 EU countries plus Switzerland, the People's Republic of China, and Brazil. These include universities, applied research institutes, Chambers of Agriculture, an SME and the European Commission that has developed a coherent framework for soil management aimed at sustainable food production across Europe. LANDMARK is led by Wageningen University and Research (WUR) and is supported by a series of organisations which are members of the Stakeholder Steering Committee (FAO, COPA-COGECA, EFI, EUFRAS, DG-AGRI, DG-ENV, EMBRAPA, EFSA, EEA, EIONET, etc.)

Source: https ://landmark2020.eu/project-details/.

Large private sector actors, e.g. agri-food companies and co-operatives, play an important role in the promotion of agri-food innovations and the adoption of new technologies and innovative practices on farms. Dutch companies are among the world's leading innovators. In the Netherlands, they are actively involved in determining the direction of agricultural research and innovation through the Top Sector Agri & Food and participate in many projects through their own innovation endeavours or collaborations with research actors (particularly through public-private financing schemes of the Top Sector) (OECD, 2015[1]). Examples are Smart Industry Field Labs or Food Valley NL, experimental sites where companies and knowledge institutes develop, test and implement innovative solutions for agriculture.

With the privatisation of the farm extension services, the advisory vacuum was replaced by a range of private providers, conveying practical knowledge to farmers and facilitating innovation activities. They are either sales-driven (e.g. consultants, agricultural input providers) or independent advisors (e.g. *Land en Tuinbouworganisaties*). In the former case, the farmer does not pay for the service explicitly, but the costs of advice are calculated into the product cost. In the latter case, farmers (or the government) pay independent advisors directly. The independent advisors are connected through the Association of Agricultural Business Advisors (*Vereniging Agrarische Bedrijfsadviseurs*) which offers a platform for the exchange of ideas (Dortmans, Van Geel and Van der Velde, 2020[15]).

Finally, farmers' organisations, in particular the Netherlands Agricultural and Horticultural Association (LTO), and its regional compartments, have an important role as central connection points between farmers, the government, and the Dutch advisory system. Their main functions include farm advisory, the co-ordination and facilitation of innovation projects, the creation of network opportunities and the representation of farmers' interests in discussions with the government (Dortmans, Van Geel and Van der Velde, 2020[15]).

4.4.2. Funding flows and strategic prioritisation

Within the scope of the government's research and innovation policy for agriculture, funding for numerous programmes exist that stimulate the development and uptake of innovation (Figure 4.6). The authority on the strategic orientation of most of the public funding comes from the Top Sector KIA of both, Agri-food and Horticulture & Starting Materials, decided jointly with the private sector and academia (except for most of the EU fund like Horizon Europe. In this context, the national government and regions provide funding through various research and innovation schemes. National schemes are mainly implemented through the Dutch Research Council (NOW) and the Netherlands Enterprise Agency (RVO). TKI Agri-food additionally offers its own funding schemes for agricultural innovation and co-finances further existing research and innovation programmes. In addition, the EU provides important funding, mainly through Horizon Europe, but also from the European Agricultural Fund for Rural Development (EAFRD). Other non-agriculture EU funds (LIFE, etc.) may also contribute.

With financial resources from LNV and, to lesser extent, the Ministry of Education (EZK), the RVO provides various financial schemes to promote innovation among the entrepreneurs of the Top Sectors. Most importantly, those include the SME innovation Stimulus for regional and top sector (MIT) (a subsidy scheme to foster innovation collaboration among SMEs), reductions of payroll tax in research and development (WBSO) and Public-Private Partnership Allowances (PPP) (RVO, 2022[19]).

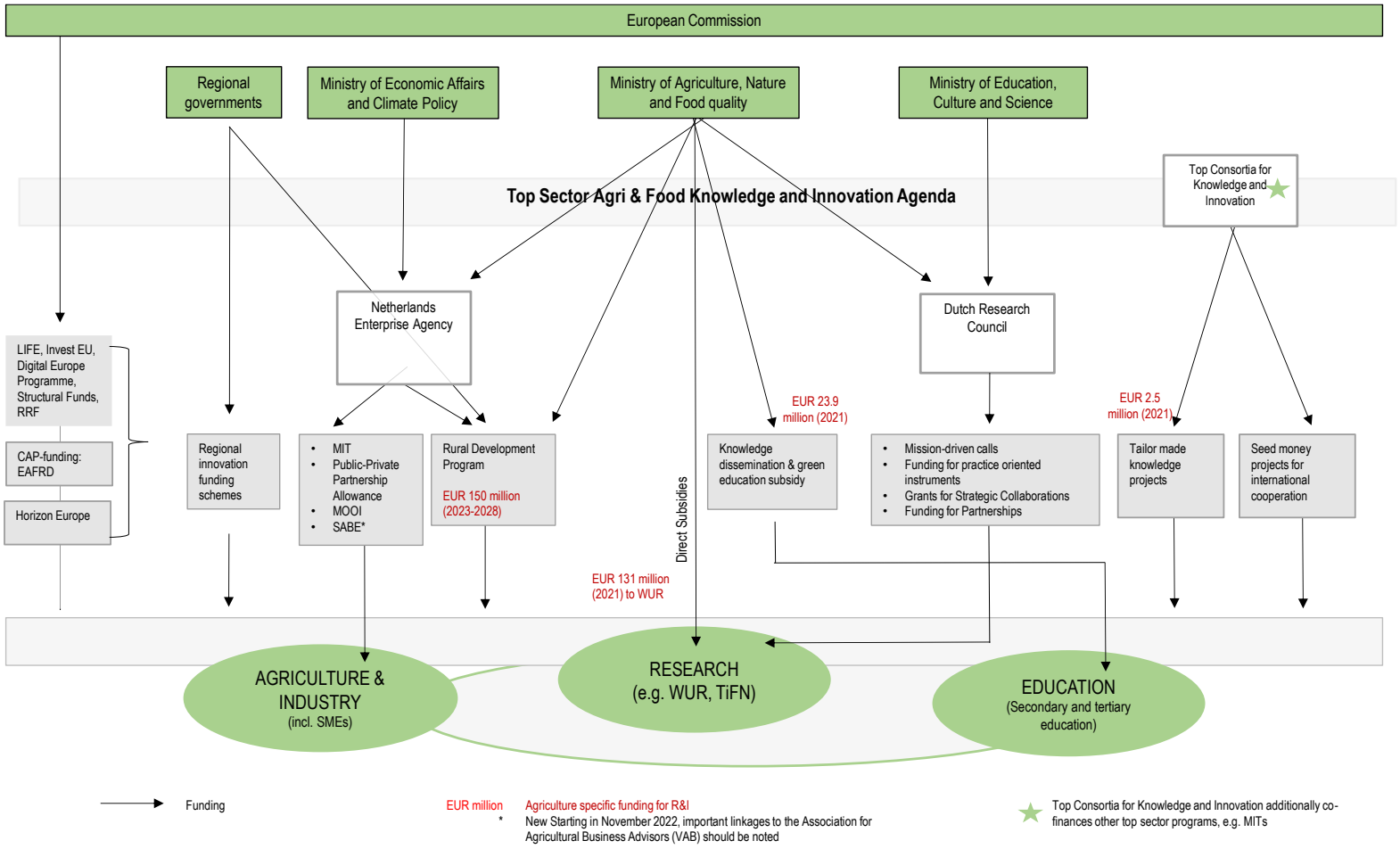
The RVO also channels funding to foster agricultural research and innovation on the farm through the Dutch Rural Development Programme (RDP), based on EU funding from Pillar 2 of the CAP with the respective national and regional contributions provided by LNV. One of the aims of the current Dutch RDP (2014-22) is to disseminate knowledge and stimulate innovation with and for farmers. For this aim, it provided around EUR 150 million for EIP-AGRI activities on knowledge exchange and innovation within the AKIS, including fostering collaborations for innovation through national and regional EIP-AGRI operational groups and by supporting training opportunities (European Commission, 2021[20]).

