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

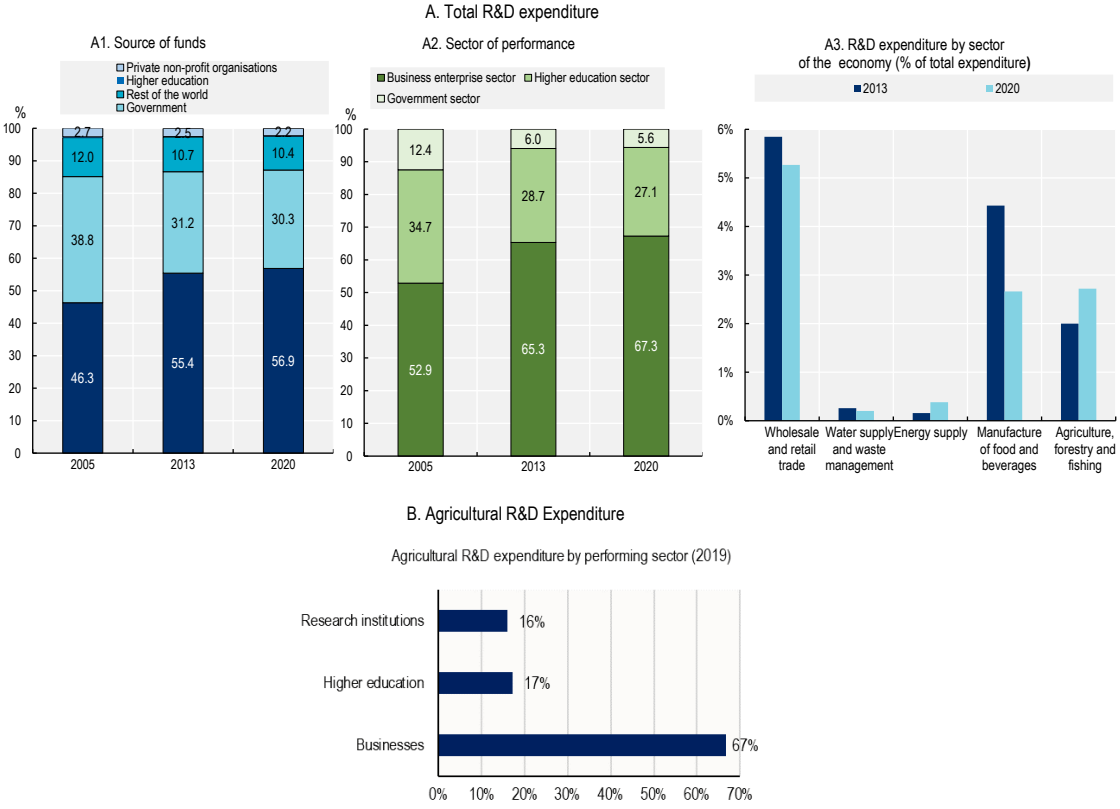
The Netherlands set a R&D intensity target to increase combined public and private investment in R&D to 2.5% of GDP by 2020 (Rakic and et al., 2021[6]). While this was not reached, actual expenditures may be undercounted due to the relatively large proportion of R&D of Dutch multinationals that is carried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

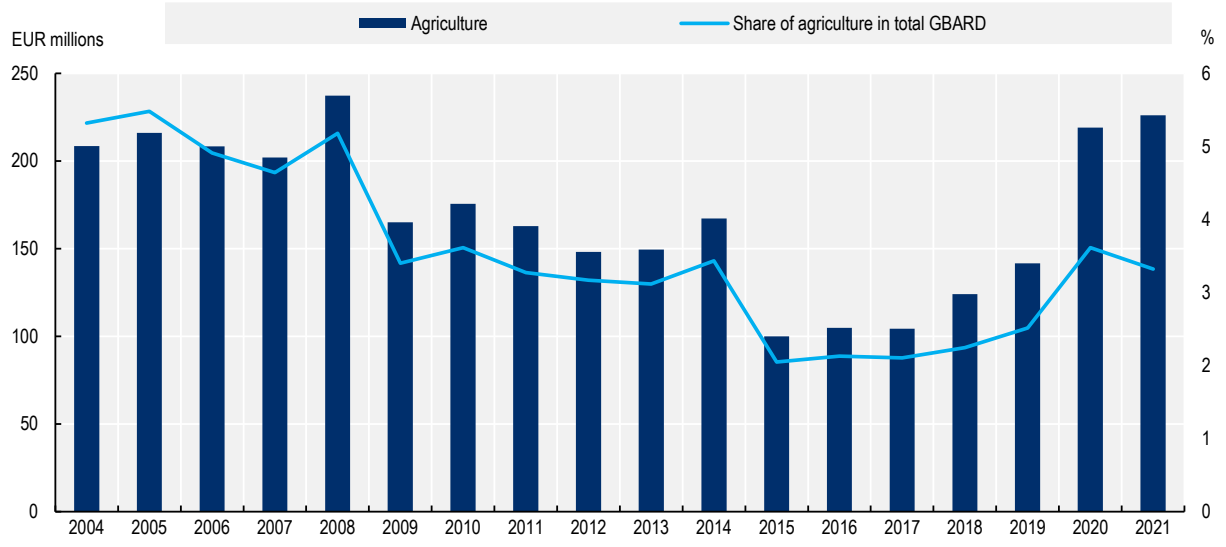
In the new Horizon Europe framework programme, which started in 2021, the most recent call awarded 52 WUR projects (and EUR 37.5 million) of the 128 submitted projects in cluster 6, "Food, Bioeconomy, Natural Resources, Agriculture and Environment". In addition, the success rate of WUR projects in this 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).

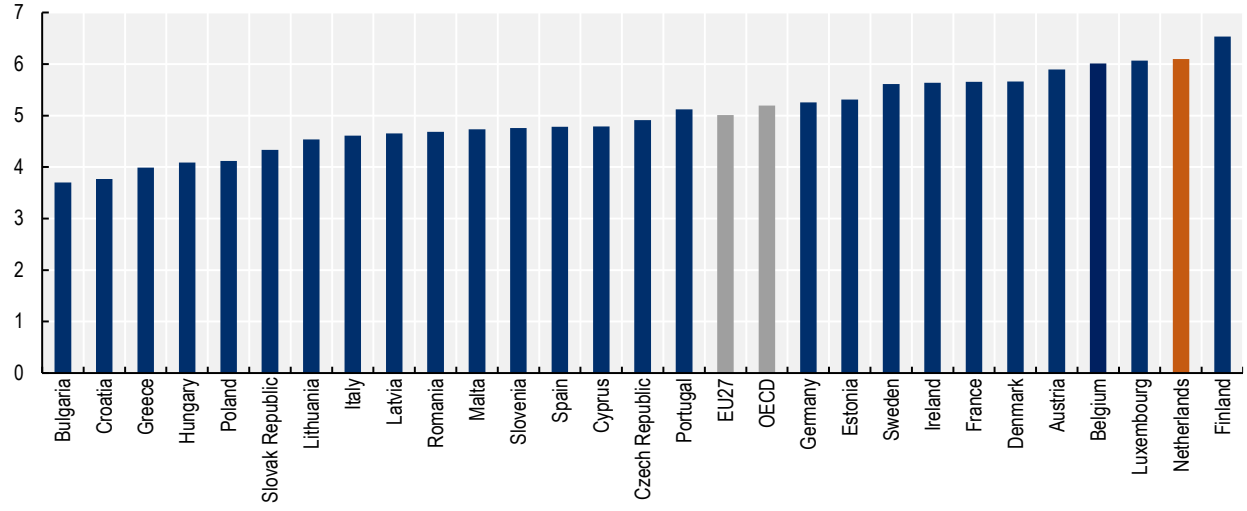
4.3. Protection of intellectual property rights

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]).