The NWO, based on the KIA of the Top-Sector Agri-food and Horticulture & Starting Materials, offers a set of instruments to stimulate fundamental and applied research in the agricultural sector with a focus on fostering research collaborations between scientists as well as public and private actors inside and outside the country. Several of those schemes additionally benefit from Horizon Europe funding under Cluster 6 "Food, Bioeconomy, Natural Resources, Agriculture and Environment" or promote the participation in its partnerships that aim at fostering sustainable agricultural innovation on the farm (NWO, 2022[21]).

The TKI Agri-food co-finances several of the schemes provided by the government through NWO and RVO as well as those of the European Union and additionally offers its own financing schemes to booster sustainable innovation that is practical for farmers. These include tailor-made knowledge projects (EUR 2.5 million annually) and seed money projects for international co-operation. The former aim at translating existing knowledge from research and practice into action, to foster the application of sustainable innovation, with a particularly focus on farmers. The latter are international projects to stimulate international innovation co-operation within and outside the European Union (Agri & Food Top Sector, 2022[22]).

In addition, the LNV provides subsidies that contribute to the described schemes or serve as additional financial resources. The ministry dedicates most of those direct subsidies to WUR (EUR 131 million in 2021), to support their work on sustainable agricultural research and policy support. Additionally, the LNV provides EUR 23.9 million to for knowledge dissemination and green education projects, and EUR 65.4 million for multi-year mission driven innovation projects, with the later intended to foster collaborations on relevant themes or the start-up of living labs (Rijksoverheid, 2021[23]).

Figure 4.6. The Dutch funding ecosystem to foster sustainable agricultural innovation is broad and multi-layered



Notes: This is a stylised not fully comprehensive diagram.

4.4.3. Innovation on the farm

In 2019, the LNV introduced a new policy measure, “Innovation on the Farm”, to encourage individual farmers’ adoption of agricultural methods that contribute to biodiversity, sustainability, and mitigation of climate change. This policy aims to stimulate the transfer of knowledge and innovation to the farm, and thus the practical use of existing and proven knowledge and innovations. The knowledge is brought or transferred to the farm in a manner that the individual farmer can understand and apply this knowledge in his own business model. The designed instruments are based on various learning method such as self-teaching, expert teaching, and peer exposure. More than 10 000 farmers have been supported with knowledge and advice as part of this programme.

The *Subsidieregeling Agrarische Bedrijfsadvisering en Educatie* (SABE) programme helps farmers to access expert advice. It is part of the Innovation on the Farm programme and is included in the CSP for the CAP programming period 2023-27 (Box 4.4). Expert advice comes from a system of independent business coaches or advisers. These advisers are registered in a system *Bedrijfsadviseringssysteem* (BAS). An independent committee is responsible for the BAS on behalf of LNV. They check the skills and knowledge of advisors and register them into the system for the specific advice areas. This is intended to make a large number of independent private advisers available on several topics. Peer to peer learning is available by facilitating farmers to practice new concepts and share the experiences of practical applied knowledge on their farms.

Box 4.4. *Subsidieregeling Agrarische Bedrijfsadvisering en Educatie (SABE)*

The SABE subsidy scheme was established in 2020. Under this scheme, farmers can apply for a government funded voucher worth up to EUR 1 500 to finance impartial advice from an independent registered advisor. The advice is targeted towards specific areas such as biodiversity, precision farming, sustainable soil, reduction of carbon emissions, reduction of nitrogen, personal enterprising and sustainability or nature inclusive agriculture. The advice is requested based on the specific needs of the farmer so it can be used in his own business operations. For the period 2020-23, 15 000 vouchers are available. Each year these vouchers reach about 10% of the farmer population.

In addition, farmers may apply for a free SABE-voucher for a course (developed, with a subsidy by the government, by the green higher education institutions) about nitrogen deposition in agriculture as well. The purpose is to improve the farmers capacity on this topic and to stimulate actions to reduce nitrogen emissions from their farms. From 2022 on, farmers can also use a voucher for courses about nature-inclusive farming and precision farming as well.

For the 2021-22 period, SABE also subsidies demonstration farms and business plans for a sustainable fundamental business transition of the farmer’s business operations. The concept of demonstration farms is about farmers showing other farmers (for inspiration and learning) the lessons learned about which measures and techniques work effectively in real life situations on the farm. Operational groups in which farmers learn and work together on specific topics can receive a subsidy for a three-year period. These groups share knowledge and best-practices to improve their working methods with focus on issues such as circular agriculture, reduction of nitrogen emissions and animal welfare.

With the instrument “business plan” SABE provides farmers with vouchers for financing sustainable business plans (by an approved independent advisor). It is targeted towards farmers with serious intentions to transform into a sustainable business operation. These business plans can then help facilitate access to external finance for their business.

Source: https://www.rvo.nl/onderwerpen/duurzame-landbouw/sabe.

The Farm Information Network of Wageningen Economic Research, on behalf of LNV, undertakes the "Innovation Monitor", an annual study about the innovation behaviour of entrepreneurs in the agricultural and horticulture sector for the LNV. An innovative farm is defined as a farm that introduced innovations that have a distinct impact on business operations. The study aims to assess the share of innovative companies in the sector and the perception of entrepreneurs in the field of innovations.[15] In 2020, the share of innovators and early followers amounted to 9%, a slight increase compared to a year earlier. LNV aims for 10% of innovative farms. Horticultural farmers were the most innovative sector in 2020. The study also indicated that 90% of entrepreneurs in the primary sector take the initiative to innovate on the farm by themselves.

4.5. International co-operation in agricultural innovation

The Netherlands' foreign policy makes use of its capacity in agriculture innovation, committing significant funds to knowledge creation, innovation, training and knowledge-sharing platforms across businesses and countries as well as international engagement in agricultural sustainability collaborations (Achterberg and Quiroz, 2021[24]). The Netherlands is part of the Global Research Alliance (GRA), which seeks to bring countries together to find ways to grow more food without additional greenhouse gas emissions. GRA intends to strengthen knowledge systems and to foster partnerships to improve research co-operation and increase investment in mitigation practices and technologies.

WUR collaborates with the Consultative Group on International Agricultural Research (CGIAR), a global research partnership to address societal challenges such as climate change, agriculture and food security. The NL-CGIAR research programme aims to enhance collaboration between the Netherlands and CGIAR researchers to jointly contribute to transformational change in agriculture around the world by advancing food system knowledge and joint public and private innovation.[16] The Dutch Government contributed EUR 79.9 million to a three-year collaboration with the CGIAR, of which EUR 15 million was dedicated to the NL-CGIAR research programme.

The Netherlands works with its partners to help farmers in developing countries to adapt to climate challenges. The Netherlands Ministry of Foreign Affairs in collaboration with the Netherlands Space Office (NSO) launched the Geodata for Agriculture and Water (G4AW) to help improve farming practices and enhance productivity by addressing farmers' needs and constraints (Box 4.5). Similarly, the Netherlands participates on the FAO WapoR project that monitors the performance of water use in agriculture.[17]

Box 4.5. Geodata for Agriculture and Water (G4AW)

With over 20 initiatives in 15 countries and nearly 4 million users, G4AW can convert satellite data into relevant advice regarding weather and hazardous conditions. The initiative also offers loans and insurance so that farmers can protect their income against the consequences of climate change. Moreover, it encourages collaboration between countries through a platform in which NGOs, farming unions, private and public organisations and research institutes can come together to share expertise and solutions. As a result, countries can help each other reach food security worldwide. And, together, reducing hunger and malnutrition, and maintaining a diversity of seeds and farmed animals. A programme such as G4AW is especially beneficial to help raise food production and improve the livelihood of local farmers and fishermen sustainably.

Source: https://www.nlplatform.com/articles/g4aw-empowering-farmers-through-international-collaboration-and-data-collection.

4.6. Human capital and skills

As described in the previous section, agricultural education and training are key components of the AKIS system. In 2015, the Netherlands projected an important shortage of technically qualified workers and responded creating the Strategy for Green Education 2016-2025, covering agriculture, nature, and the food sectors. This is an important part of the overall set of educational opportunities available to workers who participate in the sector, but some gaps remain in general training needs, in particular for migrant and temporary workers who may face specific difficulties in the job market.

4.6.1. Skills mismatches

The Dutch education system and the skill profile of the population are very strong overall (OECD, 2017[25]). However, globalisation and technological advances are rapidly reshaping the skills needed for success in work and life. As a result, continuous learning in adulthood is seen as increasingly important for adaptability and resilience. On this metric, Dutch adults have a low "readiness to learn" when compared with their peers in other OECD countries.

The average level of education of Dutch farmers is very good: 72% have some agricultural training This is well above the European average, where most farmers rely only on practical experience.[18] However, the latest OECD Skills for Jobs database suggest that significant skill mismatches are present in the agriculture labour force. Skills mismatches occur when a worker's skills either exceed, or fall short of, those required for the job under current market conditions, and can be measured as either qualification mismatch or field-of-study mismatch (OECD, 2016[26]).[19]

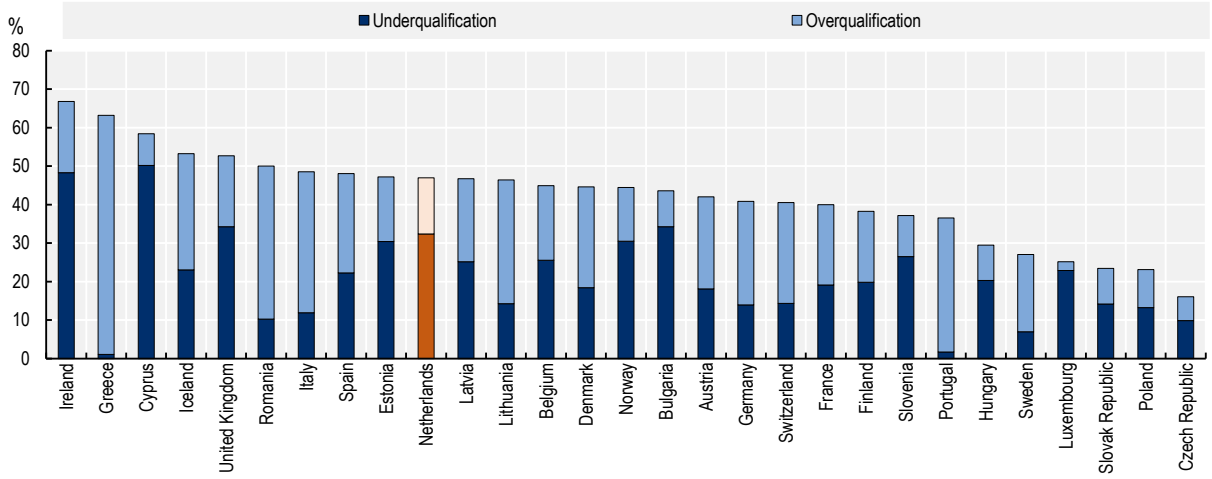
Qualification mismatch is when workers have an educational attainment that is higher or lower than what is required by their job. Forty-seven per cent of workers in the agriculture, forestry and fishing sectors are classified as having a qualification mismatch and 32% of workers have lower education attainment than needed (Figure 4.7). The ratio is above both the EU average and its neighbours, Belgium, Denmark, and Germany. Field-of-study mismatch, where a worker is employed in a field that is different from their specialisation, is 45% for the Dutch agriculture, forestry and fishing sectors, nearly the same as the EU average (46%). Skill mismatches can negatively affect economic growth through their effects on increased labour costs, lower labour productivity growth, and slower adoption of new technologies (OECD, 2016[26]). Skills mismatches can also cause individuals to experience a higher risk of unemployment, lower wages and lower job satisfaction (OECD, 2016[26]).

Workers in the green domain most commonly mention the need for digital skills, job specific skills, creativity, social skills, and learning ability.[20] Workers in the green domain have more ambitious learning objectives than those in other sectors.[21] However, underqualification is a problem in the green domain, and those involved in operational tasks often are classified as having modest educational attainment.

Skills mismatches are expected to increase due to large changes demanded from the agricultural sector in terms of production, company size, and the development of new business models related to the twin transitions to sustainable agriculture and a nature-based society. Additionally, demographic changes will be important as experienced workers retire.

Figure 4.7. Underqualified workers are a relatively common problem

Qualification mismatches in agriculture, forestry and fishing sectors in European countries, 2019



Notes: Qualification mismatch arises when workers have an 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 over-qualified; if the opposite is true, they are classified as underqualified.
Source: OECD (2022), Skills for Jobs database, www.oecdskillsforjobsdatabase.org.

4.6.2. Education attainment levels

The qualification mismatch in the Netherlands described above is linked with the characteristics of agricultural labourers in elementary occupations who perform simple and routine tasks. According to (Eurostat, 2016[27]), the European Union wide educational attainment levels of the working population in the agricultural sector are lower compared to other sectors. In the Netherlands, there is a similar pattern where most of the agricultural work force has a lower or medium level of education attainment than do workers in other sectors.

However, the education attainment in the Dutch agriculture (low, 33.7%, medium 51.4% and high 13.9%) is higher than the EU average (low 40.7%, medium 50.2% and high 8.9%). The lower level of education attainment in agriculture can be explained due to several factors, including the relatively old population, the high level of immigrants employed in the sector, and the high share of very young workers without a diploma. Also, the routine nature of labour-intensive activities that are especially needed in peak seasons can explain the need of this type of workers. An illustrative example is that temporary employees are hired for harvesting activities. When it comes to farm managers, 64.2% of them have a basic form of training and 8% has obtained full agricultural training.[22] Only 29% of managers have practical experience, compared to the EU average of 70.7%.

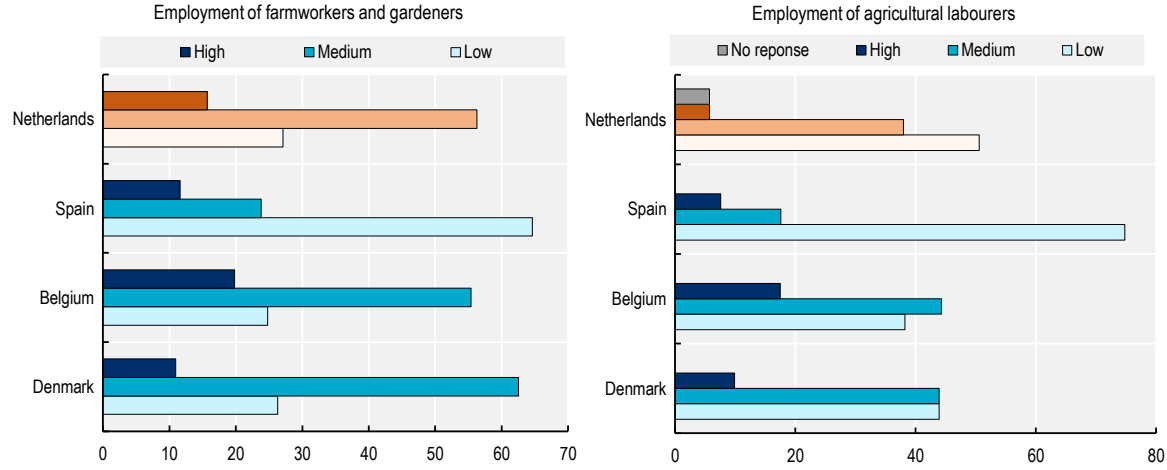
Recently, there has been progress in making agriculture-related education more attractive and responsive to the changing skills needs in the labour market and students' choices, by emphasising job opportunities and societal values. Moreover, many technological developments aim at reducing the dependence on migrant workers in the future. However, technological developments are also increasing the demand for highly skilled workers, which has increased labour productivity in the agricultural sector (Ryan, 2023[28]).

According to more recent data from the European Union Labour Force Survey (EU LFS), about 13% of workers in the Dutch agriculture, forestry and fishing sectors are classified as agricultural labourers while 52% are skilled farm workers (CEDEFOP, 2022[29]). In comparison to skilled farm workers, agricultural labourers have a low level of education attainment and are young (Figure 4.8). Half of agricultural labourers have relatively low education levels, a higher share than in Belgium or Denmark. Over 40% of Dutch

agricultural labourers are aged between 15-24 years, which is significantly younger than the other comparison countries (Figure 4.9). This may indicate that temporary employment in horticulture is an attractive job option for students.