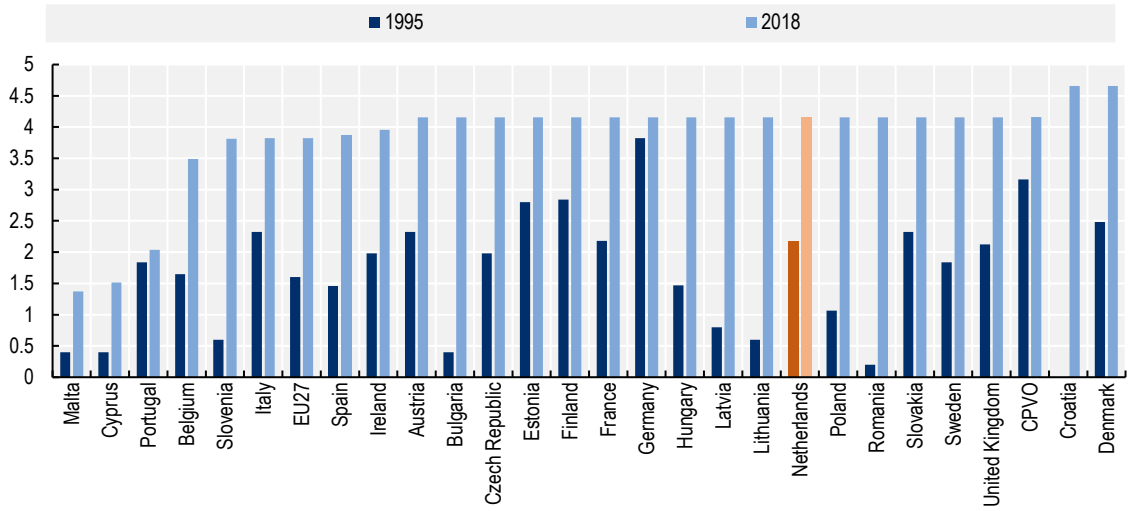
4.3.1. Plant breeding rights

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

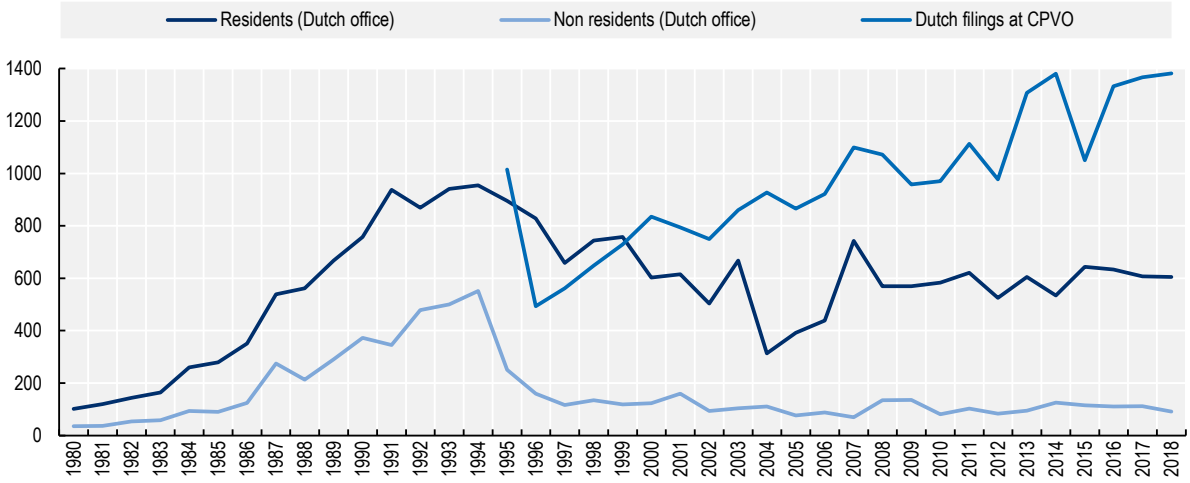
Index of legal IPRs protection for plant varieties (by EU Member States) 1995 vs. 2018
Score from lowest (0) to highest (5) protection



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]).