Figure 4.8. The education level of agricultural labourers is lower than regional peers like Belgium and Denmark

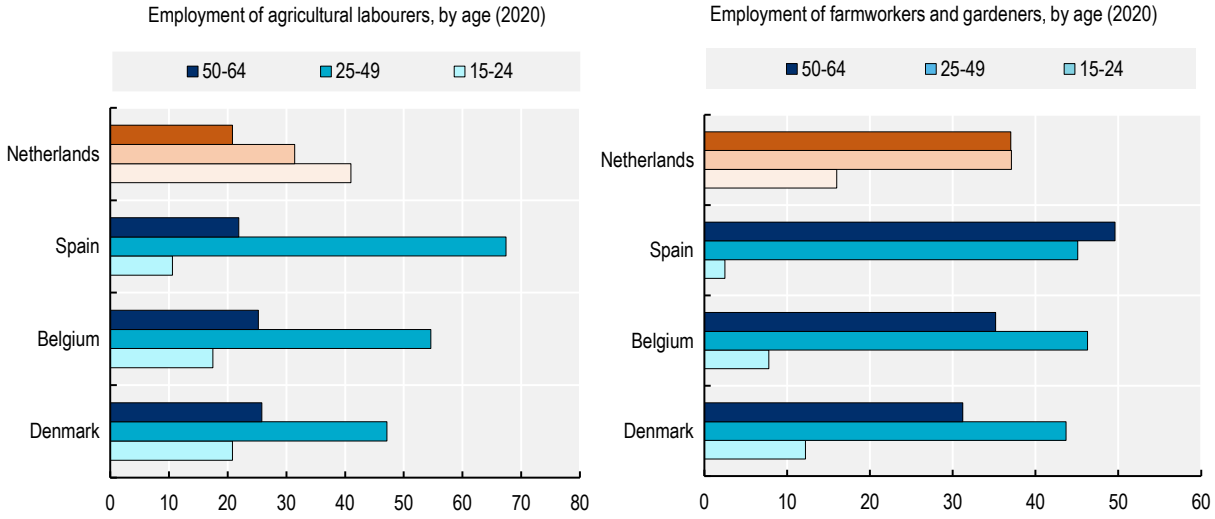
Agricultural employment by education level in 2020



Note: "Agricultural labourers" perform simple and routine tasks as part of agriculture, forestry, and fishery production processes. "Farmworkers and gardeners" plan, organise, and perform farming operations to grow and harvest field or tree and shrub crops and to produce a variety of animals and animal products for sale or delivery on a regular basis to wholesale buyers, marketing organisations or at markets (CEDEFOP, 2022[29]).
Source: European Union Labour Force Survey (EU LFS).

Figure 4.9. The agriculture labour force is relatively young

Agricultural employment by age in 2020



Note: "Agricultural labourers" perform simple and routine tasks as part of agriculture, forestry, and fishery production processes. "Farmworkers and gardeners" plan, organise, and perform farming operations to grow and harvest field or tree and shrub crops and to produce a variety of animals and animal products for sale or delivery on a regular basis to wholesale buyers, marketing organisations or at markets (CEDEFOP, 2022[29]).
Source: European Union Labour Force Survey (EU LFS).

Farmworkers and gardeners, are those who plan, organise, and perform farming operations to grow and harvest field or tree and shrub crops and to produce a variety of animals and animal products for sale or delivery on a regular basis to wholesale buyers, marketing organisations or at markets. They usually need to have completed the first stage of secondary education but in some instances, they will need to have completed the second stage of secondary education, including through specialised vocational education and training (CEDEFOP, 2022[29]). Although more educated than agricultural labourer, most of them have a medium or low level of education. In contrast, farmworkers and gardeners are mainly aged between 49 and 64 years old.

The 2019 agricultural census estimated that temporary or seasonal workers in agriculture was equivalent to nearly 30 000 full-time job equivalents (CBS, 2020[30]). Most of the non-regular agricultural labour force are active in horticulture, which has a high labour requirement during planting and harvesting periods. The horticultural sector accounted for almost 87% of these types of jobs in agriculture and 19% of the total migrant labour.

Migration has created many challenges for the Dutch agricultural workforce, despite being an important source of labour, especially temporary labour, for the agri-food sector. Although these groups perform better than their counterparts in most other OECD countries, their lower skills relative to their Dutch peers means that they may struggle to find work and participate fully in society. In the broader context labour immigration is also a sensitive issue in the Netherlands with increasing public concern over the conditions of migrant labour. Additionally, even with the significant inflow of migrant workers, there continues to be a significant shortage of technical skills in agriculture and the food sector (Ryan, 2023[28]).

4.6.3. Lifelong learning programme Green Pact

In 2016, LNV joined forces with about 40 partners to start a new national platform Green Pact (*GroenPact*).[23] Green Pact is a collaboration between LNV, the green education institutes and the green sector. The basic goal of Green Pact is to stimulate the quality and attractiveness of Dutch Green education so that it can meet the demands for green labour. The third phase (Greenpact 3.0) started in 2021.

Green Pact is a national support programme for promoting education, lifelong learning and innovating professional practice in agriculture, horticulture, food and nature and the living environment. It focuses on four Pillars:

- National Platform to interconnect multiple stakeholders and foster joint agendas and investments
- Accelerator Programs focusing on knowledge transfers
- Basic Infrastructure, establishing Knowledge Clusters, Centre of Expertise and Centre of Innovation
- Public-Private Arrangements.

Specific examples include the establishment of a green labour market monitor, the formation of a new National Centre for Innovative Craftmanship (*CIV Groen*) as created by the green institutes or a renewed interactive digital platform (*Groen Kennisnet*), developed by WUR, which serves not only education but also farmers, advisory services, and other groups in the green domain.

Green Pact has grown in recent years to include more than 90 partners. New partners have joined in the field of nature and biodiversity, the food chain, water management and area development. It now also includes youth organisations in the fields of agriculture, food and climate to strengthen participation of students and young professionals in the green sector. Another new participant is the Association for Agricultural Advisors (VAB). The Green (labour market) Monitor will help identify skills gaps and the development of a new lifelong learning (skills) strategy, with the first the first comprehensive Green Pact Monitor expected soon. Additional research is also being conducted on the field of skills forecasting.

Compared to other countries in the European Union, the Netherlands is doing relatively well in the field of lifelong development according to the Social and Economic Council (SER) learning culture monitor. In almost one in four companies, more than three-quarters of employees followed training in 2019. However, the learning culture appears to be developing in a limited way over time. Learning behaviour shows a slight decrease and the sense of urgency among workers and employers remains stable. At the same time, development is more stimulated, and more training opportunities are available. With respect to informal learning, there is room for improvement. In the agricultural sector, the indicators show lower numbers compared to other sectors. The SER identified several specific groups in their learning culture monitor that are likely to do poorly, namely workers with less education, on flexible contracts, or who are above 50 years of age. Young people with less education under flexible contracts are over-represented in the agricultural sector, which can affect sector statistics.

4.6.4. Farmer to farmer learning

There is a long tradition of farmer study groups that jointly identify weak and strong points in their farms and farm strategies and learn from each other. LNV stimulates operational groups in which farmers learn and work together on specific topics and also provides a subsidy to operational groups for a three-year period. The innovation system makes good use out of “operational groups”, with more than 300 Operational Groups supported under the RDP EIP-AGRI[24] (Operational Groups) co-operation under Measure 16.[25] With Operational Groups now included in the Dutch RDP, local and regional scale innovation has benefited. A mid-term evaluation (*tussentijdse evaluatie van EIP-AGRI*) showed the added value of this instrument. In the current CAP period, the provinces manage and co-finance EIP measures.