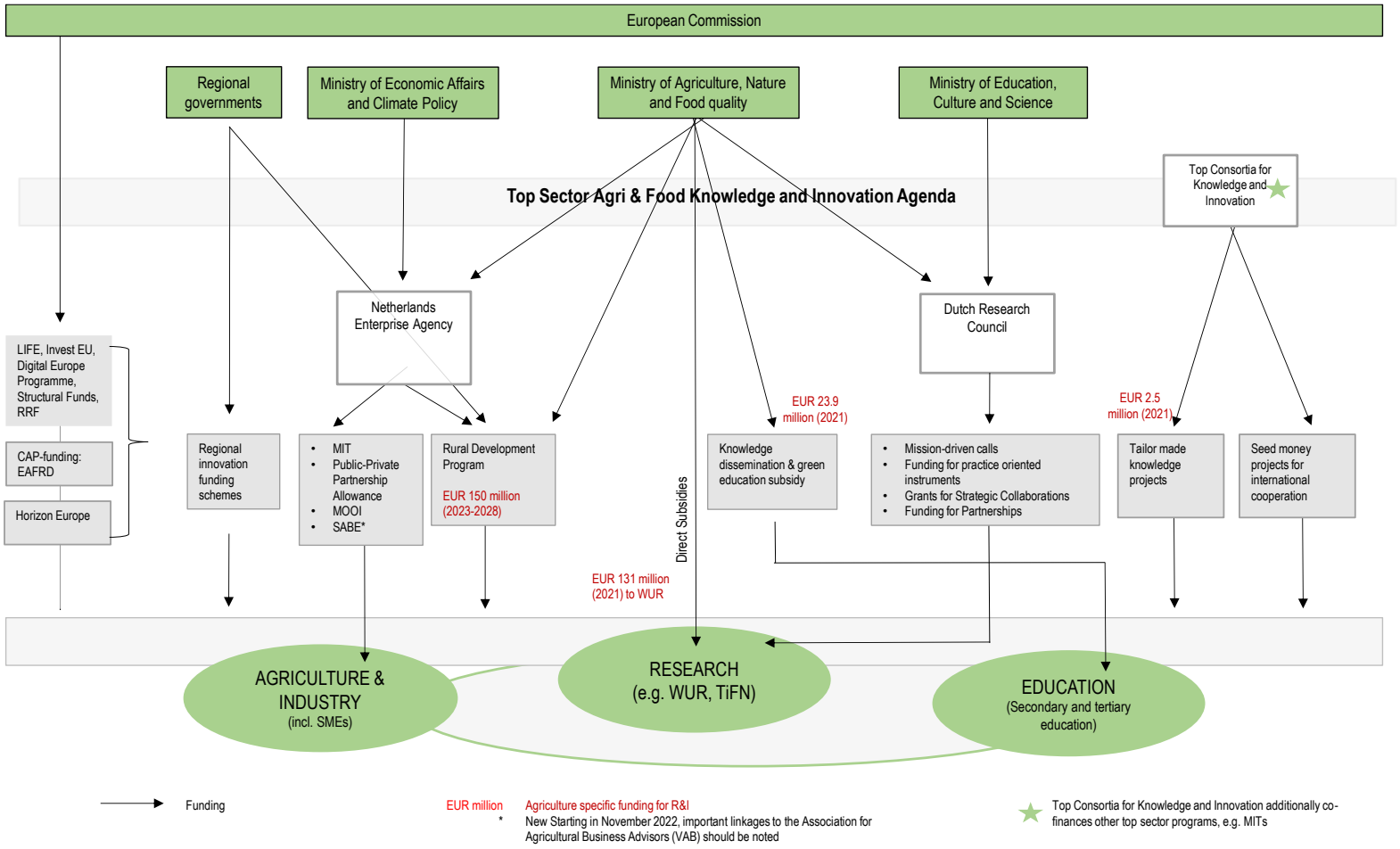
The RVO also channels funding to foster agricultural research and innovation on the farm through the Dutch Rural Development Programme (RDP), based on EU funding from Pillar 2 of the CAP with the respective national and regional contributions provided by LNV. One of the aims of the current Dutch RDP (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]