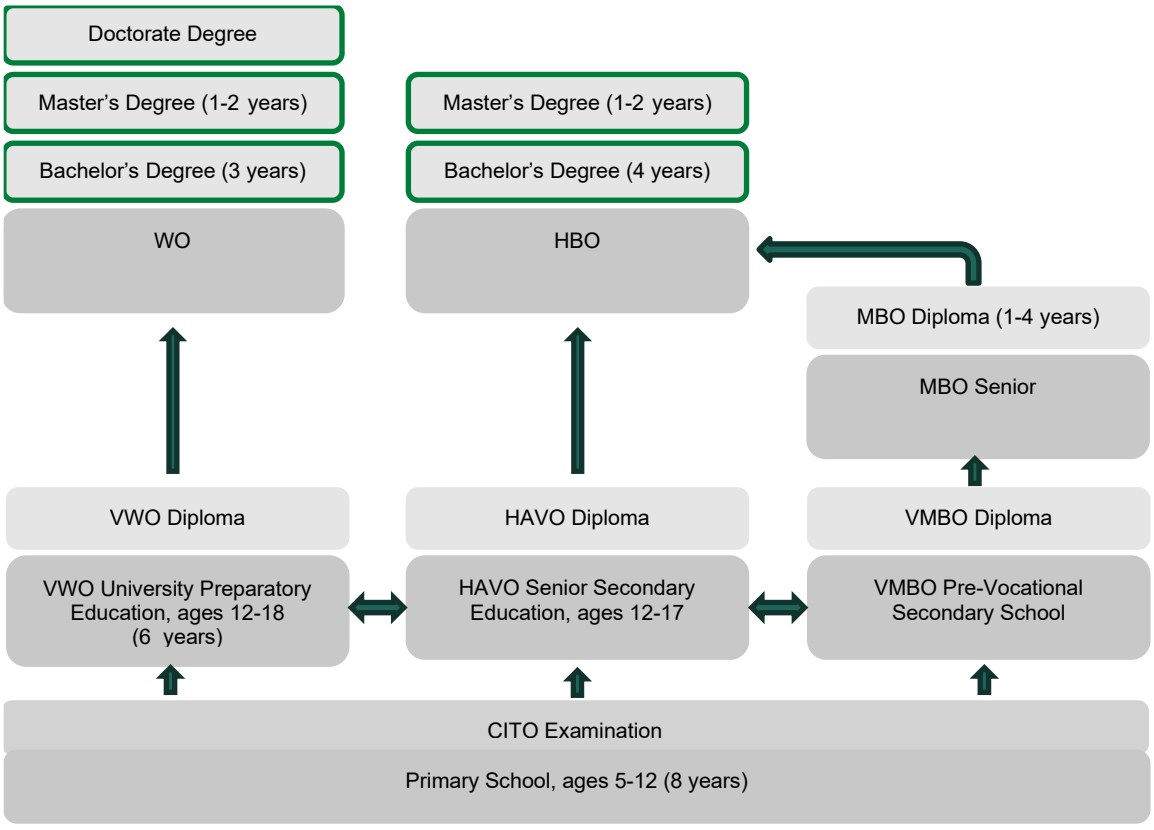
4.6.5. Green Deal Nature Inclusive Education

Green education is the collective name used for all programmes in the fields of plant, animal, food and health, and nature and the living environment. Several universities include nature-inclusive agriculture in the curriculum of green education programmes. Nature-inclusive agriculture is a more sustainable form of agriculture that seeks to minimise negative ecological impacts, maximise positive ones, while benefiting from natural processes (Chapter 3).

Green education follows the regulatory framework of the Dutch education system (Figure 4.10). Secondary education includes pre-vocational secondary education (VMBO) programmes that combine general and vocational education and prepare pupils for senior secondary vocational education and training (MBO). There are 19 institutions for green education in the Netherlands, from vocational to university education. “Dark green” studies are those that are provided by green education institutes and concern the primary agricultural sector. “Light green” studies are either provided by a green education institute that does not concern the primary agricultural sector, or by a non-green education institute that concerns the primary agricultural sector.

According to the green monitor of 2020,[26] the number of MBO students in dark green studies has decreased by 23% over the past ten years, while the number MBO students in light green studies in the same period increased, although with a drop in recent years. A similar trend is visible for higher vocational education and university level, however, the number of students that follow dark green studies at university level has increased. Similar trends are found for university education (WO) and higher vocational education (HBO), although the number students from dark green courses at the university level is higher. The number of green MBO courses is falling more rapidly than the number of non-green vocational education. These decreasing trends fit into a national demographic trend. The number of participants in green HBO and WO training is increasing parallel with the national trend.

Figure 4.10. The Dutch education system



Note: CITO: Central Institute for Test Development; HAVO: Senior general secondary education; HBO: Higher Professional Education; MBO: Secondary vocational education; VMBO: Pre-vocational secondary education; VWO: Pre-university secondary education; and WO: University education.
Source: Caggiano (2014), "AKIS and advisory services in The Netherlands. Report for the AKIS inventory (WP3) of the PRO AKIS project". Online resource: www.proakis.eu/publicationsandevents/pu.bs.

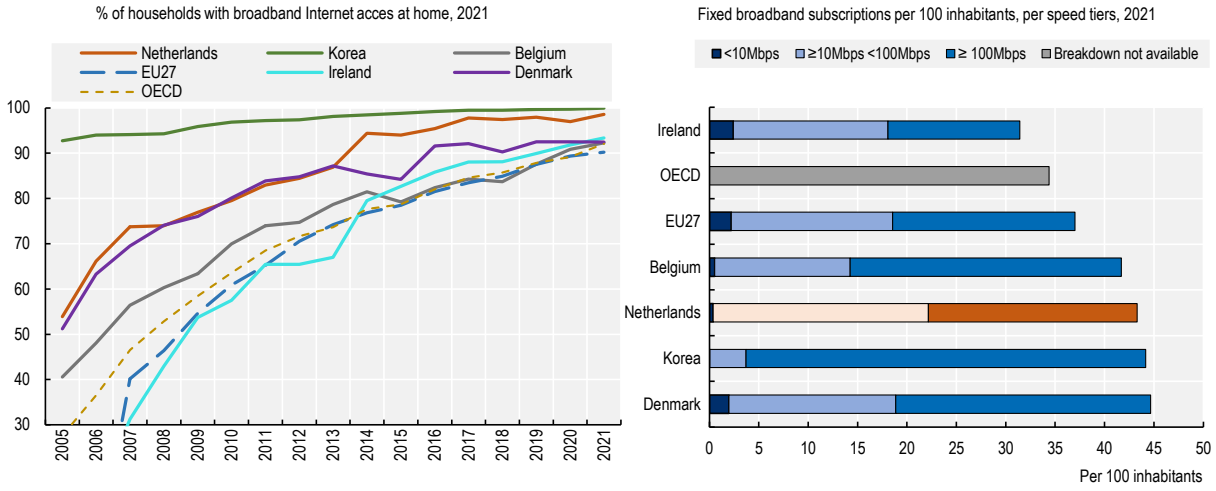
According to a recent study, more than half of MBO-2 and MBO-3 graduates and just under half of MBO-4 graduates end up in a green profession.[27] As the level of education rises, the share of women in both the non-green and the green professions increases. In the past ten years, the number of female MBO students that chose for a green profession has increased significantly, although the share of women workers in the agricultural sector is lower on average than in other sectors (Ryan, 2023[28]).

4.7. Digitalisation

The Dutch Government defines digitalisation as "(the transition to) using digital data and the relevant technologies to support the insights, decisions, and actions of private partners and governments and their executive agencies" (LNV, 2021[31]). The vision of digitalisation in agriculture, nature and food quality outlines what is necessary to realise the application and adaptation of digital technologies in the agricultural sector (LNV, 2018[32]). The workforce is well-educated and ICT infrastructure is strong with a very high percentage of broadband access which puts it in a good position to adopt digital technologies (Figure 4.11). Unlike many other countries, there is not a digital gap between rural and urban areas in terms of broadband access (OECD, 2021[33]).

Figure 4.11. ICT infrastructure is ready for new digital technologies

Broadband access in the Netherlands



Note: Panel B: Based on 2020 speed tiers. EU27 simple average
Source: OECD Broadband statistics, www.oecd.org/sti/broadband/broadband-statistics (accessed August 2022).

There is a long history of collecting sustainability data in the scope of the Dutch farm accountancy data network (FADN). Member States are obliged to have a network for the collection of data on the incomes and business operation of agricultural holdings. This task is carried out by Wageningen Economic Research for the Centre for Economic Information (*Centrum voor Economische Informatievoorziening*, CEI) (LEI, 2018[34]).

Data collection principles are flexible to respond to new policy and research needs. This system collects farm level data to fulfil the EU requirement with respect to FADN and fulfil other national and international data needs. Examples of other statutory tasks are the estimation of fertiliser use, antibiotics use, energy use, sustainable investments, and innovation. It has been suggested by researches from WUR that the current FADN network could be expanded to include sustainability indicators as foreseen under the Farm Sustainability Data Network (FSDN) of the European Union (Vrolijk and Poppe, 2021[35]).

Policy has a role to play to support digital uptake. Recent OECD work showed that countries can accelerate digitalisation by reducing regulatory barriers to competition, improving the mobility of talent and capital, upgrading skills, and easing financing conditions of young and innovative firms (Sorbe et al., 2019[36]). Tackling issues such as the lack of trust in digital systems is also seen as essential as it slows farmers' adoption of digital technologies (Jouanjean et al., 2020[37]; McFadden, Casalini and Antón, 2022[38]; McFadden et al., 2022[39]).

The Netherlands is well placed to reap the potential of digitalisation, but should continue to invest in digital infrastructure, skills and services complementary to the adoption of digital technologies (OECD, 2021[33]). Further deployment and take-up of faster fibre networks and next generation 5G wireless networks is a prerequisite for the adaptation of the latest digital technologies such as cloud computing (Sorbe et al., 2019[36]).

Technologies related to smart farming and precision agriculture, precision crop protection and monitoring systems for grazing and milking systems are advancing quickly (Box 4.6). At a higher (service and governance) level, data sharing services, data infrastructures and agreement on data sharing (e.g. via data sharing authorisation and permits) are priority issues. Furthermore, digitalisation is an opportunity for better policy design, including for agri-environmental polices and monitoring systems (OECD, 2019[40]).

Several bottlenecks remain to be addressed. For example, it is still impossible to bring all their data together in an easy to use, own dashboard. There are up to 25 data platforms to choose from for arable farmers alone (Kempenaar et al., 2020[41]). An overall data strategy that connects different data sources could underpin future advances.

Box 4.6. Precision agriculture

Within the framework of circular agriculture, the Dutch Government is trying to encourage farmers to adopt precision agriculture. In 2018, the National test Farm Precision Agriculture (*Nationale Proeftuin Precisielandbouw*, NPPL) was established to help farmers apply the latest techniques.

Precision agriculture or Smart Farming means that plants (or animals) get exactly the treatment they need, determined with great accuracy. It is a farming management concept based on observing, measuring and responding to variability in crops to achieve greater efficiency and yields. This method allows farmers to optimise and increase soil quality and productivity by putting in place a series of targeted key interventions. It is possible to perform the right intervention in the right place at the right time, responding to the specific demands of individual crops and individual areas of land with superior levels of precision.

Source: https://www.proeftuinprecisielandbouw.nl/.

The government promotes access to and adoption of digital technologies and tools in the agri-food sector and in rural areas in a variety of ways. These instruments span the innovation system, from training vouchers (SABE) to subsidies for related investments on the farm (MIA, VAMIL and others).[28] In addition, field labs and experimental farms have proven to be important instruments in developing and promoting new technologies and bringing them to higher technology readiness levels.

The Netherlands also supported the development of the Horizon Europe partnership “Agriculture of Data”.[29] The key criteria to promote digital technology use is the added value a specific technology has towards climate, biodiversity, and sustainability goals. This criterion is applied throughout the Dutch knowledge and innovation policy for agri-food. The partnership Agriculture of Data (AgData) aims to improve climate, environmental and socio-economic sustainability and productivity of agriculture and to strengthen Member States’ capacities for policy monitoring and evaluation by leveraging the potential of Earth observation (Earth Observation, EO) and other environmental and agricultural data combined with data technologies such as AI.

4.8. Innovation and sustainability

The Dutch agricultural sector has intensified in recent decades, resulting in fewer but larger and more specialised farms (Vrolijk, Reijs and Dijkshoorn-Dekker, 2020[42]). While improved productivity has been good for the competitiveness of the sector and has reduced emissions intensity, it has not enabled an ambitious path to sustainability. This was raised as a concern in the 2015 Innovation review, which noted that the Top Sectors approach, which has a strong role for private-sector funding and participation, could lead to less emphasis on public goods. Rebalancing the Top Sector system’s attention to productivity, sustainability and resilience remains a central challenge for policy makers.

The 2015 Innovation Review (Chapter 2) also pointed to the possibility that the private sector draws more from the AKIS system in value than it contributes, which speaks as well to finding the proper balance between public and private outputs. The 2015 Innovation Review also mentions the heavy reliance on tax credits as problematic, as it provides relatively more benefits to larger companies with substantial R&D

units. To this can be added a transparency problem: it is hard for LNV to evaluate total government expenditure versus total public benefits from R&D and as part of the Top Sector approach without good information on the value of these tax expenditures. That is, the public contribution to the Top Sectors might be underestimated.

The components of the AKIS system are already well placed to do more to ensure the long-term sustainability of the sector. The capacity for the research community, the available funding, and the links up and down the value chain, including farmers, are all valuable assets in this regard. Stronger government leadership on the research agenda, better targeting of funding, and more incentives for farmers to engage on sustainability issues are needed to convert this capacity to results.

Agricultural education is still focused on conventional agriculture, with many students who have grown up on conventional farms demanding education in line with what they have experienced (Vermunt et al., 2022[43]). Many of the current tools available as part of the AKIS have potential to do more to advance on-farm sustainability, such as the SABE and Innovation on the Farm, but farmers tend to engage more strongly with the AKIS on issues connected with productivity than with sustainability.

Making educational opportunities related to sustainability more attractive to farmers can help. A first step is an education system for advisors that can "train the trainers" on integrated, holistic planning on farm that comprehensively tackles sustainability issues. Many of these coaches are specialised in specific systems and do not have the skills for the integrated holistic planning that many farmers will need for future challenges. The demand for coaches in the SABE system exceeds supply, and the current coaches in the system may not have the incentive to gain the new skills needed or offer them to farmers.

Investments that embody environmental innovations are supported through investment aids such as MIA, VAMIL and others. This helps to put these innovations to work on the farm, but there is not the same support to farmers wishing to engage with the AKIS on strategic environmental planning at the farm level, which can help better target investments to be cost-effective and sufficient to address sustainability requirements. Connecting investment aids to farmers' engagement with AKIS can help provide the needed support and incentivise engagement in programmes like "Innovation on the farm". For example, the Canadian Environmental Farm Planning system provides cost-shared funding for farmers to carry out needed actions identified by an educational process leading to an individualised farm plan (Box 4.7).

Box 4.7. Environmental Farm Planning in Canada

Environmental Farm Plans (EFPs) are voluntarily prepared assessments by farm families to increase their environmental awareness in up to 23 different areas on their farm. Through the EFP process, farmers highlight their farm's environmental strengths, identify areas of environmental concern and set realistic action plans with timetables to improve environmental conditions. Environmental cost-share programmes are available to assist in implementing projects.

Farmers complete an EFP by:

- attending an in-person, two-day workshop (this option is recommended for first-time participants or if it has been a long time since you participated)
- attending an in-person, 1-day renewal workshop (this option is only available if you are looking to update a 3rd or 4th edition EFP and you have your previously reviewed workbook)
- completing an electronic EFP, using the self-directed electronic format (this option is available for anyone looking to update their existing EFP workbook, but is not a replacement for the in-person, two-day workshop if you have not participated in this previously)

Each step of the EFP process is voluntary. The EFP action plan receives a confidential review by the workshop leader. Once reviewed and verified, the farmer can access cost-share funding to help cover a portion of the costs of implementing eligible projects from the action plan.