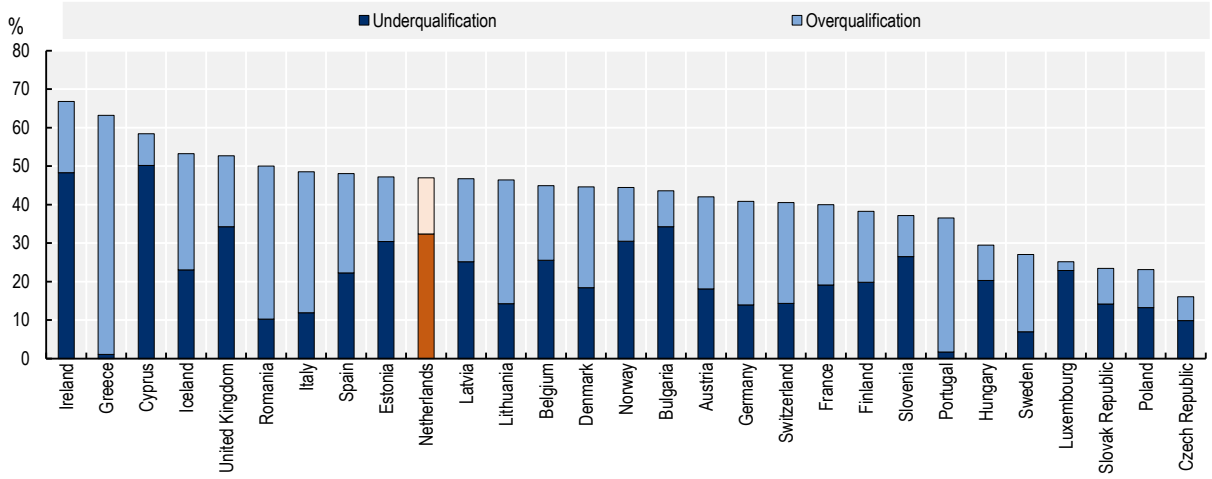
Qualification mismatch is when workers have an educational attainment that is higher or lower than what is required by their job. Forty-seven per cent of workers in the agriculture, forestry and fishing sectors are classified as having a qualification mismatch and 32% of workers have lower education 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%.

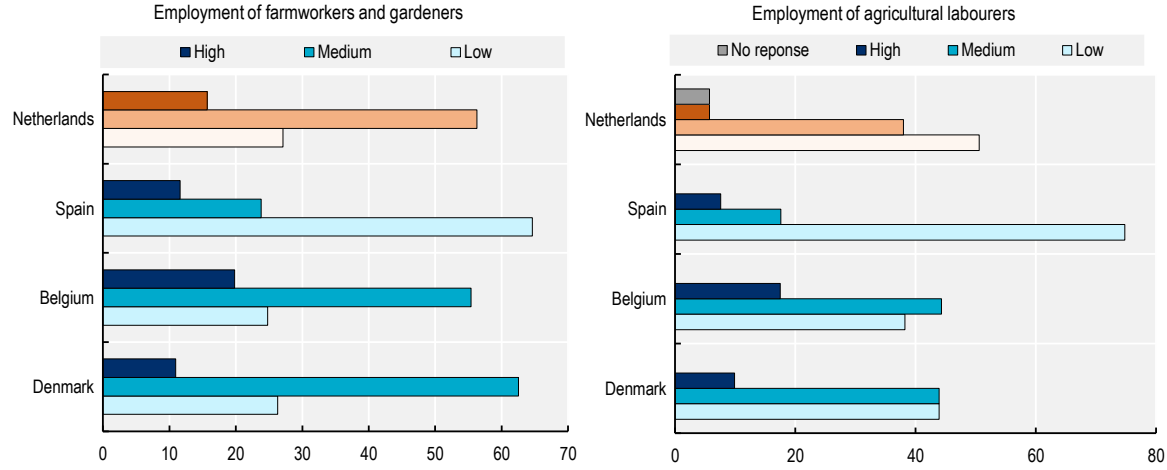
Recently, there has been progress in making agriculture-related education more attractive and responsive to the changing skills needs in the labour market and students' choices, by emphasising job opportunities and societal values. Moreover, many technological developments aim at reducing the dependence 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