EFP systems are designed and delivered at the provincial level and have variations in approach. Some involve an on-farm review with other farmers who have already been through the process and who can help identify needed actions.

Source: https://www.ontario.ca/page/canada-ontario-environmental-farm-plan-efp.

Dutch policy makers also focus on developing knowledge and markets for organic and nature inclusive agriculture. WUR and the Louis Bolk Institute are the main partners in government-funded research on organic agriculture. The Ministry of Economic Affairs provides up to a maximum of 60% of the funding for research into organic food and farming. The rest is paid for by the sector[30] (Verburg, Verberne and Negro, 2022[44]). A national organic strategy has recently been released (Chapter 3).

4.9. Innovation in practice

This section provides some examples of Dutch agricultural and horticultural innovations and related initiatives, which can help address current and future societal challenges.

4.9.1. Innovation on arable farms: Farm of the future

The arable sector is highly productive but faces challenges due to the high cost of land and labour, as well as increasing pressure to reduce pesticide usage. A network of experimentation facilities (Farm of the Future) has been developed which function as experimentation hubs for innovative circular farming concepts based on agro-ecology, digitalisation, and robotics (Box 4.8).

Box 4.8. Farm of the Future (FotF)

At the initiative of LNV, WUR, the Province of Flevoland, and the agricultural sector, the FotF started in 2019 as a Field Lab for the arable sector in Flevoland. It aims to accelerate the transition to circular agriculture by inspiring, connecting, and sharing knowledge through a systems approach to circular agriculture in a regional context. The facility is used for the development, demonstration, and validation of innovative circular agriculture concepts with agro-ecology, digitalisation, and robotics as important building blocks in a semi-practical situation (field lab).

In addition to the above functions, the FotF acts as a consultation platform for stakeholders involved in the transition to circular agriculture. The FotF offers start-ups, students, and others the opportunity to collaborate via subsidy instruments. Groups of growers are associated with the FotF who implement innovations on their farm and share their experiences with colleagues and other involved parties. Through this approach, the FotF acts as an innovation hub for regional co-operation for the implementation of circular agriculture. Other regions in the Netherlands are also adopting this approach. The vision is that a nationwide network of regional, collaborating Field Labs will be developed soon.

The FotF is managed in a way that it (1) maintains natural resources (e.g. soil fertility), (2) is climate robust, (3) grows resilient varieties, (4) applies integrated pest management (IPM) and minimises pesticide use with (almost) zero emissions and residues, (5) minimises artificial fertiliser use and closes nutrient cycles, (6) is at least energy neutral and positive on greenhouse gas emissions, (7) stimulates

biodiversity and contributes nature values, (8) applies sustainable water use, and (9) increase the socio-economic situation of the farmer.

Source: https://farmofthefuture.nl/en/farm-of-the-future-in-lelystad/.

4.9.2. Innovation in the livestock sector: Improving sustainability

Ground and surface water pollution, poor air quality, soil and biodiversity deterioration, and GHG emissions are the main environmental problems associated with ruminant livestock (Hoes et al., 2019[45]). Given the importance of ruminants in the agri-food sector, this is a major challenge for the Netherlands to meet both its national and EU environmental commitments (OECD, 2021[46]). Policies and implementation of new technologies have significantly reduced the environmental footprint of the livestock sector since 1990 but the sector faces major changes to control emissions damaging to sensitive nature areas. Government funding has also been made available over the period 2020-30 from the Climate Budget to support the ruminant livestock sector with the adoption of climate-friendly practices and innovation (Government of the Netherlands, 2019[47]).

The programme for a Sustainable Livestock Sector was published in September 2019 (MINLNV, 2020[48]). It has three main pillars: inspiring and experimenting, improving the conditions allowing farmers to farm sustainably, and private sector plans. In addition, the Dutch Dairy Association and dairy farmers, in partnership with other organisations, have also developed the Sustainable Dairy Chain which includes goals on climate neutrality, livestock health and welfare, preservation of grazing, and protection of biodiversity and the environment (Duurzamezuivelketen, 2019[49]). Projects like the floating farm act as living labs to demonstrate circular agriculture principles (Box 4.9).

Box 4.9. The floating farm

The floating farm in Rotterdam, started in 2019, produces fresh dairy products close to the consumer in a sustainable, innovative and transparent manner, with animal welfare as a priority. The floating farm is based on circular agriculture and aims to eliminate food waste, minimise food transport and improve the overall quality of food.

A large proportion of the raw materials used, including the feed material for the cows, comes from the residual flows from the city. For example, the cows are fed brewers' grains from a number of breweries in Rotterdam, bread from bakers, potato scraps and grass cut from playing fields and golf courses in the city. The farm focuses on the development of urban farming: producing healthy food in cities, close to the consumer, thereby reducing transport emissions.

The structure was developed to follow circular design principles. It generates all of its own electricity from floating solar panels and provides fresh water through an integrated rainwater collection and purification system. In addition, they use their manure to create a natural fertiliser. A milking robot allows cows to be milked as they choose and there is also an automatic belt feeder that distributes animal feed.

Source: https://floatingfarm.nl/.

4.9.3. Innovation in the horticultural sector: Technology at work

The horticultural sector is one of the world's biggest exporters and continues to be both a significant employer and source of value added. Some challenges relate to its high use of energy (particularly gas for heating) and pressure to further reduce the use of pesticides within the production system. In recent decades, steps have been taken towards a more sustainable production. Many firms have invested in

energy-saving technologies, such as heat storage, co-generators and energy screens (Aramyan, Lansink and Verstegen, 2007[50]; Pietola and Lansink, 2006[51]). Several companies have already switched to geothermal energy (heat from deep underground), while others are experimenting with the temporary storage of (solar) heat. On the other hand, an increasing number of firms use artificial growing light installations to prolong the growing season of the plants, leading to additional energy usage (WUR, 2021[52]).

The programme *Kas als energiebron* is an innovation programme aimed at developing new technologies, increasing knowledge about energy saving in glasshouses, stimulating sustainable energy use (such as bioenergy, sunlight, and geothermal), and stimulating innovations that can be a sustainable breakthrough for the sector. The programme is a collaboration between the LNV and *Glastuinbouw Nederland*. and pays a lot of attention to involving practitioners: horticultural entrepreneurs, consultants, suppliers.[31] All research projects are supervised by practitioners via supervisory committees. These groups also actively contribute ideas about the direction of future research.

4.9.4. Innovation in food processing: Responding to consumers' demands

The Netherlands is a major food processor of both domestic and imported food products. Domestic and international consumers are increasingly looking for high quality safe, functional foods yet also at affordable prices. To meet these evolving demands, innovation in food is crucial and an important consideration of the relevant top sector approach.

Both top sectors are tackling the theme of healthy and safe eating and the JPI A healthy diet for a healthy life, which is aimed at research into nutrition and innovation. The Agri-food's innovation contract also covers the alignment with subjects such as food processing, consumer behaviour (explaining and influencing eating behaviour), valorisation of waste flows, resource efficiency and sustainable livestock farming.

The second innovation programme of the Horticulture and Plant Material Top Sector is called Food security and food safety. This programme aims to assist producers to provide objective, reliable data in a controlled chain on origin, production method, transport, authenticity, content and security of the product. Furthermore, the Netherlands is currently also taking part in 12 ERA networks on specific themes, such as sustainable food production, plant genomics and organic agriculture.

4.10. Conclusions

The Dutch AKIS, now converted to a broader "Green KIS" that cuts across sectors, has active private sector and public support and benefits from a long history of use that has refined and improved the system over time. It involves many stakeholders and provides good opportunities for communication and coordination between them, allowing the knowledge generated within the AKIS to flow between the different actors in a co-ordinated way. The system has brought a high standard of productivity and is a model of how to successfully innovate in a competitive world.

The government co-ordinates agricultural research and innovation predominantly through the Top Sector Agri & Food, and the Top Sector Horticulture & Propagation Materials. The Top Consortia for Knowledge and Innovation (TKI) co-ordinates the creation of the Knowledge and Innovation Agenda (KIA), specifying the research programming and financial resources for the Agri-food sector (and for the Horticulture Sector) and fosters innovation with its own financing schemes.

Research institutes collaborate through public-private partnerships such as the TiFN and are also involved with international partners. Farmers' organisations have an important role as central connection points between farmers, the government, and the Dutch advisory system. Their main functions include farm advisory, the co-ordination and facilitation of innovation projects, the creation of network opportunities and the representation of farmers' interests in discussions with the government.

Government funding for agricultural R&D has increased in recent years, although the private sector (through the Top Sectors) is still the main contributor of funding for R&D (though tax credits for R&D expenditures increases the effective government share in the total). International collaboration and partnerships on R&D raise the profile of Dutch researchers and their outputs. The Dutch Government and agri-food research sector play an important role in global and bilateral co-operation initiatives.

While the average level of education of Dutch farmers is very good, the latest OECD Skills for Jobs database suggest that significant skill mismatches are present in the agriculture labour force. The Green Pact can stimulate the quality and attractiveness of Dutch Green education so that it can meet the demands for green labour. Green Pact has grown in recent years to include partners in the field of nature and biodiversity, the food chain, water management and area development. It now also includes youth organisations in the fields of agriculture, food and climate to strengthen participation of students and young professionals in the green sector.

The Netherlands is well placed to reap the potential of digitalisation, but should continue to invest in digital infrastructure, skills, and services complementary to the adoption of digital technologies. Further deployment and take-up of faster fibre networks and next generation 5G wireless networks is a prerequisite for the adaptation of the latest digital technologies such as cloud computing. Data sharing, portability, and trust are still bottlenecks to achieving the full potential of digital technologies for agriculture.

The AKIS system is increasingly turning its attention and resources towards sustainability. This is important to the long-term prospects of the sector and requires careful attention and leadership from the government. Many recent policy actions are designed to help the sector in the twin transition to sustainable agriculture and a nature-based society. A new mission-driven approach to tackle societal challenges has given additional focus and coordination to the Top Sector approach. The overarching mission is to achieve GHG emission reduction targets by 2050 through a cross-sectoral energy transition and improved sustainability. A key conclusion is that the government has still more work to do to align public and private incentives and provide the needed funding and leadership to ensure that the AKIS delivers the public goods needed in the short and long term.

New AKIS elements are doing a better job of bringing environmental innovation to the farm level. “Innovation on the Farm” has encouraged individual farmers to adopt agricultural methods that contribute to biodiversity, sustainability, and mitigation of climate change by stimulating the transfer of knowledge and innovation to the farm. The *Subsidieregeling Agrarische Bedrijfsadvisering en Educatie* (SABE) scheme provides government funded vouchers to finance impartial advice from independent advisors. Providing more incentives to farmers to engage on sustainability issues can help the AKIS support current environmental objectives and give farmers prospects for the long term.

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Notes

[1] See https://investinholland.com/doing-business-here/industries/agrifood/.

[2] Following the widely accepted (OECD/Eurostat, 2005[53]) definition, innovation refers to all scientific, technological, organisational and commercial activities that lead to, or are intended to lead to, the implementation of technologically new or improved products or services.

[3] See https://www.nationaalgroeifonds.nl/english/the-national-growth-fund.

[4] In 2011, the Netherlands introduced an industrial policy covering research, higher education and innovation through a new form of public-private collaboration in nine key economic areas (the so-called Top Sectors): Agriculture and food; Creative industries; Chemical industry; Energy; High tech systems and materials; Horticulture and Starting Materials; Life sciences & health; Logistics; and Water.

[5] Also sometimes referred to as the "Dutch Diamond".

[6] Starting materials refers to source material such as seeds, planting materials or seed potatoes.

[7] See Horizon 2020 (europa.eu).

[8] See Horizon Europe | European Commission (europa.eu).

[9] See https://magazines.wur.nl/european-research-nl/voorwoord

[10] Calculated based on the share of Measure 1, Measure 2 and Measure 16 in Rural Development funding using EAFRD expenditure data provided by the European Commission in the frame of the OECD Agricultural Policy Monitoring and Evaluation. 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. Measure 16 also includes sub-measures that do not target innovation or knowledge exchange.

[11] See https://english.rvo.nl/information/patents-and-intellectual-property-rights.

[12] See www.upov.int.

[13] See https://impactlab.sites.uu.nl/en/introduction/ and https://www.nwo.nl/en/news/dutch-research-agenda-funds-innovative-science-communication.

[14] See https://sciencefinder.techleap.nl/ and https://www.scoutinscience.com/.

[15] See www.agrimatie.nl.

[16] See https://www.nwo.nl/en/researchprogrammes/netherlands-cgiar-research-programme.

[17] See https://www.fao.org/in-action/remote-sensing-for-water-productivity/overview/about-the-project/en/

[18] European Commission. *CAP context indicator C.24 Agricultural training of farm managers.* Based on EUROSTAT [ef_mp_training].

[19] Data on skills mismatches from the OECD Skills for Jobs database covers the whole agriculture, forestry and fishing sector. This indicates different types of occupation are included, and due to limit of sampling methods, it was not possible to disaggregate data to make comparison between, for example, “low skilled” and “high skilled” occupations. Qualification and field-of-study mismatches are calculated based on education attainment of respondents from labour force survey, and values do not reflect situation such as when farmers learn through informal and non-formal ways.

[20] Sparkey (2022), https://www.groenpact.nl/images/content/files/Sparkey-Motivaction_Rapportage%20input%20personas%20werkenden%20in%20het%20groene%20domein%20tav%20leren%20en%20ontwikkelen_Groenpact_Imagro_incl%20verdieping.pdf.

[21] In the research a practical persona categorisation has been created to capture a variety of different types of workers in the green domain who have a similar set of ambitions and thresholds towards learning.

[22] See c7957b31-be5c-4260-8f61-988b9c7f2316 (europa.eu) Farm Structure Survey, pg. 32.

[23] See Samen bouwen aan groene innovaties en kansen. (groenpact.nl).

[24] The EIP-AGRI brings together innovation actors (farmers, advisers, researchers, businesses, NGOs and others) in agriculture and forestry, at EU level. Together they form an EU-wide EIP network.

[25] See https://enrd.ec.europa.eu/sites/default/files/rdp_analysis_m16-1.pdf.

[26] See https://www.groenpact.nl/images/content/Groene%20Monitor/De%20Groene%20Monitor_RGB%20spread.pdf.

[27] Sparkey (2022): https://www.groenpact.nl/images/content/files/Sparkey-Motivaction_Rapportage%20input%20personas%20werkenden%20in%20het%20groene%20domein%20tav%20leren%20en%20ontwikkelen_Groenpact_Imagro_incl%20verdieping.pdf.

[28] See https://english.rvo.nl/subsidies-programmes/mia-and-vamil.

[29] See https://research-and-innovation.ec.europa.eu/document/download/a1fccc86-af53-43d4-94d2-79c54a353d0e_en?filename=ec_rtd_he-partnership-agriculture-data.pdf.

[30] See Organic Europe - Country report - Netherlands (organic-europe.net).

[31] See https://www.glastuinbouwnederland.nl/english/.

OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in the Netherlands

The Netherlands has built an agricultural sector that is a world leader in productivity and competitiveness. But environmental challenges have grown increasingly urgent and the sector will have to adjust. A recent court ruling on nitrogen pollution has set the stage for a transition towards a more environmentally sustainable path that will be difficult and contentious. Leveraging the strong innovation capacity of the sector will be key to finding long-term solutions that work for farmers, citizens and the environment.

Policies for the Future of Farming and Food in the Netherlands takes stock of the current situation in the agriculture sector. It applies the OECD Productivity, Sustainability and Resilience (PSR) analytical framework along with the latest data from the *OECD Agri-Environmental Indicators* to benchmark the country's sustainable productivity performance and to identify the main challenges facing the sector, and make suggestions for a possible path forward.

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