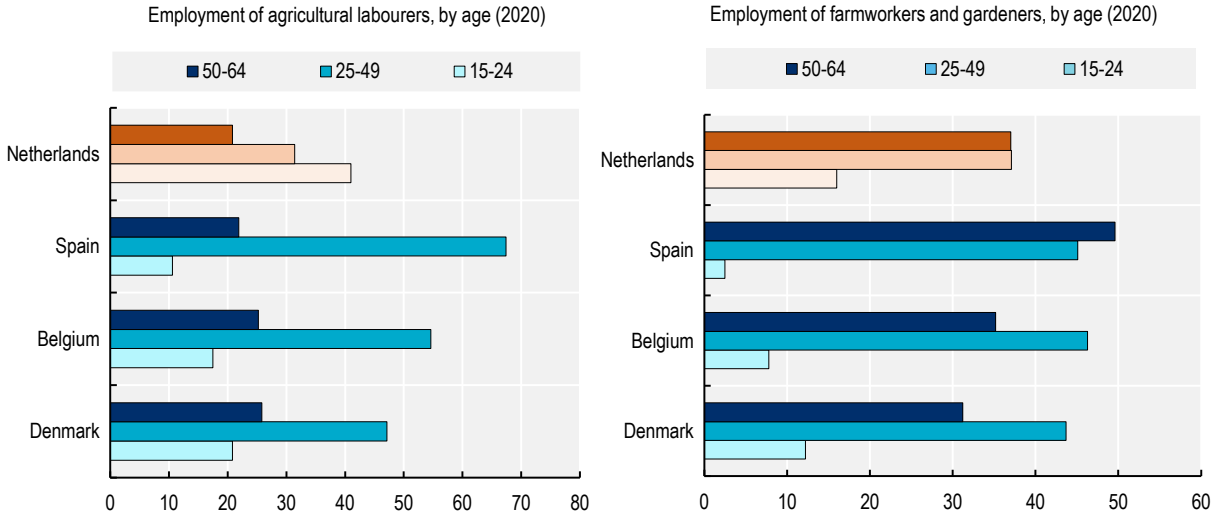
Agricultural employment by education level in 2020



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.

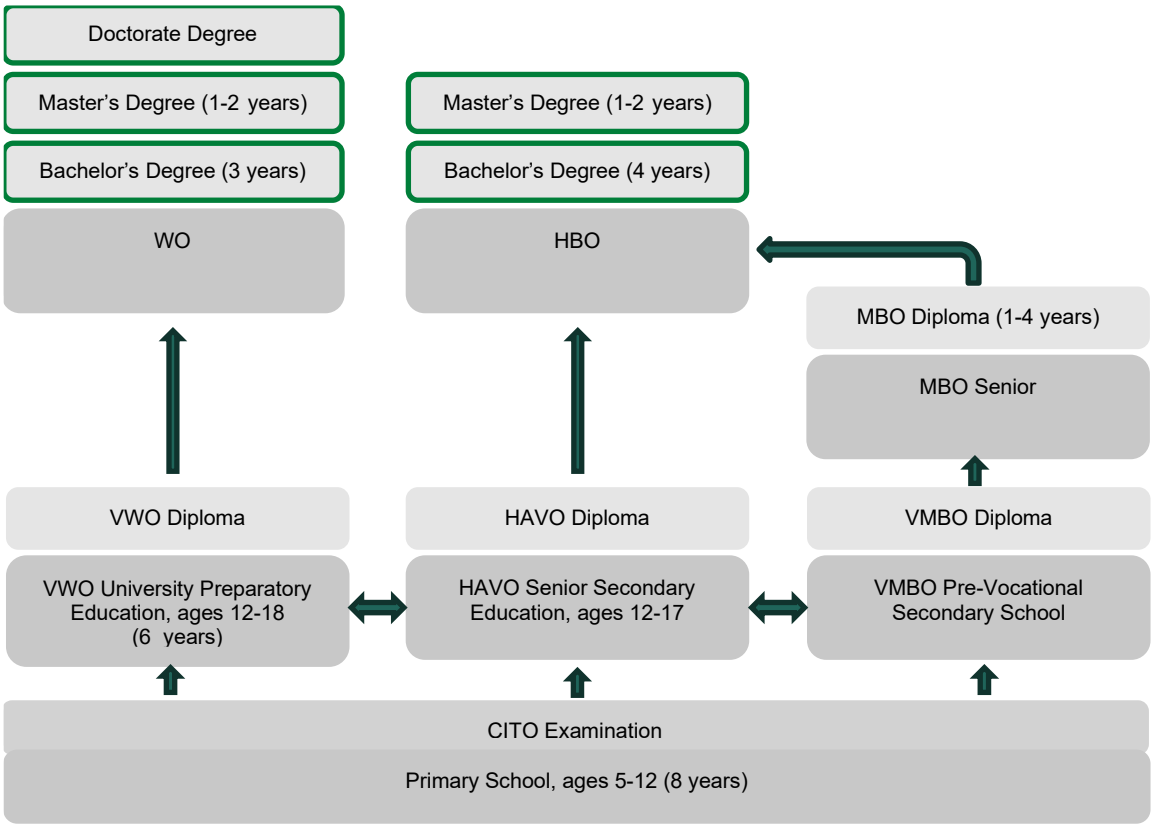
4.6.5. Green Deal Nature Inclusive Education

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.

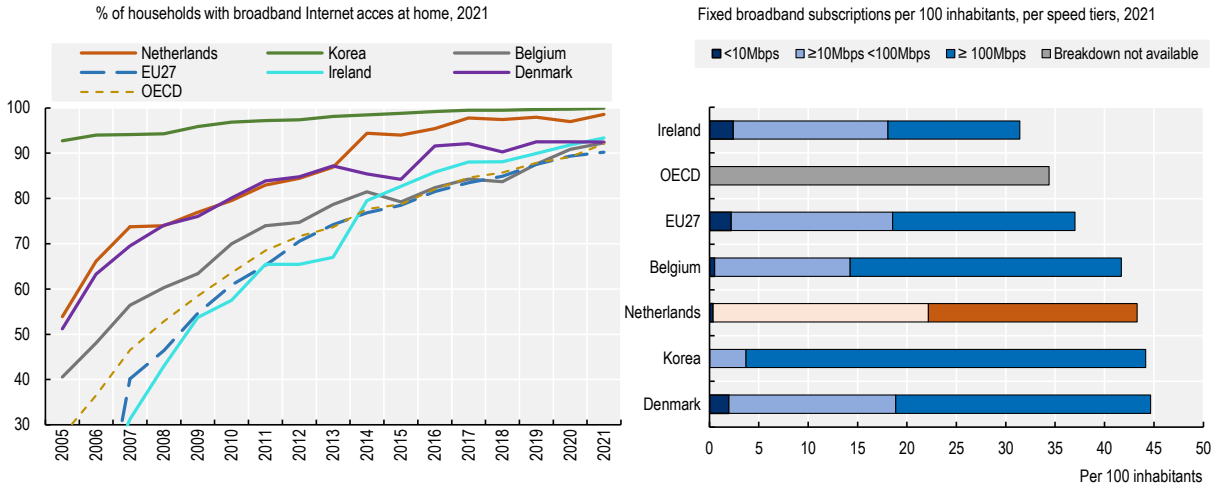
According to a recent study, more than half of MBO-2 and MBO-3 graduates and just under half of MBO-4 graduates end up in a green profession.[27] As the level of education rises, the share of women in both the non-green and the green professions increases. In the past ten years, the number of female 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/.